

**Expert Declaration of
Richard Thomas Di Giulio, Ph.D.**

**EVALUATION OF EPA FOURTH FIVE-YEAR REVIEW REPORT
FOR
AGRICULTURE STREET LANDFILL SUPERFUND SITE
NEW ORLEANS, ORLEANS PARISH, LOUISIANA**

Prepared in connection with *Residents of Gordon Plaza, Inc. v. Cantrell, et al.*
United States District Court for the Eastern District of Louisiana
Civil Action No. 18-cv-04226-ILRL-DMD

February 21, 2019

Testimony of Richard Thomas Di Giulio, Ph.D.
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Director, Duke University Superfund Research Center
Director, Environmental Health and Toxicology Program
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Duke University
Durham, North Carolina 27708-0328

I. My Qualifications

1. I am a toxicologist. Toxicology is the study of the biological effects of substances—including pollutants—on organisms. Toxicologists are interested in identification of hazards posed by pollutants as well as the dosages at which pollutants are, or may be, hazardous.

2. I have published more than 170 papers in the field of toxicology in peer-reviewed journals.

3. I direct the Duke University Superfund Research Center and Duke's graduate program in Environmental Health and Toxicology. I am a member of EPA's Board of Scientific Counselors, Chemical Safety for Sustainability Subcommittee and have served on the Risk and Technology Review (RTR) Methods Panel of EPA's Scientific Advisory Board.

4. As a toxicologist I maintain a familiarity with developments in the related fields of environmental risk assessment and epidemiology and, due to my research and experience, I have specialized knowledge in those fields that informs my professional opinions and endeavors.

5. An accurate copy of my Curriculum Vitae is attached as Exhibit A to this Declaration and is incorporated by reference. My biography on the Duke University web page is located at this link: <https://nicholas.duke.edu/people/faculty/digiulio>.

II. The Purpose of this Declaration and Opinion

6. I have been asked for an opinion about whether EPA's Fourth Five-Year Review Report for the Agriculture Street Landfill Superfund Site establishes the lack of a significant threat to the health of residents living in a neighborhood that is located on the Agriculture Street Landfill.

7. I have also been asked whether residents living on this municipal landfill may be exposed to an elevated risk of adverse health effects.

8. All opinions offered in this Declaration are grounded in the methods and procedures of science, including evaluation of the facts specific to the Agriculture Landfill Site and known characteristics of municipal landfills in light of current scientific knowledge and also in light of the limitations of current scientific knowledge and tools. In general, there are no certainties in science; my opinions are therefore based on current scientific knowledge in fields where research is ongoing.

9. I understand that this Declaration will be submitted to the U.S. District Court for the Eastern District of Louisiana in connection with a defense motion for summary judgment in *Residents of Gordon Plaza, Inc. v. Cantrell, et al.*, Civil Action No. 18-cv-04226-ILRL-DMD.

III. Opinions

10. The information presented in EPA's Fourth Five-Year Review is not sufficient to establish the lack of a significant threat to the health of Agriculture Street Landfill residents.

11. Agriculture Street Landfill residents are most likely subject to a significant elevated probability of developing adverse health effects due to contaminants in the landfill. "Significant" in the context of this Declaration means more than trivial or *de minimis*.

12. Location of a housing development on top of a municipal landfill is not prudent in terms of public health. This is because current risk assessment tools are inadequate to assess reliably the cumulative and potentially synergistic effects of potential residential exposures to the mixtures of chemicals typically present in a municipal landfill and because engineered barriers to public exposures are never completely reliable, especially when those barriers are not applied consistently.

13. Accordingly, contaminants at the Agriculture Street Landfill may pose a significant risk (*i.e.*, more than a trivial risk) of adverse health effects to Agriculture Street Landfill residents.

IV. Bases for My Opinions

Background Part A–Site Information

14. The Agriculture Street Landfill served as a City of New Orleans municipal landfill from approximately 1909 until the late 1950s. EPA *Record of Decision* at p.1 (April 2002). The landfill received municipal waste, ash from incineration of such waste, and ash and debris from open burning. *Id.* It reopened for approximately one year in 1965 for open burning and disposal of waste from Hurricane Betsy. *Id.* EPA summarized the landfill’s operational history as follows:

A 1951 Refuse Disposal Study for New Orleans (Study) reported that the ASL site was used as a disposal facility for commercial refuse from 1909 through 1934. During this period, practically all household garbage generated within the municipality of New Orleans was disposed of by incineration and a portion of the resulting ash was land filled at the ASL. During the years from 1934 through 1939, a restrictive budget limited the incineration of household wastes causing the ASL to be opened to receive municipal and commercial waste. Between the years of 1939 and 1942, incineration again became the chief means for the reduction of household garbage. During World War II, a lack of labor again diverted household wastes to the ASL. Actual operation of the ASL as a permanent, sanitary, controlled landfill began in October 1948. A contract was awarded for salvage materials to be recovered and a 5-year lease was signed with the landowner. The Study states that poor operation and inadequate supervision during this period resulted in fires and other nuisances at the location.

In approximately 1958, operations at the landfill were terminated. The landfill was temporarily reopened in 1965 to receive debris resulting from the effects of hurricane Betsy. Debris was reported to have been deposited at a rate of up to 300 truckloads per day and open burning was used as a means of waste reduction. The landfill was officially closed in 1966, although determining the exact closure date is complicated by evidence of unofficial or illegal dumping.

EPA, *Phase II Close Out Report for the Agriculture Street Landfill Superfund Site*, New Orleans, Louisiana (CERCLIS No.: LAD981056997) at p. 2-2 (June 2001).

15. EPA engaged in several “removal actions” at the Agriculture Landfill Site during the mid-1990s until early 2000. EPA, *Fourth Five-Year Review Report* at p. 6.

- A. EPA erected a fence around the undeveloped portion of the landfill (approximately 48 acres). EPA *Record of Decision* at p. 3 (April 2002)
- B. EPA removed playground equipment at the Shirley Jefferson Community Center and backfilled and sodded that area. *Id.* at p. 4.
- C. EPA repaired the fence around the undeveloped area, which trespassers had damaged. *Id.*
- D. EPA cleared and graded the undeveloped area, placing a permeable geotextile mat and orange fencing on that area. EPA covered the mat with twelve inches of fill and re-established vegetation. *Id.* at p. 5.
- E. In residential areas (with exceptions), EPA excavated 24 inches of soil, putting down a permeable geotextile mat/marker, backfilling, and covering with sod. *Id.*
- F. EPA decided to take no action to clean up groundwater or at the Moton Elementary School. EPA, *Fourth Five-Year Review Report* at p. 7.

16. In 2002, EPA decided to take no further action. *Id.*

17. In 2006, the U.S. Agency for Toxic Substances and Disease Registry (ATSDR) estimated, “Incidental ingestion of soil containing [a sampled] concentration [on the landfill] would yield a cancer risk of 2.70×10^{-4} or 27 excess cancers per 10,000 people exposed over a lifetime.” This is outside of EPA’s “acceptable risk” range. Because ATSDR considers such estimates to be “accurate within one order of magnitude,” the risk calculation might actually represent 27 excess cancers per 1000 people—*i.e.*, a risk elevated by 2.7% from only one type of chemical present at the landfill. ATSDR, *Health Consultation (EPA Facility ID: LAD981056997)* (Aug. 29, 2006) at pp. 6, 7.

18. In 2006—long after EPA’s removal actions were complete, the ATSDR concluded that “PAH concentrations pose an indeterminate public health hazard at the [Agriculture Street Landfill] site.” ATSDR, *Health Consultation (EPA Facility ID: LAD981056997)* (Aug. 29, 2006) at p. 7 (also discussed at p. 6).

19. Recent EPA sampling found several dangerous contaminants at the Agriculture Landfill Site, including lead, arsenic, and polynuclear aromatic hydrocarbons (PAHs). EPA, *Fourth Five-Year Review Report* at p. 5 (July 2018).

Background Part B—Environmental Risks and Municipal Landfills in General

20. Risks from environmental contamination are often expressed in a mathematical formula that states a probability of a bad outcome over a 70-year lifespan. For example, a risk of 1×10^{-6} refers to a one-in-one-million risk of harm over such a lifespan. A risk of 1×10^{-4} refers to a one-in-ten-thousand risk of harm. A risk of 1×10^{-3} refers to a one-in-one-thousand risk of harm over such a lifespan.

21. In general, risks of 1×10^{-6} (one-in-one-million) or less are considered trivial or *de minimis*. For example, EPA has explained that “a *de minimis* risk is usually considered by

regulatory agencies to be a risk at or below 10^{-6} over a 70-year life time.” EPA, *Hazardous Waste Management System; Identification and Listing of Hazardous Waste Final Exclusion*, 67 Fed. Reg. 1888, 1892 (Jan. 15, 2002).

22. In the Superfund program, EPA has adopted an “acceptable risk” range of 1×10^{-6} to 1×10^{-4} , *i.e.*, one-in-one-million to one-in-ten-thousand. EPA discussed its selection of the 1×10^{-4} (one-in-ten-thousand) number as within an “acceptable” range in a Clean Air Act rulemaking. At that time, EPA acknowledged that a 1×10^{-4} does not represent a de minimis or trivial risk, explaining “EPA does not believe that the terms de minimis and ‘acceptable risk’ are synonymous.” EPA, *National Emission Standards for Hazardous Air Pollutants*, 54 Fed. Reg. 38,044, 38,055 (Sept. 14, 1989). Based in part on an analysis that “driving a car or breathing city air are risk-laden activities that society does not consider ‘unsafe,’” EPA explained that “the determination of what is an ‘acceptable risk’ is discretionary” with the agency. *Id.* In the Superfund program, EPA explained that it has a “preference [but not a presumption] for setting cleanup levels at the more protective end of the risk range” [*i.e.*, 1×10^{-6}]. EPA, *National Oil and Hazardous Substance Pollution Contingency Plan*, 55 Fed. Reg. 8666, 8717 (Mar. 8, 1990).

23. Under the Superfund Program, EPA has developed guidance for remedial action at municipal landfills. In that document, EPA noted that “future residential use of the landfill source area itself is not considered appropriate” EPA, *Presumptive Remedy for CERCLA Municipal Landfill Sites* at p. 5 (EPA 540-F-93-035, Sept. 1993).

24. EPA has explained that available data “do not provide strong support for distinguishing the health and environmental threats” posed by municipal landfills from risks posed by hazardous waste landfills. EPA, *Solid Waste Disposal Facility Criteria*, 56 Fed. Reg. 50,978, 50,982 (Oct. 9, 1991). The agency noted that data “do not reveal significant differences in the number of toxic constituents and their concentrations in the leachates of the two categories of facilities.” *Id.* In other words, people living on a municipal landfill are not necessarily safer than those living on a hazardous waste landfill.

Agriculture Street Landfill Specific Information

25. For its Fourth Five-Year Report, EPA collected 36 soil samples from 33 locations (including three field duplicate samples). EPA, *Fourth Five-Year Review Report* at p. ES-1 and Appendix J Chain of Custody Record. Only four of these samples were collected from residential properties. *Id.* at p. 12.

26. In the introduction of the Fourth Five-Year Report, EPA claims that all samples were tested for PAHs, arsenic and lead (page ES-1); however, closer inspection of the report reveals that soil samples from only 8 of the 33 locations were tested for PAHs (see Appendix J, Chain of Custody Record and data tables).¹ Benzo(a)pyrene exceeded the EPA screening level at 50% of the locations tested for PAHs (samples ASL-SS-01, ASL-SS-31, ASL-SS-32, and ASL-SS-33) and exceeded the RECAP screening level at 25% of the locations tested for PAHs (samples ASL-SS-01 and ASL-SS-33). *Id.* at Appendix K, Tables K-1 and K-2. In sample ASL-SS-33,

¹ The ECF Document page numbers are pp. 336-338 and 372 for the Chain of Custody Record, and pp. 239-297 and 344-350 for the data tables in ECF Document 36-4.

collected under the slab of a residence, the level of benzo(a)pyrene was more than 20 times the EPA screening level. *Id.* at Appendix K, Table K-2.

27. For its Fourth Five-Year Review soil sampling, EPA only took soil samples from the top “zero to three inches of soil.” EPA, *Fourth Five-Year Review Report* at p. 12. Residents, including children, could easily dig or otherwise disturb soil below three inches. Indeed, the highest concentration of lead detected in EPA’s 2005 sampling (conducted in response to Hurricane Katrina) was found in a sample from the 3 to 6-inch layer of soil. EPA, *Hurricane Katrina Response Agriculture Street Landfill, New Orleans Site Inspection and Sampling Results* p. 9-10 (Jan. 30, 2006). Thus, EPA’s samples were not sufficient to characterize potential exposures.

28. EPA’s Fourth Five-Year Review Report does not consider synergistic or additive effects from potential exposure to chemical mixtures. For example, substantial synergistic toxicity towards the developing cardiovascular system has been observed between PAHs with different molecular mechanisms of action (Billiard et al., 2008).

29. EPA’s Fourth Five-Year Review Report does not consider the mental stress of living on a Superfund site. For example, the report notes the “low” odor threshold for some compounds detected in a soil sample, stating that odors “could be a nuisance” EPA, *Fourth Five-Year Review Report* at p. 12. According to EPA, “During the fourth FYR... the resident [of the Agriculture Street site] reported to EPA odor issues in the home....” EPA, *Vapor Intrusion Investigation Property No. 01 Results Technical Memorandum Agriculture Street Landfill Superfund Site – New Orleans, Louisiana* (Nov. 12, 2018). Whether or not the exposures underlying the detection of odor were overtly toxic, it is likely that these odors would create anxiety given the potential for adverse health effects. More broadly, the health benefits of aesthetically pleasing environments versus the negative effects of degraded environments (such as demonstrated for the Agriculture Street Landfill in the photos provided in EPA, *Fourth Five-Year Review Report* at Appendix A) are being increasingly recognized (e.g., Coutts, 2015).

30. The screening levels and acceptable risk ranges that EPA employed for PAHs appear to be based on cancer risks. While cancer is certainly an important health impact of PAHs, there is growing evidence that for the developing fetal/embryonic organism other effects are very important, including effects on cardiovascular development (see para. 28, above) and neurological development (e.g., Perera et al., 2011; Peterson et al, 2015). Importantly, these effects appear to be based on mechanisms different from those underlying cancer (*i.e.*, direct damage to DNA). Also, the targets for PAH analysis appear to be the 16 PAHs EPA selected for priority in 1976, plus 1-methylnaphthalene and 2-methynaphthalene. This is not an adequate list because it does not include what are reported to be very toxic PAHs, including dibenzo[a,l]pyrene, dibenzo[a,i]pyrene, and benzo[c]fluorene (Anderson and Achten, 2015).

31. The arsenic assay was not sensitive enough to ensure reliable results. Specifically, the lower threshold of detection for arsenic that EPA used for its Fourth Five-Year Review Report ranged from 10.3 ppm – 13.8 ppm,² while EPA’s Region 6 Residential Soil Screening Level is 0.68 ppm and the Louisiana RECAP screening level is 12 ppm. Thus, arsenic could be present at

² EPA, *Fourth Five-Year Review Report* at Appendix J (ECF Doc. 36-4 at pp. 242-297, 347).

the ASL at concentrations above both the federal Screening Level and the state RECAP screening level but remain undetected. Thus, EPA's statement that it found arsenic above screening levels at only one location, *id.* at p. ES-1, fails to describe the extent of arsenic contamination at the site.

32. EPA placed unexplained reliance on the state RECAP screening levels which are generally significantly higher than EPA's own screening levels.³ For example, discussing samples that showed benzo(a)pyrene levels at more than twice the EPA screening level, the report states "because the RECAP screening level is not exceeded, no further action is recommended." EPA, *Fourth Five-Year Review Report* at p. E-2 and p. 14. EPA does not provide an explanation for failing to address federal screening levels in this evaluation. This approach is problematic given the large disparity between screening levels for EPA and RECAP with respect to multiple contaminants, (for example, 0.68 ppm versus 12 ppm for arsenic, respectively), EPA, *Fourth Five-Year Review Report* at p. 13.

33. The Fourth Five-Year Review Report lacks data for any element besides arsenic and lead (for example, chromium). The analysis used (inductively coupled plasma mass spectrometry) typically yields data on an entire suite of heavy metals. I would have expected these data to be included in the report.

34. PAHs are relatively insoluble, but they can still move with water. Given that this site is subject to severe flooding, EPA, *Fourth Five-Year Review Report* at p. 15 and EPA, *Hurricane Katrina Response Agriculture Street Landfill* at p. 3, the potential for PAH migration in the soil is a concern.

V. Documents reviewed

35. In preparation for this Declaration, I have reviewed the following documents:

EPA, *Fourth Five-Year Review Report for the Agriculture Street Landfill Superfund Site, New Orleans, Orleans Parish, Louisiana* (July 2018)

EPA, *Hurricane Katrina Response Agriculture Street Landfill, New Orleans Site Inspection and Sampling Results* p. 9-10 (Jan. 30, 2006)

EPA, *Vapor Intrusion Investigation Property No. 01 Results Technical Memorandum Agriculture Street Landfill Superfund Site – New Orleans, Louisiana* (Nov. 12, 2018)

EPA, *Record of Decision* (April 2002)

³ RECAP refers to Louisiana's Risk Evaluation/Corrective Action Program (RECAP), which comprise the state agency's "minimum remediation standards for present and past uncontrolled constituent releases."

<https://deq.louisiana.gov/index.cfm?md=pagebuilder&tmp=home&pid=recap>. EPA has explained, with regard to federal soil screening levels (SSLs), "Generally, where contaminant concentrations equal or exceed SSLs, further study or investigation, but not necessarily cleanup, is warranted." EPA, *Soil Screening Guidance: User's Guide* at p. 1 (July 1996).

- EPA, Human Health Risk Assessment (Appendix S to EPA, *Remedial Removal Integrated Investigation Report, Agriculture Street Landfill New Orleans, Orleans Parish, Louisiana*, v. 4 (Mar. 1995)
- EPA, *Phase II Close Out Report for the Agriculture Street Landfill Superfund Site*, New Orleans, Louisiana (CERCLIS No.: LAD981056997) (June 2001)
- EPA, *Hazardous Waste Management System; Identification and Listing of Hazardous Waste Final Exclusion*, 67 Fed. Reg. 1888, 1892 (Jan. 15, 2002)
- EPA, *National Oil and Hazardous Substance Pollution Contingency Plan*, 55 Fed. Reg. 8666, 8717 (Mar. 8, 1990)
- EPA, *Presumptive Remedy for CERCLA Municipal Landfill Sites* at p. 5 (EPA 540-F-93-035, Sept. 1993)
- EPA, *National Emission Standards for Hazardous Air Pollutants*, 54 Fed. Reg. 38,044, 38,055 (Sept. 14, 1989)
- EPA, *Hazardous Waste Management System; Identification and Listing of Hazardous Waste Final Exclusion*, 67 Fed. Reg. 1888, 1892 (Jan. 15, 2002)
- EPA, *Solid Waste Disposal Facility Criteria*, 56 Fed. Reg. 50,978, 50,982 (Oct. 9, 1991)
- U.S. Agency for Toxic Substances and Disease Registry, *Health Consultation (EPA Facility Id: LAD981056997)* (Aug. 29, 2006)
- EPA, *Soil Screening Guidance: User's Guide* (July 1996)
- Andersson, J.T., and C. Achten. 2015. Time to Say Goodbye to the 16 EPA PAHs? Toward an Up-to-Date Use of PACs for Environmental Purposes. *Polycyclic Aromatic Hydrocarbons* 35:330-354.
- Billiard, S.M., Meyer, J.N., Wassenberg, D.M., Hodson, P.V., and Di Giulio, R.T. 2008. Nonadditive effects of PAHs on early vertebrate development: mechanisms and implications for risk assessment. *Toxicological Sciences* 105:5-23.
- Coutts, C. 2015. *Green Infrastructure and Public Health*. Routledge, New York, NY, 312 pp.
- Perera, F.P., S. Wang, J. Vishnevetsky, B. Zhang, K.J. Cole, D. Tang, V. Rauh, and D.H. Phillips. 2011. Polycyclic Aromatic Hydrocarbons-Aromatic DNA Adducts in Cord Blood and Behavior Scores in New York City Children. *Environmental Health Perspectives* 119:1176-1181.
- Peterson, B.S., V.A. Rauh, R. Bansal, X. Hao, Z. Toth, G. Nati, K. Walsh, R. L. Miller, F. Arias, D. Semanek, and F. Perera. 2015. Effects of Prenatal

Exposure to Air Pollutants (Polycyclic Aromatic Hydrocarbons) on the Development of Brain White Matter, Cognition, and Behavior in Later Childhood. JAMA Psychiatry 72:531-540.

VI. Publications

36. To the best of my knowledge, all of my publications from the past 10 years are listed on my Curriculum Vitae, which is attached as Exhibit A to this Declaration and incorporated by reference.

VII. Past Testimony

37. I have not provided trial or deposition expert testimony in federal, state, or administrative cases in the past four years

VIII. Fees for Services

38. For reviewing appropriate information and preparing this testimony, I expect to receive a flat fee of \$5,000.00.

I declare under the penalty of perjury that the statements in this report are true and accurate to the best of my knowledge. Executed on February 21, 2019.


Richard Thomas Di Giulio, Ph.D.

CURRICULUM VITAE

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CURRENT POSITION: Sally Kleberg Professor of Environmental Toxicology
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PERSONAL DATA: Born: 13 October 1950

EDUCATION: Ph.D., Virginia Polytechnic Institute and State University, 1982
M.S., Louisiana State University, 1978
B.A., University of Texas at Austin, 1972

PROFESSIONAL EXPERIENCE:

Sally Kleberg Distinguished Professor, Nicholas School of the Environment, Duke University, 2016 – present
Chair, Environmental Science and Policy Division, Nicholas School of the Environment, July, 2016 – December, 2018
Professor, Nicholas School of the Environment, Duke University, 1998 – 2016
Secondary Professor, Pratt School of Engineering, Duke University, 2012 - present
Director, Duke University Superfund Research Center, 2000 - present
Director, University Program in Environmental Health and Toxicology, Duke University, 2001 – present
Director, Center for Comparative Biology of Vulnerable Populations, 2005 - 2010
Associate Professor, School of the Environment, Duke University, 1991-98
Assistant Professor, School of Forestry and Environmental Studies, Duke University, 1985 - 1991
Assistant Professor and Research Associate, School of Forestry and Environmental Studies, Duke University, 1982-85

SOCIETY MEMBERSHIPS:

Society of Environmental Toxicology and Chemistry
Society of Toxicology
Phi Kappa Phi
Sigma Xi

AWARDS:

Fellow, Society of Environmental Toxicology and Chemistry (SETAC). Awarded 2018, for significant long-term scientific contributions and service and leadership within SETAC.

Professor of the Year, 1984-85. Awarded annually by graduate students of the School of Forestry and Environmental Studies, Duke University.

The A. B. Massey Honorarium, 1982. Awarded to outstanding graduate student in Department of Fisheries and Wildlife Science, VPI&SU.

College of Agriculture and Life Sciences Fellowship, VPI&SU, 1978-1981. Awarded to top 10 graduate applicants in 1978.

National Wildlife Federation Fellowship Awards, 1980-1981 and 1981-1982.

KEY PROFESSIONAL ACTIVITIES:

Member, External Advisory Committee, Dartmouth College Superfund Research Center, June, 2018 – present.

Member, U.S. EPA Board of Scientific Counselors, Chemical Safety for Sustainability Subcommittee, January 1, 2018 – present.

Member, NC Department of Environmental Quality and Department of Health and Human Services Secretaries' Science Advisory Board, September, 2017 – present.

Member, U.S. EPA Scientific Advisory Board, Risk and Technology Review (RTR) Methods Panel, Arlington, VA, June 29-30, 2017.

Member, External Advisory Board, Environmental Health Science Center (P30), Texas A&M University, March, 2016 – present.

Member, U.S. EPA Scientific Advisory Board, Ecological Processes and Effects Committee, November, 2011 – July, 2018.

Member, U.S. EPA Scientific Advisory Board. Lake Erie Phosphorous Objectives Review Panel, November, 2014 – May, 2017.

Member, Editorial Review Board, Journal of Exposure Science and Environmental Epidemiology, June, 2013 – present.

Member, Qualifications Review Board, for selection of Editor-in-Chief, Environmental Health Perspectives, April, 2014 – October, 2015.

Member, U.S. Department of Defense, Strategic Environmental Research and Development Program, Scientific Advisory Board, October, 2011 – July, 2015.

Associate Editor, Environmental Health Perspectives, January 2008 – present.

Member, NIEHS Review Committee, Superfund Research Program, August – November, 2012.

Member, NIEHS Review Committee, International Collaborations in Environmental Health, May – July, 2012.

Member, Committee on Human and Environmental Exposure in the 21st Century. The National Academy of Science, National Research Council, Washington, D.C. March, 2010 – November, 2012.

Member, Computational Toxicology Committee, Board of Scientific Counselors, U.S. EPA, Washington, D.C. December 2004 – July, 2013.

Member, Executive Committee, North Carolina Center of Innovation for Marine Biotechnology, January, 2008 – March, 2009.

Associate Editor, Toxicological Sciences, January 2004 – December, 2007.

Member, Review Committee, U.S. EPA Safe Pesticides, Safe Products Program, Board of Scientific Counselors, February – May, 2007.

Member, Committee on Assessment of the Health Implications of Exposure to Dioxin. The National Academy of Science, National Research Council, Washington, D.C. October, 2004 – October, 2006.

Member, Nomination Committee, Society of Environmental Toxicology and Chemistry, 1991 – 1993, and 2003 - 2006.

Member, Review Team for U.S. Army Environmental Health Research Center, Fort Detrick, MD, June, 2003.

Member, Contaminated Sediments Science Plan Review Committee, U.S. EPA, Scientific Advisory Board, October, 2002 – March, 2003.

Member, Review Committee, NIEHS Environmental Health Science Center, SUNY, Stony Brook, May, 2001.

Member, Review Team for the Board of Scientific Counselors, U.S. EPA, to review the National Center for Environmental Research (NCER), October – December, 1997, and September, 2001 – March, 2002.

Member, Expert Advisory Committee, Canadian Network of Toxicology Centres, January, 1998 – March, 2003.

Consultant, U.S. EPA, Scientific Advisory Board, February, 1991 - present.

Member, Review Committee, Hudson River Foundation, NYC, NY, January, 2000 and October, 2001 – March, 2002.

Member, Advisory Council, Chesapeake Ecotox Research Consortium (a consortium of Maryland and Virginia scientists), January, 2000 – October, 2001.

Member, Board of Directors and Chair, Membership Committee, Society of Environmental Toxicology and Chemistry (SETAC), November, 1995 – November, 1998.

Member, Program Committee, SETAC 19th Annual Meeting, November 15-19, 1998, Charlotte, NC (Chair, Plenary Session).

Member, Academic Advisory Board, Ecotoxicology Program, University of California-Davis, 1992 - 1997.

Secretary-Treasurer, Society of Toxicology, North Carolina Chapter, April, 1994 - April, 1996.

Member, U.S. EPA Environmental Biology Peer Review Panel, Office of Exploratory Research. Reviews attended: Gatlinburg, TN, May 18-20, 1988; New Orleans, LA, February 21-23, 1990; Fort Worth, TX, May 29-31, 1990; Portland, OR, July 18-20, 1990; Tempe, AZ, December 13-15, 1990; Washington, D.C., June 2-4, 1991; Knoxville, TN, June 27-29, 1991; Fort Worth, TX, January 12-14, 1995; Washington, DC, August 28, 1996 (Drinking Water Disinfection By-Products).

Member, Site Review Team, U.S. EPA-sponsored Environmental Research Centers, June - August, 1991.

Member, Technical Committee, Society of Environmental Toxicology and Chemistry, November, 1987 - 1991.

Member, Board of Directors, and Secretary, Carolinas Chapter of the Society of Environmental Toxicology and Chemistry, August 1991 - December, 1993.

Member, Editorial Board, Human and Ecological Risk Assessment, January, 1995 – December, 2005.

Member, Editorial Board, Toxicological Sciences, January, 2000 – 2003.

Member, Policy Board, Ecotoxicology Section, Chemosphere, March, 1989 – December, 2002.

Member, Editorial Board, Environmental Health Perspectives, March, 1993 – December, 2000.

Member, Editorial Board, Ecotoxicology, August, 1991 – December, 2000.

Member, Editorial Board, Environmental Toxicology and Chemistry, November, 1987 - December, 1990 and January, 1994 - December, 1996.

Reviewer (last 5 years) for Aquatic Toxicology, Archives of Environmental Contamination and Toxicology, Comparative Biochemistry and Physiology, Ecological Applications, Environmental Health Perspectives, Environmental Science and Technology, Environmental Toxicology and Chemistry, Human and Environmental Risk Assessment, Journal of Toxicology and Environmental Health, Marine Biology, Marine Environmental Research, Toxicological Pathology, and Toxicological Sciences.

Member, Biological Monitoring Task Force, North Carolina Department of Environment, Health, and Natural Resources. October, 1990 - March 1993.

Member, Fish Tumor Task Force, September, 1985 - August, 1988. Dr. John Hickey, U.S. "Fish and Wildlife Service, Cortland, NY, Director.

Member, North Carolina Coastal Energy Impact Program Research Team, "Cumulative Impacts of Peat Mining," July, 1983 - July, 1984.

MAJOR CONFERENCES AND WORKSHOPS:

Invited Participant and Speaker, Elizabeth Project Sediment Remediation Partnership, Portsmouth, VA, November 3, 2016.

Invited Participant and Speaker, Tri Services Environmental Risk Assessment Work Group, Portsmouth, VA, September 14, 2016.

Invited Participant and Speaker, Invited Participant, Aggregate Exposure Pathway Workshop, May 9-11, 2016, U.S. EPA NHEERL, RTP, NC.

Organizer and Speaker, The Toxicity of Power Symposium, sponsored by Duke University ITEHP and Superfund Research Center, November 13, 2015, Durham, NC.

Member, International Scientific Committee, Pollutant Responses in Marine Organisms (PRIMO 18), Trondheim, Norway, May 24-27, 2015.

Keynote Speaker, Carolinas SETAC Annual Meeting, April 24-26, 2014, Clemson, SC. "A Case Study in Evolutionary Toxicology – the Elizabeth River Story."

Invited Speaker, Elizabeth River Project Sediment Remediation Partnership, August 1, 2013, Portsmouth, VA.

Session Chairman, Pollutant Responses in Marine Organisms (PRIMO 17), Faro, Portugal, May 5-8, 2013.

Invited Speaker, North Carolina One Health Collaborative, January 29, 2013, North Carolina Biotechnology Center, RTP, NC. "Ecological and Human Health Impacts of Mountaintop Mining."

Invited Speaker: Federal Workshop on the NAS Report: Exposure Science in the 21st Century – a Vision and a Strategy. December 3, 2012, EPA NHEERL, RTP, NC.

Organizer and Co-Host: Superfund Research Program 25th Annual Meeting. A Quarter Century of Transdisciplinary Research and Training to Protect Human and Environmental Health. October 21-24, 2012, Raleigh, NC

Symposium Organizer: "Causes and Consequences Connecting Environmental and Human Health." Sponsored by the Duke Superfund Research Center, the Integrated Toxicology and Environmental Health Program, the Nicholas School of the Environment and the School of Medicine, April 20, 2012, Durham, NC.

Panel Moderator, Nanomaterials, for TSCA Policy Workshop, March 28, 2012, Durham, NC.

Member, International Advisory Committee, 16th International Symposium on Pollutant Responses in Marine Organisms, May 15-19, 2011, Long Beach, CA.

Invited participant and panelist, Gulf Oil Spill SETAC Focused Topic Meeting, Pensacola, FL, April 26-28, 2011.

Symposium Organizer: "Mountaintop Coal Mining: Human Health and Ecological Concerns." Sponsored by the Foundation for the Carolinas and the Duke Integrated Toxicology and Environmental Health Program, April 9, 2010, Durham, NC.

Session Co-Chairman, Toxicity and Ecotoxicology, First International Conference on the Environmental Implications of Nanotechnology, September 9-11, 2009, Washington, D.C.

Member, Organizing Committee, and Session Chairman, 21st Annual Superfund Basic Research Program Meeting, December 7-9, 2008, Pacific Grove, CA.

Session Co-Chairman, Mechanisms of PAH toxicity in Aquatic Animals, a session for the 29th Annual Meeting of the Society of Environmental Toxicology and Chemistry, November 16-20, 2008, Tampa, FL.

Session Chairman, Human and Ecological Effects and Risks, Environmental Health Summit Meeting, "Pharmaceuticals in Water," November 10-11 2008, Research Triangle Park, NC.

Invited Speaker, Franco-American Workshop on Environmental Nanotechnology, October 27-28, 2008, Washington, D.C.

Co-host and Organizer, Superfund Basic Research Program: 20 Years of Success and a Vision for the Future, 20th Annual Superfund Basic Research Program Meeting, December 3-5, 2007, Durham, NC.

Member, Organizational and Advisory Committee, 14th International Symposium on Pollutant Responses in Marine Organisms, May 6-9, 2007, Florianopolis, Brazil.

Member, review team for College of Charleston Graduate Program in Marine Sciences, March - May, 2007.

Invited speaker and participant, "Fundulus Genomics Workshop", sponsored by NSF, May 4-5, 2006, Charleston, SC.

Invited speaker and participant, "Cancer and the Environment", sponsored by the Duke University Comprehensive Cancer Center and the Nicholas School, March 30-31, 2006, Durham, NC.

Invited speaker and participant, "Applications of Toxicogenomics to Cross-species Extrapolation" a workshop sponsored by the National Academy of Sciences, August 12-13, 2004, Washington, D.C.

Co-Chairman, "Emerging Molecular and Computational Approaches for Cross-Species Extrapolations" a SETAC/SOT sponsored workshop, July 18-22, 2004, Portland, OR.

Member, Organizational and Advisory Committee, 12th International Symposium on Pollutant Responses in Marine Organisms, May 8-13, 2003, St. Petersburg, FL.

Invited Participant, Symposium on Environmental Change and Human Health. Carolina Environmental Program, University of North Carolina at Chapel Hill. April 14-15, 2003, Chapel Hill, NC.

Organizer and participant, The Malaria – DDT Dilemma: Science, Policy, and Law. Duke University Integrated Toxicology Program, Superfund Basic Research Center, and Center for Environmental Solutions. November 7, 2002, Durham, NC.

Invited Participant and Moderator, Superfund Basic Research Program Meeting, Transitioning Basic Science into Practical Applications to Meet Environmental and Public Health Challenges, November 3-6, 2002, Tucson, Arizona.

Invited Participant, The Role of Environmental Agents in Cardiovascular Disease, sponsored by NIEHS, August 6-7, 2002, Durham, NC.

Member, Organizational and Advisory Committee, 11th International Symposium on Pollutant Responses in Marine Organisms, July 16-19, 2001, Plymouth, UK.

Invited participant, U.S. EPA Environmental Monitoring and Assessment Workshop, Gulf Breeze, FL, May 16-18, 2001

Member, Organizing Committee, "Oxidative Processes: Stress to Remediation." Sponsored by NIEHS, Duke University, and UNC – Chapel Hill, December 12-14, 2000, Chapel Hill, NC.

Invited participant, "Carolina Conference on Coastal Waters and Health." Sponsored by NIEHS, UNC, Wilmington, and IKA Works, USA, September 7-8, 2000, Wilmington, NC.

Chair, Steering Committee for "Environmental - Human Health Interconnections," a SETAC/SOT sponsored workshop. June 10-15, 2000, Snowbird, Utah.

Invited participant, "Workshop to Evaluate Research Priorities for Endocrine Active Compound Risk Assessment Methods." Sponsored by U.S. EPA, NIEHS, and the Chemical Manufacturers Association, August 31 and September 1, 1999, Research Triangle Park, NC.

Member, Organizational and Advisory Committee, 10th International Symposium on Pollutant Responses in Marine Organisms, April 25-29, 1999, Williamsburg, VA.

Invited Participant, "ICPS/OECD/EPA Scoping Meeting on Approaches to Integrated Risk Assessment," a workshop sponsored by the United Nations, World Health Organization, and U.S. EPA, April 30 – May 2, 1998, Cary, NC.

Invited Participant, Bivalve Biomarkers Workshop, sponsored by NOAA, March 19–21, 1998, Charleston, SC.

Chair, Steering Committee for "Reproductive and Developmental Effects of Contaminants in Oviparous Vertebrates," a SETAC sponsored Pellston Workshop, July 12-18, 1997, Butte, Montana.

Invited Participant, "Impacts of Pulp and Paper Mill Effluents on Fish Reproduction and Development," Workshop sponsored by The National Council for Air & Stream Improvement, June 19-20, 1997, Chapel Hill, NC.

Invited Participant, "Endocrine Screening Methodology Workshop," sponsored by U.S. EPA, World Wildlife Fund, and Chemical Manufacturers Association, July 15-16, 1996, Duke University, Durham, NC.

Invited Participant and Author, "Biotransformation in Environmental Risk Assessment," a workshop sponsored by SETAC-Europe, Noordwijkerhout, The Netherlands, April 28 - May 1, 1996.

Chairman, "Endocrine Disrupters in the Environment," Integrated Toxicology Program Symposium, Duke University, March 4, 1996, Durham, NC.

Session Co-Chairman, "Xenobiotics : Biotransformation, Metabolism and Consequences," 8th International Symposium on Pollutant Responses in Marine Organisms, April 2-5, 1995, Pacific Grove, CA.

Invited Participant, First International Symposium on Ecosystem Health and Medicine, June 19-23, 1994, Ottawa, Ontario.

Session Chairman, "Interconnections Between Human and Ecosystem Health," 14th Annual Meeting of the Society of Environmental Toxicology and Chemistry, November 14-18, 1993, Houston, TX.

Session Co-Chairman, "Oxidative Stress and HSP", 7th International Symposium on Responses of Marine Organisms to Pollutants, April 20-22, 1993, Göteborg, Sweden.

Session Co-Chairman, "Aquatic Toxicology," 12th Annual Meeting of the Society of Environmental Toxicology and Chemistry, November 3-7, 1991, Seattle, WA.

Invited Participant and Author, NATO Advanced Research Workshop: "Strategy for Biomarker Research and Application in the Assessment of Environmental Health," Texel, The Netherlands, May 11-19, 1991.

Invited Participant, "Paper Industry Research Challenges," sponsored by the Technical Association of the Pulp and Paper Industries and the American Paper Industry, November 28-30, 1990, Charlotte, NC.

- Invited Participant and Author, "The Population Ecology and Wildlife Toxicology of Agricultural Pesticide Use: A Modeling Initiative for Avian Species," a conference sponsored by the Society of Environmental Toxicology and Chemistry, Kiawah Island, SC, July 22-27, 1990.
- Session Co-chairman, "Biomarkers," 14th ASTM Symposium on Aquatic Toxicology and Risk Assessment, April 22-24, 1990, San Francisco, CA.
- Invited Participant, Sediment Genotoxicity Workshop, U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, MS, March 6-8, 1990.
- Invited Participant and Author, "Biomarkers" Workshop sponsored by the Society of Environmental Toxicology and Chemistry, Keystone, CO, July 23-28, 1989.
- Invited Speaker, The Annual Biomedical Sciences Symposium -- Volatile Organic Compounds: Environmental and Human Health Significance. Wright State University, Dayton, Ohio, May 19, 1989. Title of Talk: "Oxyradical and Antioxidant Defenses: An Environmental Perspective."
- Invited Participant and Author, "Ecological Assessments of Hazardous Waste Sites," Workshop sponsored by U.S. EPA, Corvallis, OR, May 3-4, and Seattle, WA, July 25-27, 1988.
- Invited Lecturer, Wildlife Toxicology Workshop, December 14-16, 1987, Bellingham, Washington. Sponsored by U.S. Fish and Wildlife Service and the Institute of Wildlife Toxicology, Huxley College of Environmental Studies, Western Washington University, Bellingham.
- Session Co-Chairman, "Biochemical Responses of Wildlife to Toxic Chemicals," 8th Annual Meeting of the Society of Environmental Toxicology and Chemistry, November 9-12, 1987, Pensacola, FL.
- Invited Participant, "Research Priorities in Environmental Risk Assessment," August 17-21, 1987, Breckenridge, CO. Sponsored by Society of Environmental Toxicology and Chemistry (SETAC). Workshop report published by SETAC.
- Member, Planning Committee, Health Risk Reporting Conference, September 22, 1987, Chapel Hill, NC. Sponsored by Institute for Health Policy Analysis, Georgetown University.
- Invited expert witness, U.S. EPA FIFRA Scientific Advisory Panel, for "Guidance Document for Conducting Terrestrial Field Studies," January 7-8, 1987, Arlington, VA.
- Session Chairman, "Teratogenesis in Fish and Wildlife," 7th Annual Meeting of the Society of Environmental Toxicology and Chemistry, November 2-5, 1986, Alexandria, VA.
- Invited Participant, Avian Testing Issues Workshop, September 16-17, 1986, Washington, D.C. Sponsored by the National Agricultural Chemicals Association.
- Chairman, Steering Committee, Session Co-Chairman, and Invited Speaker, Wildlife Toxicology Symposium. Sponsored by Society of Environmental Contamination and Toxicology, November 11-12, 1985, St. Louis, MO.
- Invited Participant, Workshop on "Risk Assessment of Contaminants in Terrestrial Ecosystems," May 19-21, 1986, Corvallis, OR. Sponsored by U.S. EPA.
- Invited Participant and Speaker, Workshop on "Toxics in North Carolina Waters," October 16, 1985, Raleigh, North Carolina. Sponsored by North Carolina Water Resources Research Institute and the Department of Natural Resources and Community Development.
- Invited Participant and Speaker, Workshop on "Mercury in Florida Aquatic Systems," November 13, 1984, Atlanta, GA. Sponsored by U.S. EPA and State of Florida.

UNIVERSITY AND SCHOOL SERVICE:

Member, Intellectual Community Planning Group. Health as an Ecosystem: Expanding Our Imaginations of Health. January 1, 2018 – present.

Member, Intellectual Community Planning Group. Marine Medicine: Multidisciplinary Research at the Nexus of the Environment and Human Health. January 1, 2018 – present.

Member, Program Committee, Duke Environmental Health Scholars Program, Fall Forums: Health and the Environment in North Carolina, November 30 – December 1, 2017, and November 1-2, 2018, Durham, NC.

Member, Environment and Population Health Planning Committee, Duke University, June 1, 2017 – May 31, 2018.

Interim Chair, Environmental Science and Policy Division, Nicholas School of the Environment, September, 2016 – December, 2018.

Member, Campus Conflict of Interest Committee, Duke University. September, 2010 – August, 2015.

Member, Faculty Recruitment and Review Committee for Dr. Jim Zhang, March, 2012 – May, 2013.

Chair, Faculty Review for Dr. Joel Meyer, August, 2012 – May, 2013.

Member, Faculty Review Committee for Dr. Heather Stapleton, August - December, 2011.

Member, Faculty Review Committee for Dr. Andrew Read, June - November, 2011.

Chair, Faculty Review Committee for Dr. Marie Lynn Miranda, October, 2010 – March, 2011.

Member, Search Committee, Director of the Office of Research Support, Duke University. May - December, 2010.

Member, Research Administration Continuous Improvement Committee, Duke University, January, 2008 – present.

Director, Integrated Toxicology and Environmental Health Program, Duke University, January, 2001 – present.

Director, Duke University Superfund Research Center, June, 2000 – present.

Director, Center for Comparative Biology of Vulnerable Populations, April, 2005 – March, 2010.

Member, Academic Council, Duke University, April 1989 - April 1991, April 1993 – 1999, April 2001 – April 2006, April 2008 – April 2009, and April 2010 – April, 2012.

Member, Duke University Committee for Appointment, Promotion and Tenure, September, 2006 – 2009.

Chair, Search Committee, Global Environmental Health, March 2008 – May, 2009.

Chair, Faculty Review Committee for Dr. Heather Stapleton, January - April, 2008.

Chair, Provost's Working Group, The Environment and Health Sciences, September, 2005 – December, 2007.

Member, Nicholas School Dean Search Committee, December, 2006 – May, 2007.

Member, Nicholas Hall Building Committee, June 2004 – June, 2007.

Chair, Environmental Molecular Toxicology Search Committee, October, 2005 – April, 2006.

Chair, Environmental Chemistry Search Committee, November, 2004 – May, 2005.

Chair, Minority Faculty Recruitment Initiative, Division of Environmental Science and Policy, Nicholas School of the Environment and Earth Sciences (NSEES), May, 2003 – October, 2004.

Chair, Faculty Review Committee for S. Kullman, November, 2003 – April, 2004.

Member, Faculty Review Committee for M.L. Miranda, February – May, 2004.

Member, Provost's Review Committee for Vice Provost for Research (J. Siedow), March – April, 2004.

Member, Space Committee, Division of Environmental Science and Policy, NSEES, September, 2002 – present.

Chair, Tenure Review Committee for J. Freedman, NSEES, May, 2000 – March, 2001.

Member, Search Committee, Dean, Nicholas School of the Environment and Earth Sciences, May, 2000 – March, 2001.

Chair, Review Committee for S. Kullman, Nicholas School of the Environment and Earth Sciences, May, 2001.

Core Leader, Biochemistry, Marine and Freshwater Biomedical Center, Duke University Marine Laboratory, January, 1995 – May, 2001.

Member, Research Policy Committee, Duke University, September, 1989 - August, 1993, and September, 1995 – May, 2000.

Chair, Search Committee, Environmental Toxicologist (endowed chair), Nicholas School of the Environment, December 1996 – May, 2000.

Chair, Environmental Toxicology, Chemistry, and Risk Assessment Program (Master of Environmental Management), Nicholas School of the Environment, April, 1990 – August, 1999.

Member, Faculty Council, Nicholas School of the Environment, January, 1998 – May, 1999.

Member, Radiation Safety Committee, Duke University, September, 1991 – May, 1999.

Member, Self Study Steering Committee, Duke University, for the Southern Association of Colleges and Schools, February, 1996 – May, 1998.

Member, Search Committee, Environmental Chemist (tenure-track), Nicholas School of the Environment, November, 1996 – April, 1997.

Member, Provost's Task Force on Geology and Environmental Science at Duke University, September, 1995 - January, 1996.

Member, Search Committee, Water Quality Scientist (non-tenure track), School of the Environment, February, 1996 - May, 1996.

Member, Search Committee, Microbial Ecologist (tenure track), School of the Environment, November, 1994 - May, 1995.

Member, Curriculum Committee, Biohazards Program, Division of Occupational and Environmental Medicine, Duke University, September, 1992 - August, 1995.

Chair, Search Committee, Environmental Toxicologist (tenure track), School of the Environment, September, 1993 - May 1994.

Theme Leader, Environmental Toxicology and Chemistry, Marine Biomedical Center, Duke University Marine Laboratory, July, 1991 - January, 1995.

Member, Science Resources Initiative Planning Committee, Duke University, 1990 - 1991.

Member, Conflict of Interest Committee, Duke University, March, 1990 - May, 1991.

Member, Advisory Committee, Duke University Marine Laboratory, March, 1987 - June, 1990.

Member, Duke University Integrated Toxicology Program Review Committee, April - December, 1989.

Member, Admissions Committee, Duke University Integrated Toxicology Program, January, 1983 - August, 1986.

Previously served on following committees for the School of the Environment (Forestry and Environmental Studies), Duke University: Admission and Awards (1983-1992; chair, 1985), Faculty Council (1990-92), Commencement (chair, 1990), Environmental Chemist Search Committee (1987), Water Resources Scientist Search Committee (1988), Space Committee (1992-1994), Alumni Council (1994-96), Commencement, 1999-2002.

Howard Hughes Research Mentor, Duke University, June - August, 1990 – 2011.

Mentor for: (1) Duke Fellows Program (for area high school teachers), 1991- 1996. (2) North Carolina School of Science and Mathematics University Program, September 1993 - May, 1996.

CONSULTING:

Consultant for Federal Public Defender, Nashville, TN concerning a death row appeal, December, 2014 – 2016.

Consultant for Wallace and Graham, P.A. Salisbury, NC, for assessment of occupational exposures, September, 2009 – 2016.

Consultant for Plaintiff's Steering Committee, New Orleans, LA, for ecological effects of the Deepwater Horizon oil spill, July, 2011- December, 2013.

Consultant for the American Chemistry Council, Washington, D.C., concerning ecotoxicogenomics of bisphenol A, July, 2011 – May, 2013.

Consultant for NOAA and Stratus Consulting for design of studies to determine ecological impacts of the BP Deep Horizon oil spill in the Gulf of Mexico, August, 2010 – January, 2011.

Reviewer for Gulf Medical College, Amjen, United Arab Emirates, for proposed Graduate Program In Toxicology, April – May, 2008.

Reviewer for Eastern Research Group of “Validation of the Fish Short-Term Reproduction Assay: Integrated Summary Report,” U.S. EPA, Endocrine Disruptor Screening Program, January, 2008.

Consultant for analysis of environmental impacts of Hurricane Katrina, for IEM, under contract to FEMA, Washington, DC, December, 2005 – May, 2006.

Consultant, for analysis of ecological impacts of creosote in estuarine systems, for NOAA, under contract to Stratus Consulting, Inc., Boulder, CO, February - June, 2005.

Consultant, for preparation of Carcinogenesis Background Documents for the National Toxicology Program, NIEHS, under contract to Technology Planning and Management Corporation, Durham, NC, August, 2001- May, 2003.

Consultant, Peer Review Process for the Fox River Human and Ecological Risk Assessment, sponsored by the Association for the Environmental Health of Soils, Amherst, MA, December, 1999 – May, 2001.

Member, External Review Committee, School of Environmental Studies, Queen's University, Kingston, Ontario, November, 1999.

Invited speaker, “Emerging Issues in Environmental Pollution,” Battelle, Chicago, IL, January 19, 1999.

Chair, Committee to review proposed Ph.D. program in environmental science at Arkansas State University, Jonesboro, September, 1997.

Consultant to Search Committee for Chair, Department of Environmental Toxicology, Clemson University, September, 1997.

Scientific advisor on water quality issues for Lake Steilacoom Improvement Club, Tacoma, WA, August, 1996 – June, 1997.

Scientific advisor on mercury in south Florida wetlands for Hopping, Boyd, Green and Sams, February, 1994 – May, 1995.

Scientific advisor on aquatic toxicology for Research and Evaluation Associates, January, 1993 - December, 1995.

Mentor, National Human Exposure Assessment (NHEXAS) Program, sponsored by U.S. EPA, administered by the Cadmus Group, 1991 -1993.

Scientific advisor for ecological risk assessments of Superfund sites for Hydrosystems, Inc. January, 1990 - December 1992.

Scientific advisor for ecological hazards associated with contaminated sediments in the Hudson River, NY, for Gradient, Inc., February, 1991 - June, 1992.

Scientific advisor for environmental hazards associated with bleached kraft mill effluents, Georgia-Pacific Corp., August 1991 - February, 1992.

Scientific advisor assisting with research needs and hazard assessments relevant to pesticide registration for Jellineck, Schwartz, Connolly and Freshman, Inc., Washington, D.C., May, 1988 - December, 1991.

9	Sabbatical	2009-10
12 14	13	2010-11
18 19	20	2011-12
12 19	15	2012-13
16 14	30	2013-14
11 26	30	2014-15
18 18	27	2015-16
10 11		2016-17
15		2017-18
7 17		2018-19

Course Titles for Above Courses:

ENV 360: Environmental Chemistry and Toxicology (formerly ENV 160)

ENV 501: Environmental Toxicology (formerly ENV 212)

ENV 215: Environmental Physiology

ENV 537: Environmental Health (formerly ENV 298.50)

ENV 319: Mechanisms in Environmental Toxicology

ENV 299: Independent Projects

ENV 313: Advanced Topics in Environmental Toxicology

ENV 318: Ecological Risk Assessment: Theory and Practice

ADVISING: (completed degrees supervised)

Master of Environmental Management: 72

Master of Science theses: 9

Ph.D. dissertations:

Habig, Clifford. 1987. Comparative toxicity of the cotton defoliant S,S,S, tri-n-butyl phosphorotrithioate (DEF) to channel catfish and blue crabs.

Mihaich, Ellen Mather. 1989. Biochemical responses in channel catfish exposed to bleached kraft pulp and paper mill effluent.

Gallagher, Evan P. 1991. Glutathione-dependent metabolism and utilization in the channel catfish (*Ictalurus punctatus*).

Watson, David E. 1995. Bioactivation and genotoxicity of 2-aminoanthracene in two Ictalurid species.

Ploch, Stephen A. 1997. Comparative activation and genotoxicity of benzo[a]pyrene in two species of Ictalurid catfish.

Monteverdi, George H. 1999. Vitellogenin-mediated chemical uptake by oocytes of the estuarine killifish (*Fundulus heteroclitus*).

- Kelly, Susan A. 2000. Developmental toxicology of estrogenic alkylphenols in an estuarine killifish.
- Meyer, Joel N. 2003. Mechanisms of adaptation and fitness costs associated with adaptation to a chemically-contaminated environment.
- Rau, Michelle A. 2004. Expression and function of the tumor suppressor gene p53 in fish models.
- Wassenberg, Deena M. 2004. Interactive effects of polycyclic aromatic hydrocarbons on cytochrome P4501A activity and embryonic development in the killifish, *Fundulus heteroclitus*.
- Augspurger, Thomas P. 2006. The wood duck (*Aix sponsa*) as a sentinel of exposure to and effects of polychlorinated dibenzo-*p*-dioxins and dibenzofurans at contaminated sites,
- Timme-Laragy, Alicia R.V. 2007. Mechanisms underlying synergistic developmental toxicity of polycyclic aromatic hydrocarbons in zebrafish.
- Battle, Lauren P. 2008. Polycyclic aromatic hydrocarbon metabolism in two populations of *Fundulus heteroclitus* with different exposure histories.
- Jung, Dawoon. 2009. Mitochondria as a target of benzo[a]pyrene toxicity in a PAH-adapted population of the Atlantic killifish (*Fundulus heteroclitus*).
- Clark, Bryan. 2010. Molecular mechanisms underlying adaptation to PAHs in *Fundulus heteroclitus*.
- Fleming, Carrie. 2010. Interactions between environmental factors and polycyclic aromatic hydrocarbons (PAHs) in developing fish: molecular and developmental implications.
- Van Tiem, Lindsey A. 2011. Molecular mechanisms of polycyclic aromatic hydrocarbon-induced teratogenesis in zebrafish (*Danio rerio*).
- Arnold, Mariah C. 2014. Impacts of mountaintop removal coal mining on the Mud River, West Virginia: selenium accumulation, trophic transfer, and toxicity in fish.
- Bone, Audrey J. 2015. Incorporating environmental realism into the toxicity of nanoparticles to early life stage fish.
- Brown, Daniel R. 2015. Later life consequences of subteratogenic exposure to a complex PAH mixture in the Atlantic killifish (*Fundulus heteroclitus*).
- Brandt, Jessica. 2018. Coal combustion residuals in receiving lake ecosystems: trophic transfers, toxicity, and tracers.
- Kozal, Jordan S. 2018. Persistent effects of polycyclic aromatic hydrocarbon exposure across generations: a bioenergetic and mitochondrial perspective.

RESEARCH INTERESTS:

My research is focused upon molecular and organismal responses of aquatic animals to environmental stressors, particularly contaminants. The laboratory is concerned with both basic studies of mechanisms of contaminant metabolism, adaptation and toxicity, and with the development of sensitive, mechanistically-based indices of exposure and toxicity that can be used in biomonitoring of free-living organisms.

Additionally, through collaborations, I seek innovative approaches for elucidating linkages between human and ecological health.

Current research activities are focused on the following three subjects: 1. The effects of polycyclic aromatic hydrocarbons (PAHs) on embryonic development, later life consequences, and adaptations in fish models, including mechanistic laboratory studies and field studies. 2. The effects of nanomaterials and nanoplastics on vertebrate development, including interactions with other environmental variables such as UV radiation, organic matter, temperature and other contaminants. 3. The impacts of fossil fuel extraction, use and waste disposal on human and ecological health.

REFEREED PUBLICATIONS:

- Brandt, J.E., M. Simonin, R.T. Di Giulio, and E.S. Bernhardt. Beyond selenium: coal combustion residuals lead to multi-element enrichment in receiving lake food webs. Environmental Science and Technology (in review).
- Jayasundara, N., and R.T. Di Giulio. Bioenergetic consequences of pollution adaption in teleost fish *Fundulus heteroclitus*. In: Newman, M.C. Fundamentals of Ecotoxicology, 4th Edition (in review).
- Lindberg, C.D., and R.T. Di Giulio. Polycyclic aromatic hydrocarbon and hypoxia exposures result in mitochondrial dysfunction in zebrafish. Aquatic Toxicology (in review).
- Mello, D., R. Trevisan, N. Rivera, N.K. Geitner, R.T. Di Giulio, M.R. Wiesner, H. Hsu-Kim, and J. Meyer. Silver nanoparticle interference with in vitro assays: implications for the accurate assessment of in vitro cytotoxicity. Nanomedicine: Nanotechnology, Biology, and Medicine (in review).
- Saleh, N, R. Trevisan, C. Murphy, R. Di Giulio, S. Hossein Abtahi, and Peter J. Vikesland. Implications of aspect ratio on the uptake and nanotoxicity of gold nanomaterials to *Corbicula fluminea*. NANOIMPACT (in review).
- Simonin, M., R.T. Di Giulio, X. Le Roux, E.K. Richmond, J.R. Rohr, E.J. Rosi, N.M. van Straalen, and E.S. Bewrnhardt. Stress ecology: transcending disciplinary boundaries to study the ecology of the Anthropocene. Ecology Letters (in review).
- Volkoff, S.J., J.S. Osterberg, N. Jayasundara, E.M. Cooper, H. Hsu-Kim, L. Rogers, G.E. Gehrke, S. Jayaraman, and R.T. Di Giulio. Embryonic *Fundulus heteroclitus* responses to sediment extracts from differentially contaminated sites in the Elizabeth River, VA. Marine Pollution Bulletin (in review).
- Brandt, J.E., N.E. Lauer, A. Vengosh, E.S. Bernhardt, and R.T. Di Giulio. Strontium isotope ratios in fish otoliths as biogenic tracers of coal combustion residual inputs to freshwater ecosystems. Environmental Science and Technology Letters (accepted).
- Gearhart-Serna, L.M., J.B. Davis, N. Jayasundara, M.K. Jolly, S.J. Sauer, H. Levine, R. Di Giulio, and G.R. Devi. Low dose exposure to a complex polycyclic aromatic hydrocarbon mixture triggers an aggressive phenotype in estrogen receptor positive breast cancer cells. Carcinogenesis (in review).
- Di Giulio, R.T., and M.C. Newman. 2019. Ecotoxicology. Pp. 1433-1464 in: Klaassen, C.D., ed. *Casarett and Doull's Toxicology. The Basic Science of Poisons*, Ninth Edition. McGraw Hill, New York, 1620 pp.
- Gearhart-Serna, L.M., N. Jayasundara, M. Tacam, R.T. Di Giulio, and G. R. Devi. 2018. Assessing cancer risk associated with aquatic polycyclic aromatic hydrocarbon pollution reveals dietary routes of

- exposure and vulnerable populations. Journal of Environmental and Public Health (Article ID 5610462, 10 pp. <https://doi.org/10.1155/2018/5610462>).
- Massarsky, A., A. Abdel, L. Glazer, E.D. Levin, and R.T. Di Giulio. 2018. Neurobehavioral effects of 1,2-propanediol in zebrafish (*Danio rerio*). Neurotoxicology 65:111-124.
- Massarsky, A., N. Jayasundara, L. Glazer, E. Levin, G.L. Prasad, and R.T. Di Giulio. 2018. Outcomes of developmental exposure to total particulate matter from cigarette smoke in zebrafish (*Danio rerio*). Neurotoxicology 68:101-114.
- Osterberg, J., K. Cammen, T. Schultz, B. Clark, and R. Di Giulio. 2018. Genome-wide scan reveals signatures selection related to pollution adaptation in non-model estuarine Atlantic killifish (*Fundulus heteroclitus*). Aquatic Toxicology 200:73-82.
- Pitt, J.A., R. Trevisan, A. Massarsky, J.S. Kozal, E.D. Levin, and R.T. Di Giulio. 2018. Maternal transfer of nanoplastics to offspring in zebrafish (*Danio rerio*): a case study with nanopolystyrene. Science of the Total Environment 643:324-334.
- Massarsky, A., G.L. Prasad, and R.T. Di Giulio. 2018. Total particulate matter from cigarette smoke disrupts angiogenesis in zebrafish brain (*Danio rerio*). Toxicology and Applied Pharmacology 339:85-96.
- Pitt, J.A., J. S. Kozal, N. Jayasundara, A. Massarsky, R. Trevisan, N. Geitner, M. Wiesner, E. D. Levin, and R. T. Di Giulio. 2018. Uptake, tissue distribution, and toxicity of polystyrene nanoparticles in developing zebrafish (*Danio rerio*). Aquatic Toxicology 194:185-194.
- Brown, D.R., J. Thompson, M. Chernick, D.E. Hinton, and R.T. Di Giulio. 2017. Later life swimming performance and persistent heart damage following subteratogenic PAH mixture exposure in the Atlantic killifish (*Fundulus heteroclitus*). Environmental Toxicology and Chemistry 36:3246-3253. DOI: 10.1002/etc.3877. PMID:PMC5942201.
- Arnold, M.C., R.L. Bier, T.T. Lindberg, E. Bernhardt, and R.T. Di Giulio. 2017. Biofilm mediated uptake of selenium in streams with mountaintop mine drainage. Limnologica 65:10-13.
- Brandt, J., E. Bernhardt, G. Dwyer, and R. Di Giulio. 2017. Selenium ecotoxicology in freshwater lakes receiving coal combustion residual effluents: A North Carolina example. Environmental Science and Technology 51:2418-2426.
- Burton, G.A., R. Di Giulio, R. Costello and J. Rohr. 2017. Slipping through the cracks: Why is the U.S. Environmental Protection Agency not funding extramural research on chemicals in our environment? Environmental Science and Technology 51:755-756.
- Hartman, J., J.S Kozal, R.T. Di Giulio, and J.N. Meyer. 2017. Zebrafish have an ethanol-inducible hepatic 4-nitrophenol hydroxylase that is not CYP2E1-like. Environmental Toxicology and Pharmacology 54:142-145.
- Jayasundara, N., P.W. Fernando, J.S. Osterberg, K.M. Cammen, T.F. Schultz, and R.T. Di Giulio. 2017. Cost of tolerance: physiological consequences of evolved resistance to inhabit a polluted environment in teleost fish. Environmental Science and Technology 51:8763-8772. PMID: PMC5745795
- Lindberg, C.D., N. Jayasundara, J.S. Kozal, T.C. Leuthner, and R.T. Di Giulio. 2017. Evolved resistance to polycyclic aromatic hydrocarbon toxicity and associated bioenergetic consequences in a population of *Fundulus heteroclitus*. Ecotoxicology 26:435-448.

- Massarsky, A., A. Abdel, L. Glazer, E.D. Levin, and R.T. Di Giulio. 2017. Exposure to 1,2-propanediol impacts early development of zebrafish (*Danio rerio*) and induces hyperactivity. Zebrafish 14:216-222.
- Massarsky, A., J.S. Kozal, and R. T. Di Giulio. 2017. Glutathione and zebrafish: old assays to address a current issue. Chemosphere 168:707-715.
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PAPERS/ABSTRACTS FOR PROFESSIONAL MEETINGS:

2018

- Outcomes of developmental exposure to total particulate matter from cigarette smoke in zebrafish (*Danio rerio*). Society of Toxicology (SOT) 57th Annual Meeting, March 11-15, San Antonio, TX (with A Massarsky, N. Jayasundara, L. Glazer, E. D. Levin, and G. L. Prasad).
- Developmental distribution and toxicity of polystyrene nanoparticles in zebrafish (*Danio rerio*). SOT 57th Annual Meeting, March 11-15, San Antonio, TX (with J. A. Pitt, J. S. Kozal, N. Jayasundara, A. Massarsky, R. Trevisan, N. Geitner, M. Wiesner, and E. D. Levin).
- One Health approach to addressing a mysterious kidney disease. Society of Environmental Toxicology and Chemistry (SETAC) Annual Meeting, November 4-8, Sacramento, CA (with N. Jayasundara, R. Babich, A. Massarsky, Y. Sugano, K. Wanigasuriya, P. Manage, and I. Drummond).
- Mitochondrial dysfunction contributes to the persistent effects of benzo(a)pyrene across multiple generations: mechanisms and consequences. SETAC Annual Meeting, November 4-8, Sacramento, CA (with J.S. Kozal, R. Trevisan, S. Heissenberger, and N. Jayasundara).
- The oxidative stress response of developing zebrafish embryos exposed to hypoxia and a complex mixture of polycyclic aromatic hydrocarbons. SETAC Annual Meeting, November 4-8, Sacramento, CA (with C.D. Lindberg and R. Trevisan).
- Metabolic tradeoffs of pollution adaptation in teleost fish *Fundulus heteroclitus*. SETAC Annual Meeting, November 4-8, Sacramento, CA (with N. Jayasundara).

Effects of waterborne and dietary exposures of nanoplastics in zebrafish: maternal transfer, mitochondrial bioenergetics, and interaction with PAHs. SETAC Annual Meeting, November 4-8, Sacramento, CA (with R. Trevisan, J.A. Pitt, C. Voy, S. Chen, and O. Saleh).

Fish otoliths as tracers and records of inorganic contamination exposure – testing the key assumption. SETAC Annual Meeting, November 4-8, Sacramento, CA (with J. Brandt, M.R. Ross, and E.S. Bernhardt).

Metabolomics-DNA methylation cross-talk in killifish from the New Bedford Harbor Superfund site. SETAC Annual Meeting, November 4-8, Sacramento, CA (with S. Bea, N. Chatterjee, D. Jung, D.E. Nacci, D. Yoon, S. Kim, and J. Choi).

2017

Inclusion of multiple aquarium model fish enhances research and interaction. 8th Annual Meeting, Aquatic Models of Human Disease, January 7-12, Birmingham, AL (with D.E. Hinton, H.M. Stapleton, W. Dong, M. Chernick, J. Mu, M. Zhu, J. Brandt, N. Jayasundara, J. Kozal, A. Massarsky, R. Trevisan, and C. Lindberg).

Tracing coal ash through aquatic food webs. Society of Freshwater Science Annual Meeting, June 4-8, Raleigh, NC (with J. Brandt and E. Bernhardt).

Transgenerational exposure to benzo(a)pyrene affects metabolic plasticity and thermal stress response capacity. PRIMO 19, June 30 - July 3, Matsuyama, Japan (with J. Kozal and N. Jayasundara).

Impaired mitochondrial function in zebrafish exposed to hypoxia and polycyclic aromatic hydrocarbons. Physiological Responses in Marine Organisms (PRIMO) 19, June 30 - July 3, Matsuyama, Japan, and SETAC Annual Meeting, November 12-16, Minneapolis, MN (with C.D. Lindberg).

Patterns and ecological influences on coal combustion residual (CCR) distribution in freshwater lakes. SETAC Annual Meeting, November 12-16, Minneapolis MN (with J. Brandt, E. Bernhardt and M. Simonin).

Toxicity of nanopolystyrene plastics and their interactions with polycyclic aromatics hydrocarbons on early life stages of zebrafish. SETAC Annual Meeting, November 12-16, Minneapolis MN (with R. Trevisan, J. Pitt, J. Kozal, and N. Jayasundara).

2016

Biochemical and genotoxic responses in sheepshead minnow (*Cyprinodon variegatus*) larvae exposed to oil spill contaminants and hypoxia as a modulating stressor. Gulf of Mexico Oil Spill and Ecosystem Science Conference, February 1-14, Tampa, FL (with S. Dasgputa and A. McElroy).

What can urban land use tell us about polychlorinated biphenyls (PCBs) in fin fish from the Elizabeth River. Atlantic Estuarine Research Society, March 10-12, Virginia Beach, VA (with J. Rieger and G. Kroeger-Foley).

Aryl hydrocarbon receptor dependent mitochondrial toxicity of PAHs. Society of Toxicology (SOT) 55th Annual Meeting, March 13-17, New Orleans, LA (with N. Jayasundara, J.S. Kozal, A.J. Bone, C.D. Lindberg, J. Bailey, S. Burwell, E.D. Levin, J.N. Meyer).

Characterization of cardiac deformity, CYP induction, and developmental bioenergetics following PAH exposures in in PAH resistant and non-resistant *Fundulus heteroclitus*. SOT 55th Annual Meeting, March 13-17, New Orleans, LA (with N. Jayasundara and J.S. Kozal).

- Aryl hydrocarbon receptor 2 morpholino knockdown reduces the toxicity of total particulate matter from cigarette smoke in zebrafish (*Danio rerio*). SOT 55th Annual Meeting, March 13-17, New Orleans, LA (with A. Massarsky, A.J. Bone, G.L. Prasad).
- Transgenerational mitochondrial toxicity of benzo(a)pyrene in *Danio rerio*. Society of Toxicology (SOT) 55th Annual Meeting, March 13-17, New Orleans, LA (with J. S. Kozal, N. Jayasundara, C.D. Lindberg, A. Massarsky, A.N. Oliveri, E.D. Levin, J.N. Meyer).
- Pollution-driven evolution in the Elizabeth River. Tri-Service Environmental Risk Assessment Work Group, September 14, Naval Medical Center, Portsmouth, VA.
- Sediment toxicity and adaptation in Elizabeth River populations at multiple sites. Elizabeth River Project Remediation Partnership, November 3, Portsmouth, VA.
- Selenium ecotoxicology in freshwater lakes receiving coal combustion residual effluents: a North Carolina Example. SETAC Annual Meeting, November 6-10, Orlando, FL (with J. Brandt, E. Bernhardt and G. Dwyer).
- Transgenerational toxicity of polycyclic aromatic hydrocarbons may prolong physiological impacts of exposures. SETAC Annual Meeting, November 6-10, Orlando, FL (with J.S. Kozal, N. Jayasundara, C.D. Lindberg, A. Massarsky, A.N. Oliveri, E.D. Levin, and J.N. Meyer).
- Toxicity and fitness costs in PAH-resistant *Fundulus heteroclitus* exposed to creosote-contaminated sediment extract and hypoxia. SETAC Annual Meeting, November 6-10, Orlando, FL (With C.D. Lindberg, N. Jayasundara and J.S. Kozal).

2015

- Impacts of total particulate matter from cigarette smoke on early development of zebrafish (*Danio rerio*). SOT 54th Annual Meeting, March 22-26, San Diego, CA (with A. Massarsky, N. Jayasundara, J.M. Bailey, G.L. Prasad, and E.D. Levin).
- Energetic demands, fitness costs and tradeoffs in adapting to a polluted environment. PRIMO 18, May 24-27, Trondheim, Norway (with N. Jayasundara, J.S. Kozal, and P.W. Fernando).
- Aryl hydrocarbon receptor dependent persistent bioenergetics impairment following early life exposure to simple and complex PAH mixtures in *Danio rerio*. PRIMO 18, May 24-27, Trondheim, Norway (with J.S. Kozal, N. Jayasundara, A.J. Bone, C.D. Lindberg, J.M. Bailey, and E.D. Levin).
- Aryl hydrocarbon receptor dependent mitochondrial toxicity of simple and complex PAH mixtures - assessing early life exposure and later life consequences. Gordon Research Conference: Cellular and Molecular Mechanisms of Toxicity, August 8-9, Andover, NH (with N. Jayasundara, J.S. Kozal, A.J. Bone, C.D. Lindberg, J.M. Bailey, and E.D. Levin. (Selected for oral presentation).
- Inter-connections between human health and ecological integrity: an organizational framework for research and development. SETAC Annual Meeting, November 8-12, Salt Lake City, UT (with W.H. Benson, T. Fontaine, and R. Hines).
- Transgenerational mitochondrial toxicity of benzo(a)pyrene in *Danio rerio*. Superfund Center Program Annual Meeting, San Juan, Puerto Rico, November 18-20 (with J.S. Kozal, S.C.V. Burwell, N. Jayasundara, C.D. Linberg, A. Massarsky, A.N. Oliveri, E.D. Levin, and J.N. Meyer).

Effects of short term and multigenerational exposures to PAHs in fishes: Laboratory and field studies. Pacificchem (The International Chemical Congress of Pacific Basin Societies), Honolulu, Hawaii, December 15-20 (invited presentation, with J. Kozal and N. Jayasundara).

2014

The Elizabeth River Story: a case study in evolutionary toxicology. Keynote address, Carolinas SETAC Annual Meeting, April 24-25, Clemson, SC.

Transcriptomic analysis of AHR-dependent and AHR-independent genes involved in the synergistic cardiac developmental toxicity of PAHs. SOT 53rd Annual Meeting, March 17-21, Phoenix, AZ (with N. Jayasundara, L.V. Garner, J.N. Meyer, K. Erwin, and M. Kirby).

Toxicity of diesel exhaust particles with nano-ceria fuel additive in zebrafish. International Society of Exposure Science (ISES) Annual Meeting, October 12-16, Cincinnati, OH (with X. Cui, J. Osterberg, J. Gong, L. Zhang, K.F. Chung, and J. Zhang).

Low dose embryonic exposure to complex PAH mixtures alters later life behavior and swimming performance in *Fundulus heteroclitus*. SETAC Annual Meeting, November 9-13, Vancouver, BC (with D.R. Brown, N. Jayasundara, J. Bailey, A. Oliveri, D.E. Hinton, and E. Levin).

Bioaccumulation and trophic transfer of selenium in biofilms from a mining impacted stream. SETAC Annual Meeting, November 9-13, Vancouver, BC (with M.C. Arnold, T. Lindberg, R.L. Bier, and E. Bernhardt).

RAD Seq. analysis of variously PAH-Adapted Atlantic killifish, *Fundulus heteroclitus*, from throughout the Elizabeth River, VA. SETAC Annual Meeting, November 9-13, Vancouver, BC (with J.S. Osterberg, T.F. Schultz, K.M. Cammen, and B.W. Clark).

The costs of resistance: Energetic demands and fitness costs in adapting to a polluted environment. SETAC Annual Meeting, November 9-13, Vancouver, BC (with N. Jayasundara).

Toxicity of silver nanoparticles in complex environmental media to early life stage fishes is dependent on organic matter and UV light. SETAC Annual Meeting, November 9-13, Vancouver, BC (with A.J. Bone, C.W. Matson, and B.P. Colman).

Developmental toxicity of coal ash leachate and coal combustion residue (CCR) waste streams to embryonic zebrafish (*Danio rerio*). SETAC Annual Meeting, November 9-13, Vancouver, BC (with J.E. Brandt, J.S. Osterberg, E. Bernhardt, and A. Vengosh).

Tricyclic PAH-mediated cardiotoxicity in Atlantic killifish (*Fundulus heteroclitus*) inhabiting a highly PAH contaminated environment. SETAC Annual Meeting, November 9-13, Vancouver, BC (with J.S. Kozal, N. Jayasundara, and J.S. Osterberg).

2013

An ecological perspective on Exposure Science in the 21st Century. SOT Annual Meeting, March 10-14, San Antonio, TX.

The aryl hydrocarbon receptor pathway and aromatic hydrocarbon-mediated teratogenicity in the Atlantic killifish (*Fundulus heteroclitus*). SOT Annual Meeting, March 10-14, San Antonio, TX, (with B. Clark and C. Matson).

- Compound and mixture-specific differences in resistance to PAHs and PCB-126 among *Fundulus heteroclitus* subpopulations throughout the Elizabeth River estuary (Virginia, USA). PRIMO 17, May 5-8, Faro, Portugal (with B.W. Clark, J.S. Osterberg, E.M. Cooper, and H. M. Stapleton)
- Photocatalysis of benzo(a)pyrene using titanium dioxide nanoparticles results in increased toxicity to larval zebrafish. PRIMO 17, May 5-8, Faro, Portugal (with A.J. Bone).
- The role of differential metabolism and DNA adduct formation in the resistance of Atlantic killifish (*Fundulus heteroclitus*) to cancer. PRIMO 17, May 5-8, Faro, Portugal (with B.W. Clark, N.R. Herr, E.M. Cooper, L.B. Collins, B.C. Moeller, H.M. Stapleton, and J.A. Swenberg).
- Sublethal embryonic exposure to complex PAH mixtures alters later life behavior and swimming performance in *Fundulus heteroclitus*. PRIMO 17, May 5-8, Faro, Portugal (with D.R. Brown, A.N. Oliveri, N. Jayasundara, D. Hinton, and E.D. Levin).
- Selenium in otoliths of creek chub and green sunfish from a coal-mining impacted reach of the Mud River, West Virginia. 40th Aquatic Toxicology Workshop, Moncton, New Brunswick, Canada (with L. Friedrich, M. Arnold, T. Lindberg, N. Halden, and V. Palace).
- Trophic transfer and bioaccumulation of selenium through a food chain in the mountaintop removal coal mining-impacted Mud River, WV. Society of Environmental Toxicology and Chemistry (SETAC) Annual Meeting, November 17-21, Nashville TN (with M.C. Arnold, T. Lindberg, Y. Liu, H. Hsu-Kim, L. Frie, and V.P. Palace).
- RAD Seq of PAH-Adapted Atlantic Killifish, *Fundulus heteroclitus*, subpopulations from the Elizabeth River, VA. SETAC Annual Meeting, November 17-21, Nashville TN (with J.S. Osterberg, T.F. Schultz, K.M. Cammen, and B.W. Clark).
- Transcriptomic analysis of AHR-dependent and AHR-independent genes involved in the synergistic cardiac developmental toxicity of PAHs. SETAC Annual Meeting, November 17-21, Nashville TN (with N. Jayasundara, L.V. Garner, J.N. Meyer, H. Tsai, K. Erwin, and M. Kirby).
- Selenium in otoliths of creek chub and green sunfish from a coal mining-impacted reach of the Mud River, West Virginia. SETAC Annual Meeting, November 17-21, Nashville TN (with L. Friedrich, M.C. Arnold, T. Lindberg, N. Halden, and V.P. Palace).
- Photocatalytic degradation of benzo(a)pyrene using titanium dioxide nanoparticles results in increased toxicity to zebrafish (*Danio rerio*). SETAC Annual Meeting, November 17-21, Nashville TN (with A. Bone).

2012

- The effect of TiO₂ NPs on PAH mixture toxicity to fish under environmental relevant conditions. 7th International Conference on the Environmental Effects of Nanoparticles and Nanomaterials, September 10-12, Banff, Alberta, Canada (with A. Bone).
- Accumulation and toxicity of selenium in fish associated with mountaintop removal coal mining effluent. SETAC Annual Meeting, November 11-15, Long Beach, CA (with M. Arnold, T. Lindberg, Y. Liu, and H. Hsu-Kim).

2011

Comparative DNA damage and chronic liver toxicity of benzo[a]pyrene in tow populations of the Atlantic killifish (*Fundulus heteroclitus*) with different exposure histories. SOT Annual Meeting, March 6-10, Washington, DC (with L. Battle, D., Jung, K. Willett, and D. Hinton).

Quantitative method for the detection of benzo[a]pyrene-DNA adducts and 8-oxo-dG in Atlantic Killifish liver DNA. SOT Annual Meeting, March 6-10, Washington, DC (with N. Herr, L. Collins, B. Moeller, B. Clark, and J. Swenberg).

Optimization of high-throughput nanomaterial developmental toxicity testing in zebrafish embryos. SOT Annual Meeting, March 6-10, Washington, DC (with A. Wang, C. Matson, S. Frady, M. Arnold, S. Padilla, and K. Houck).

Toxicological uncertainties surrounding ecological impacts of the Deepwater Horizon oil spill. Gulf Oil Spill SETAC Focused Topic Meeting, Pensacola, FL, April 26-28, 2011.

Silver nanoparticle toxicity to Atlantic killifish (*Fundulus heteroclitus*) and zebrafish (*Danio rerio*) in complex environmental media: a comparison of laboratory, mesocosm and microcosm studies. International Conference on the Environmental Implications of NanoTechnology, May 9-11, Durham, NC (with A. Bone and C. Matson).

Heart-specific microarray identification of AHR-dependent and independent genes involved in the synergistic developmental toxicity of PAHs. Physiological Responses in Marine Organisms (PRIMO) 16, May 15-18, Long Beach, CA (with L. Van Tiem, J. Meyer, M. Kirby and H. Tsai).

Fundulus heteroclitus adapted to PAHs are cross-resistant to multiple insecticides. PRIMO 16, May 15-18, Long Beach, CA (with B. Clark).

Silver nanoparticle toxicity in *Fundulus heteroclitus*: particle versus dissolved metal toxicity. PRIMO 16, May 15-18, Long Beach, CA (with C. Matson, M. Auffan, T. Lindberg, M. Arnold, H. Hsu-Kim and M.R. Wiesner).

Silver nanoparticle toxicity to Atlantic killifish and zebrafish in complex environmental media: laboratory, mesocosm and microcosm studies. SETAC Annual Meeting, November 13-17, Boston, MA (with A.J. Bone, C.W. Matson, and B. Colman).

Mountain top removal coal Mining in WV: integrated field and laboratory studies elucidating biological consequences of a complex contaminant mixture. SETAC Annual Meeting, November 13-17, Boston, MA (with M. Arnold, T. Lindberg, Y. Liu, A. Watson, H. Hsu-Kim, and D.E. Hinton).

The role of differential metabolism and DNA-adduct formation in the resistance of Atlantic killifish (*Fundulus heteroclitus*) to cancer. SETAC Annual Meeting, November 13-17, Boston, MA (with B.W. Clark, N.R. Herr, E.M. Cooper, L.B. Collins, B.C. Moeller, H.M. Stapleton, and J.A. Swenberg).

The effect of CYP1A inhibition on embryotoxicity of weak aryl hydrocarbon receptor agonists in *Fundulus heteroclitus* and *Danio rerio*. SETAC Annual Meeting, November 13-17, Boston, MA (with D. Brown, B. Clark, L. Van Tiem, and K. Johnson).

Heart-specific microarray identification of AHR2-dependent and AHR2-independent genes involved in the synergistic developmental toxicity of PAHs. SETAC Annual Meeting, November 13-17, Boston, MA (with L. Van Tiem, J. Meyer, M. Kirby, K. Erwin, and H. Tsai).

2010

The role of dissolved silver in silver nanoparticle fish embryotoxicity. SETAC Annual Meeting, November 7-11, Portland, OR (with C.W. Matson, M. Auffan, T. Linberg, A.R. Badireddy, and M.R. Wiesner).

Patterns of heritability of resistance to cardiac teratogenesis and CYP1 induction by aryl hydrocarbons in *Fundulus heteroclitus*. SETAC Annual Meeting, November 7-11, Portland, OR (with A.J. Bone and B.W. Clark).

The role of zebrafish AHR1 isoforms in polycyclic aromatic hydrocarbon toxicity. SETAC Annual Meeting, November 7-11, Portland, OR (with L. Van Tiem and D. Brown).

Heart-specific microarray identification of AHR-dependent and independent genes involved in the synergistic developmental toxicity of PAHs. SETAC Annual Meeting, November 7-11, Portland, OR (with L. Van Tiem, J. Meyer, P. Hurban, H. Tsai and M. Kirby).

Physical and toxicological study on cerium oxide nanoparticles in *Caenorhabditis elegans*. SETAC Annual Meeting, November 7-11, Portland, OR (with M. Arnold, A.R. Badireddy, M.R. Wiesner, and J.N. Meyer).

2009

Compound- and mixture-specific resistance to PAHs in *Fundulus heteroclitus* subpopulations throughout the Elizabeth River estuary (Virginia, USA). SETAC Annual Meeting, November 19-23, New Orleans, LA (with B.W. Clark).

Synergistic induction of cardiac toxicity and redox-responsive genes in zebrafish embryos after co-exposure to benzo[k]fluoranthene and fluoranthene. SETAC Annual Meeting, November 19-23, New Orleans, LA (with L. Van Tiem).

Assessment of genotoxicity in the Atlantic killifish (*Fundulus heteroclitus*) from a creosote-contaminated Superfund site. New England Superfund Research Program meeting, October 4, Woods Hole Oceanographic Institute, MA (with D. Jung, C.W. Matson, L.B. Collins, G. Laban, H. Stapleton, J.A. Swenberg and J.W. Bickham).

Silver nanoparticles behavior and fish embryotoxicity across a salinity gradient. First International Conference on the Environmental Implications of Nanotechnology, September 9-11, Washington, D.C., and SETAC Annual Meeting, November 19-23, New Orleans, LA (with C. Matson, M. Auffan, and M. Wiesner).

Benzo[a]pyrene metabolism, DNA damage and liver injury in an adapted population of *Fundulus heteroclitus*. Physiological Responses in Marine Organisms (PRIMO) 15, May 17-20, Bordeaux, France (with L. Battle, D. Jung, D. Hinton, and K. Willett).

Investigation of the AHR pathway function and PAH adaptation in *Fundulus heteroclitus* using morpholino gene knockdown. PRIMO 15, May 17-20, Bordeaux, France (with B.W. Clark, C.W. Matson and D. Jung).

Identification and characterization of killifish (*Fundulus heteroclitus*) mitochondrial CYP1A1 and its relationship to effects of polycyclic aromatic hydrocarbons on energy metabolism. PRIMO 15, May 17-20, Bordeaux, France (with D. Jung, and C.P. Thompson).

The synergistic developmental toxicity of PAHs is not accompanied by synergistic induction of various phase I and redox-responsive genes. PRIMO 15, May 17-20, Bordeaux, France (with L.A. Van Tiem).

2008

- How to measure oxidative status in humans? Society for Free Radicals in Biology and Medicine Annual Meeting, November 19-23, Indianapolis, IN (with D. Il'yasova, G. Mixon, P.K. Marcom, J. Marks, I. Spasojevich, N. Craft, and F. Arredondo).
- Effects of benzo[a]pyrene on mitochondrial DNA damage in the killifish (*Fundulus heteroclitus*). Society of Toxicology (SOT) Annual Meeting, March 16-20, Seattle, WA (with D. Jung and J. Meyer).
- Effect of the CYP1A inhibitor fluoranthene on the biotransformation of benzo[a]pyrene in two populations of *Fundulus heteroclitus* with different exposure histories. SOT Annual Meeting, March 16-20, Seattle, WA (with L. Battle, S. Zhu, and K. Willett).
- NRF2 plays a protective role in response to pro-oxidant exposure of zebrafish embryos (*Danio rerio*). SOT Annual Meeting, March 16-20, Seattle, WA (with L. Van Tiem and A. Timme-Laragy).
- Is oxidative stress a significant factor in the synergistic developmental toxicity of model PAHs in zebrafish? SOT Annual Meeting, March 16-20, Seattle, WA (with A. Timme-Laragy, L. Van Tiem and D. Jung).
- Overexpression of ARNT does not alter crosstalk between the aryl hydrocarbon receptor and hypoxia pathways in PLHC-1 cells. SOT Annual Meeting, March 16-20, Seattle, WA (with C.R. Fleming, S. Billiard, and D.E. Hinton).
- Mechanisms underlying the synergistic embryotoxicity of PAH AHR agonists and CYP1A inhibitors in fish models. Society of Environmental Toxicology and Chemistry (SETAC) Annual Meeting, November 16-20, Tampa, FL (with C.W. Matson and A.R. Timme-Laragy).
- Fundulus heteroclitus* (mummichog) adapted to PAHs are cross-resistant to multiple insecticides. SETAC Annual Meeting, November 16-20, Tampa, FL (with B. Clark).
- Expression of mitochondrial cytochrome P450s in response to PAHs in killifish (*Fundulus heteroclitus*). SETAC Annual Meeting, November 16-20, Tampa, FL (with D. Jung and J. Meyer).
- Crosstalk between the AHR and hypoxia pathways in a topminnow cell line occurs with BaP but not PCB126 and is partially mediated by ARNT. SETAC Annual Meeting, November 16-20, Tampa, FL (with C. Fleming and S. Billiard).
- Effect of the CYP1A inhibitor on the biotransformation of benzo[a]pyrene in two populations of *Fundulus heteroclitus* with different exposure histories. SETAC Annual Meeting, November 16-20, Tampa, FL (with L. Battle, S. Zhu and K. Willett).
- Heart-specific microarray identification of genes involved in the synergistic developmental toxicity of PAHs: comparison of AHR-dependent and AHR-independent pathways using morpholino gene knockdown. SETAC Annual Meeting, November 16-20, Tampa, FL (with L. Van Tiem, J. Meyer and E. Lobenhofer).

2007

- Considerations for the determination of polycyclic aromatic hydrocarbon exposure risk upon consumption of fish from the southern branch of the Elizabeth River in Portsmouth, Virginia. Integrating Environment and Human Health, the 7th National Conference on Science, Policy and the Environment, National Council for Science and the Environment, February 1-2, Washington, DC (with A. Nerlinger and M. Cullen).

Developmental and molecular interactions between the hypoxia and aryl hydrocarbon receptor (AHR) pathways in zebrafish. SOT Annual Meeting, March 25-29, Charlotte, NC (with C.W. Matson, C.R. Fleming, A.R. Timme-Laragy, D. Jung and L.P. Battle).

Aryl hydrocarbon receptor regulated gene expression during synergistic developmental toxicity of polycyclic aromatic hydrocarbons in zebrafish (*Danio rerio*). SOT Annual Meeting, March 25-29, Charlotte, NC (with A.R. Timme-Laragy, C. Cockman and C. Matson).

Redox and the AHR: mechanisms of synergistic developmental PAH toxicity in zebrafish. PRIMO 14, May 6-9, Florianopolis, Brazil (with A.R. Timme-Laragy).

mRNA expression of aryl hydrocarbon receptor pathway members during polycyclic aromatic hydrocarbon synergistic developmental toxicity in zebrafish. PRIMO 14, May 6-9, Florianopolis, Brazil (with A.R. Timme-Laragy, C.J. Cockman and C.W. Matson).

Developmental and molecular interactions between the hypoxia and aryl hydrocarbon receptor (AHR) pathways in zebrafish (*Danio rerio*) and Atlantic killifish (*Fundulus heteroclitus*). PRIMO 14, May 6-9, Florianopolis, Brazil (with C.R. Fleming, C.W. Matson, and D.E. Hinton).

Effects of polycyclic aromatic hydrocarbons on mitochondrial DNA damage in the killifish (*Fundulus heteroclitus*). PRIMO 14, May 6-9, Florianopolis, Brazil (with D. Jung and J.N. Meyer).

2006

Role of the aryl hydrocarbon receptor pathway in the synergistic developmental toxicity of polycyclic aromatic hydrocarbons in zebrafish. SOT Annual Meeting, March 5-9, San Diego, CA (with S. Billiard, A. Timme-Laragy, D. Wassenberg, C. Cockman, and E. Linney).

Lessons from the wild: studies of fish coping with polluted environments. Cancer and the Environment Conference, Duke University Comprehensive Cancer Center and Nicholas School of the Environment and Earth Sciences, March 30-31, Durham, NC.

Developmental effects of polycyclic aromatic hydrocarbons: studies in *Fundulus* and zebrafish. Fundulus Genomics Workshop, May 4-5, Charleston, SC.

A morpholino approach to understand synergistic developmental toxicity of PAH in zebrafish (*Danio rerio*). Society of Environmental Toxicology and Chemistry (SETAC) Annual Meeting, November 5-9, Montreal, Canada (with A.R. Timme-Laragy, S.M. Billiard and C.J. Cockman).

mRNA expression of aryl hydrocarbon receptor pathway members during polycyclic aromatic hydrocarbon synergistic developmental toxicity in zebrafish (*Danio rerio*). SETAC Annual Meeting, November 5-9, Montreal, Canada (with A.R. Timme-Laragy, C.J. Cockman and C.W. Matson).

Developmental and molecular interactions between hypoxia and aryl hydrocarbon receptor (AHR) pathways in zebrafish. SETAC Annual Meeting, November 5-9, Montreal, Canada (with C.W. Matson and A.R. Timme-Laragy).

Interactive effects of hypoxia and polycyclic aromatic hydrocarbons (PAHs) in the developing killifish, *Fundulus heteroclitus*. SETAC Annual Meeting, November 5-9, Montreal, Canada (with C. Fleming and D. Hinton).

Effects of polycyclic aromatic hydrocarbons on mitochondrial DNA damage in killifish, *Fundulus heteroclitus*. SETAC Annual Meeting, November 5-9, Montreal, Canada (with D. Jung and J.N. Meyer).

Comparative chronic liver toxicity of benzo(a)pyrene in two populations of *Fundulus heteroclitus* with different sensitivities. SETAC Annual Meeting, November 5-9, Montreal, Canada (L.P. Battle, K.L. Willett and D.E. Hinton).

Assessing the toxicological effects of mercury in fish using biomarkers. SETAC Annual Meeting, November 5-9, Montreal, Canada (with C. Larose, R. Canuel, M. Lucotte, P. Spear, and B. Angers).

2005

Mechanisms of interactive developmental toxicity of polycyclic aromatic hydrocarbons in zebrafish. SOT Annual Meeting, March 6-10, New Orleans, LA, Physiological Responses in Marine Organisms (PRIMO) 13, June 19-23, Alessandria, Italy, and SETAC, November 13-17, Baltimore, MD (with S. Billiard, D. Wassenberg, A. Timme-Laragy, and E. Linney).

Synergistic developmental toxicity of polycyclic aromatic hydrocarbons: towards a mechanistic understanding. SOT Annual Meeting, March 6-10, New Orleans, LA; PRIMO 13, June 19-23, Alessandria, Italy; Estuarine Research Foundation Annual Meeting, October 15-19, Norfolk, VA (with S. Billiard, J. Meyer, D. Wassenberg, and P. Hodson).

Resistance to PCB induced CYP1A activity and reactive oxygen species (ROS) production in contaminated killifish (*Fundulus heteroclitus*) populations. PRIMO 13, June 19-23, Alessandria, Italy (with X. Arzuaga, E. Harmel, D.M. Wassenberg, and A.A. Elskus).

Embryotoxicity of 2,3,7,8-TCDD to the wood duck (*Aix sponsa*). SETAC Annual Meeting, November 13-17, Baltimore, MD (with T.P. Augspurger and D.E. Tillitt).

2004

Highlights from a recent Pellston workshop on emerging molecular and computational approaches for cross-species extrapolations. National Academy of Sciences workshop, August 12-13, 2004, Washington, D.C.

Developmental and behavioral effects of embryonic exposure to DE-71 in *Fundulus heteroclitus*. The Third International Workshop on Brominated Fire Retardants, June 6-9, Toronto, Ontario, Canada, and SETAC Annual Meeting, November 18-24, Portland, OR (with A.R. Timme-Laragy).

Mechanisms of PAH- and PCB-mediated impacts on embryonic development in the killifish, *Fundulus heteroclitus*. SOT Annual Meeting, March 20-25, Baltimore, MD (with D.M. Wassenberg).

Emerging molecular and computational approaches for cross-species extrapolations: a workshop summary. SETAC Annual Meeting, November 18-24, Portland, OR (with W.H. Benson, J.C. Cook, J.F. Freedman, R.L. Malek, C. Thompson, and D. Versteeg).

Lack of p53 induction in fish cells by model chemotherapeutics. SETAC Annual Meeting, November 18-24, Portland, OR (with M.A. Rau and S.M. Billiard).

Resistance to PCB induced CYP1A activity and oxidative stress in a chronically contaminated killifish (*Fundulus heteroclitus*) population. SETAC Annual Meeting, November 18-24, Portland, OR (with X. Arzuaga, A.A. Elskus, E. Harmel, and D.M. Wassenberg).

Do TIE laboratory based assessment methods really predict field effects? SETAC Annual Meeting, November 18-24, Portland, OR (with K.T. Ho et al.).

Interactive effects of pentachlorophenol with polycyclic aromatic hydrocarbons on teratogenesis and cytochrome P4501A activity in *Fundulus heteroclitus*. SETAC Annual Meeting, November 18-24, Portland, OR (with L.P. Battle)

2003

- Developmental deformities and CYP1A induction in *Fundulus heteroclitus* embryos exposed to PAH-type inducers and CYP1A inhibitors. PRIMO 12, Tampa, FL, May 9-13 (with D.M. Wassenberg and J.N Meyer).
- Analysis of CpG methylation in the promoter region of the CYP1A gene in *Fundulus heteroclitus* from creosote-contaminated and reference sites. PRIMO 12, Tampa, FL, May 9-13 (with J.N. Meyer, A.R. Timme, R.A. Waterlund, W.H. Powell, S.L. Krachner, and M.E. Hahn).
- Differential susceptibility of fish and rat liver cells to oxidative stress and cytotoxicity upon exposure to prooxidants. PRIMO 12, Tampa, FL, May 9-13, and SETAC 24th Annual Meeting, November 9-13, Austin, TX (with M.A. Rau, J. Whitaker and J.H. Freedman).
- Identification of chemical classes contributing to the toxicity of sediments from a contaminated site on the Elizabeth River, VA, USA. PRIMO 12, Tampa, FL, May 9-13 (with Y.-T. tang, L.A. Leinessch, E.M. Cooper, D. Vasudevan, and J.N Meyer).
- Oxidative stress in two killifish populations with differing contaminant exposure histories. PRIMO 12, Tampa, FL, May 9-13 (with L. R. Bacanskas, J. Whitaker, and J.N. Meyer).
- Adaptations in *Fundulus heteroclitus* inhabiting a polluted estuary: mechanisms, fitness costs and genetic consequences. Annual Meeting of the Brazilian Federation of Experimental Biology (FESBE 2003), August 27-30, Curitiba, Brazil.
- Mechanisms of cardiovascular teratogenesis in *Fundulus heteroclitus*. Aquatic Animal Models of Human Disease, Manassas, VA, September 29 – October 2 (with D. Wassenberg, S. Billiard, and J. Meyer).
- Teratogenesis and CYP1A induction in *Fundulus heteroclitus* embryos exposed to polycyclic aromatic hydrocarbon mixtures. SETAC Annual Meeting, November 9-13, Austin, TX (with D.M. Wassenberg).
- P53 induction response in two fish liver cell lines. SETAC 24th Annual Meeting, November 9-13, Austin, TX (with M.A. Rau and S.M. Billiard).
- Evidence for the role of p53 in metal-induced activation of metallothionein gene expression. SETAC Annual Meeting, November 9-13, Austin, TX (with E.S. Craft, M.A. Rau, M.G. Cherian, and J.H. Freedman).
- Differential display of hepatic mRNA from *Fundulus heteroclitus* inhabiting a Superfund estuary. SETAC Annual Meeting, November 9-13, Austin, TX (with J.N. Meyer, D.C. Volz, and J.H. Freedman).
- Characterization of the hypoxic functional response using a fish model system. SETAC Annual Meeting, November 9-13, Austin, TX (with S.M. Billiard, M.A. Rau, and B.B. Rees).
- Analysis of CpG methylation in the promoter region of the CYP1A gene in *Fundulus heteroclitus* from creosote-contaminated and reference sites. SETAC Annual Meeting, November 9-13, Austin, TX (with A. R. Timme, J.N. Meyer, D.M. Wassenberg, R.A Waterland, S.I. Karchner, and M.E. Hahn).

2002

- Nongenetic heritability of an altered cytochrome P451A phenotype in killifish (*Fundulus heteroclitus*) from a contaminated site. Developmental Toxicology in the 21st Century, NIEHS, April 22-24, RTP, NC, (with J.N. Meyer).

CYP1B mRNA expression in two catfish species. SOT Annual Meeting, March 17-21, Nashville, TN (with C. Metzger and K.L. Willett).

Alterations in the expression and inducibility of genes in the aryl hydrocarbon receptor (AhR) pathway in wild-caught killifish (*Fundulus heteroclitus*) from a creosote contaminated sediment. SETAC Annual Meeting, November 16-20, Salt Lake City, UT (with D.M. Wassenberg and E.E. Swails).

Antioxidant defenses in killifish (*Fundulus heteroclitus*) exposed to Superfund sediments: short-term and evolutionary responses. SETAC Annual Meeting, November 16-20, Salt Lake City, UT (with J. Meyer, J.D. Smith, and G.W. Winston).

Teratogenesis and EROD induction in *Fundulus heteroclitus* exposed to extracts of a creosote-contaminated site. SETAC Annual Meeting, November 16-20, Salt Lake City, UT (with D.M. Wassenberg J.N. Meyer, J.S. Manke, S.I. Karchner, and M.E. Hahn).

2001

Environmental – Human Health Interconnections. Society of Toxicology (SOT) Annual Meeting, March 25-29, San Francisco, CA (with W.H. Benson).

The role of the tumor suppressor gene, p53, in pollutant-mediated carcinogenesis in two Ictalurid species of catfish. 11th International Symposium on Pollutant Responses in Marine Organisms (PRIMO 11), Plymouth, UK, July 10-13, and SETAC 22nd Annual Meeting, November 11-15, Baltimore, MD (with M. Rau).

Effects of combined exposures to benzo[a]pyrene and 3,3',4,4',5-pentachlorobiphenyl on *Fundulus heteroclitus*. PRIMO 11, Plymouth, UK, July 10-13 (with D. Wassenberg and E. Swails).

Mechanisms of adaptation and fitness costs in F1 and F2 offspring of killifish (*Fundulus heteroclitus*) from a contaminated site. PRIMO 11, Plymouth, UK, July 10-13, and SETAC Annual Meeting, November 11-15, Baltimore, MD (with J. Meyer).

Effect of chemical mixtures on indicators of oxidative stress in fish liver cells (PLHC-1). SETAC Annual Meeting, November 11-15, Baltimore, MD (with J.W. Whitaker).

Interactive biochemical effects of AHR agonists with prooxidants in *Fundulus heteroclitus*. SETAC Annual Meeting, November 11-15, Baltimore, MD (with D.M. Wassenberg, E.S. Swails, and J. Nakamura).

Identification and distribution of a CYP1B-like message in two fish species. SETAC Annual Meeting, November 11-15, Baltimore, MD (with K.L. Willett, B. Sun, C. Metzger, and L. Lienesch).

2000

Differential benzo[a]pyrene metabolism and excretion in two related fish. SOT Annual Meeting, March 19-23, Philadelphia, PA (with K.L. Willett, P. Gardinali, and J. Rogers).

Early life stage toxicity of the estrogenic alkylphenols in an estuarine killifish: evidence for endocrine disruption? Atlantic Coasts Contaminants Workshop 2000, June 22-25, Bar Harbor, ME (with S.A. Kelly).

In vivo inhibition of CYP1A by the PAH fluoranthene. SETAC Annual Meeting, November 12-16, Nashville, TN (with K.L. Willett, D.M. Wassenberg, L.A. Lienesch, and W.L. Reichert).

Mechanisms of adaptation and fitness costs in F1 and F2 offspring of wild-caught killifish (*Fundulus heteroclitus*) from a contaminated site. SETAC Annual Meeting, November 12-16, Nashville, TN (with J.N. Meyer).

Environmental-Human Health Interconnections: A Workshop Report. SETAC Annual Meeting, November 12-16, Nashville, TN (with W.H. Benson).

Molecular Cloning of the Tumor Suppressor Gene, p53, in Two Species of Ictalurid Catfish. SETAC Annual Meeting, November 12-16, Nashville, TN (with M.A. Rau and J.M. Gross).

Can maternal fluoranthene exposure provide photo-protection in offspring of the killifish (*Fundulus heteroclitus*)? SETAC Annual Meeting, November 12-16, Nashville, TN (with T.A. Parson, J.N. Meyer, and K.L. Willett).

Developmental toxicity of alkylphenols in *Fundulus heteroclitus*: evidence for endocrine disruption? SETAC Annual Meeting, November 12-16, Nashville, TN (with S.A. Kelly).

Characterization of toxicity associated with chemical resistance of *Fundulus heteroclitus* from a Superfund site. SETAC Annual Meeting, November 12-16, Nashville, TN (with L.A. Lienesch, J.N. Meyer, and J.G. Burkhardt).

1999

Differential phase I and phase II enzyme activities in brown bullhead and channel catfish exposed to β -naphthoflavone. PRIMO 10, April 25-29, Williamsburg, VA (with K. Willett and J. Rogers).

Increased sensitivity to oxidative stress in a creosote-adapted population of mummichog (*Fundulus heteroclitus*). PRIMO 10, April 25-29, Williamsburg, VA (with J.N. Meyer and E.D. MacLean).

Interaction of estrogenic alkylphenols and tamoxifen in *Fundulus heteroclitus* embryos and larvae. PRIMO 10, April 25-29, Williamsburg, VA (with S. Kelly).

Vitellogenin-associated maternal transfer of exogenous and endogenous ligands in the estuarine fish, *Fundulus heteroclitus*. PRIMO 10, April 25-29, Williamsburg, VA (with G.H. Monteverdi).

Benzo(a)pyrene metabolism and excretion in channel catfish and brown bullhead. SETAC Annual Meeting, November 14-18, Philadelphia, PA (with K.L. Willett, R. Rogers, and P. R. Gardinali).

Determination of Benzo(a)pyrene metabolites in fish bile by atmospheric pressure chemical ionization mass spectrometry. SETAC Annual Meeting, November 14-18, Philadelphia, PA (with P. R. Gardinali and K. L. Willett).

Early life stage toxicity of estrogenic alkylphenol exposure in the estuarine killifish *Fundulus heteroclitus*. SETAC Annual Meeting, November 14-18, Philadelphia, PA (with S.A. Kelly).

Measures of fitness in F₁ and F₂ offspring of wild-caught mummichog (*Fundulus heteroclitus*) from a contaminated site, SETAC Annual Meeting, November 14-18, Philadelphia, PA (with J.N. Meyer and E.D. McLean).

Vitellogenin-associated maternal transfer of exogenous and endogenous ligands in the Estuarine fish, *Fundulus heteroclitus*, SETAC Annual Meeting, November 14-18, Philadelphia, PA (with G.H. Monteverdi).

1998

Assessment of AP site formation in isolated hepatocytes from brown bullhead upon treatment with benzo[a]pyrene. SOT Annual Meeting, March 1-5, Seattle, WA (with S.A. Ploch, J. Nakamura, and J.A. Swenberg).

Antioxidant adaptations in killifish (*Fundulus heteroclitus*) populations from PAH-impacted and PCB-impacted sites. SETAC Annual Meeting, November 15-19, Charlotte, NC (with J.A. Carey, and E.D. MacLean).

Embryo and larval toxicity of alkylphenol exposure in *Fundulus heteroclitus*. SETAC Annual Meeting, November 15-19, Charlotte, NC (with S.A. Kelly).

Phototoxicity of anthracene and fluoranthene in killifish (*Fundulus heteroclitus*) from PAH-impacted and non-impacted sites. SETAC Annual Meeting, November 15-19, Charlotte, NC (with E.D. MacLean, and J.A. Carey).

The role of vitellogenin in maternal transfer. SETAC Annual Meeting, November 15-19, Charlotte, NC (with G.H. Monteverdi, and M.J. DeVito).

1997

Comparative time-course of benzo[a]pyrene-DNA adduct formation and its relationship to CYP1A activity in two species of catfish. PRIMO 9, April 27-30, Bergen, Norway (with S.A. Ploch and L.C. King).

Developmental toxicity of alkylphenol exposure in *Fundulus heteroclitus* embryos. SETA) Annual Meeting, November 16-20, San Francisco, CA (with S. Kelly and B. Toomey).

TCDD-induced cell death in *Fundulus heteroclitus* embryos. SETAC Annual Meeting, November 16-20, San Francisco, CA (with B. Toomey, S. Cantrell, P. Wright, and D. Tillitt).

Discordance between EROD activity and BaP-DNA adduct formation in liver of two species of catfish. SETAC Annual Meeting, November 16-20, San Francisco, CA (with S. Ploch and L. King).

8 – Hydroxy – 2' – deoxyquanosine as a marker of oxidative DNA damage in catfish liver. SETAC Annual Meeting, November 16-20, San Francisco, CA (with S. Ploch, Y. Lee, and E. Maclean).

Vitellogenin binds and transports xenobiotics to developing oocytes. SETAC Annual Meeting, November 16-20, San Francisco, CA (with G. Monteverdi).

1996

Comparative *in vitro* metabolism and activation of benzo[a]pyrene from two species of catfish. SETAC Annual Meeting, November 17-21, Washington, DC (with S.A. Ploch).

Octylphenol induces apoptosis in fish cells. SETAC Annual Meeting, November 17-21, Washington, DC (with B.H. Toomey and S.A. Ploch).

Vitellogenin binds and transports xenobiotics to developing oocytes. SETAC Annual Meeting, November 17-21, Washington, DC (with G. Monteverdi).

1995

Aminoanthracene is a mechanism-based inactivator of cytochrome P4501A in channel catfish hepatic tissue. PRIMO 8, April 2-5, Pacific Grove, CA (with D.E. Watson, L. Ménard, and J.J. Stegeman).

Formation of DNA adducts in hepatic tissue of channel catfish by 2-aminoanthracene is enhanced by elevation of P4501A *in vivo* and *in vitro*. PRIMO 8, April 2-5, Pacific Grove, CA (with D.E. Watson and S.A. Ploch).

Inactivation of channel catfish CYP1A by 2-aminoanthracene. SETAC Annual Meeting, November 5-9, Vancouver, BC (with D.E. Watson, L. Ménard, and J.J. Stegeman).

1994

Mechanistic linkages between human and ecosystem health: potentials and limitations for holistic assessments. Invited presentation. First International Symposium on Ecosystem Health and Medicine. June 19-23, Ottawa, Ontario.

Pretreatment of channel catfish with β -naphthoflavone increases binding of 2-aminoanthracene to hepatic DNA. SETAC Annual Meeting, October 30 - November 3, Denver, CO (with D.E. Watson and S.A. Ploch).

1993

NADPH: phenanthrenequinone reductase and oxidative stress in channel catfish (*Ictalurus punctatus*). SOT Annual Meeting, March 14-18, New Orleans, LA (with B.M. Hasspieler). Toxicologist 12:184 (Abstr.).

Determinants of species susceptibility to oxidative stress: a comparison of channel catfish and brown bullhead. PRIMO 7, April 20-22, Göteborg, Sweden (with J. Behar, D. Carlson, B.M. Hasspieler, and D.E. Watson).

NADPH: phenanthrenequinone reductase, a novel quinone oxidoreductase in channel catfish. PRIMO 7, April 20-22, Göteborg, Sweden (with B.M. Hasspieler).

Metabolism and Mutagenicity of 2-aminoanthracene by Channel Catfish Hepatic Microsomes. SETAC Annual Meeting, November 14-18, 1993, Houston, TX (with D.E. Watson).

Effect of BKME on Hepatic Porphyrin Levels and Other Biochemical Responses in Freshwater Fishes. SETAC Annual Meeting, November 14-18, 1993, Houston, TX (with K.M. Hopkins and S.W. Kennedy).

1992

Glutathione-dependent detoxification of chlorothalonil in channel catfish tissues. SOT Annual Meeting, February 23-28, Seattle, WA (with E.P. Gallagher). Toxicologist 12:393 (Abstr.).

DT diaphorase [NAD(P)H: (quinone acceptor) oxidoreductase] and quinone redox cycling in channel catfish (*Ictalurus punctatus*). SOT Annual Meeting, February 23-28, Seattle, WA (with B.M. Hasspieler). Toxicologist 12:393 (Abstr.).

Cytochrome P450 induction and genotoxicity in feral fish collected from the Niagara River ecosystem. SOT Annual Meeting, February 23-28, Seattle, WA (with N.A. Eufemia, M.S. Kroen, D.E. Watson, T.K. Collier, and J.E. Stein). Toxicologist 12:407 (Abstr.).

Biochemical responses in brown bullhead from the Niagara River ecosystem. SETAC Annual Meeting, November 8-12, Cincinnati, OH (with N.A. Eufemia, T.K. Collier, and D.E. Watson).

Mechanisms underlying quinone-mediated oxidative stress in channel catfish (*Ictalurus punctates*). SETAC Annual Meeting, November 8-12, Cincinnati, OH (with B.M. Hasspieler).

A mechanistic approach to understanding species susceptibility to oxidative stress: a comparison of channel catfish (*Ictalurus punctates*) and brown bullhead (*Ameriurus nebulosus*). SETAC Annual Meeting, November 8-12, Cincinnati, OH (with D. Carlson and B.M. Hasspieler).

Production of 8-hydroxydeoxyguanosine *in vitro* and *in vivo* in channel catfish and brown bullhead hepatic tissue. SETAC Annual Meeting, November 8-12, Cincinnati, OH (with D.E. Watson).

1991

Studies of glutathione synthesis and turnover in channel catfish. SOT Annual Meeting, February 25 - March 1, Dallas, TX (with E.P. Gallagher). *Toxicologist* 11: 128 (Abstr.).

Interpretation of biomarker responses. NATO Advanced Research Workshop: "Strategy for Biomarker Research and Application in the Assessment of Environmental Health", Texel, The Netherlands, May 11-19, 1991.

The gills are an important site of glutathione metabolism and chlorothalonil detoxification in channel catfish. PRIMO 6, April 24-26, Woods Hole Oceanographic Institute, MA (with E.P. Gallagher).

NAD(P)H: quinone oxidoreductase (DT diaphorase) in channel catfish (*Ictalurus punctatus*). SETAC Annual Meeting, November 3-7, 1991, Seattle, WA (with B.M. Hasspieler).

1990

Indices of oxidative stress as biomarkers for pollutant exposure and sublethal effects. Invited paper, 14th ASTM Symposium on Aquatic Toxicology and Risk Assessment, April 22-24, San Francisco, CA.

Biochemical effects of Black Rock Harbor sediments in channel catfish. Atlantic Estuarine Research Society Annual Meeting, Virginia Institute of Marine Science, Gloucester Point, May 3-5.

The role of *in vitro* studies in ecological hazard assessments. Invited paper, "The Population Ecology and Wildlife Toxicology of Agricultural Pesticide Use: A Modeling Initiative for Avian Species." July 22-27, Kiawah Island, S.C., sponsored by the Society of Environmental Toxicology and Chemistry (with E.P. Gallagher and C. Habig).

Antioxidant responses in the wedge clam (*Rangia cuneata*) exposed to t-butyl hydroperoxide and elevated oxygen. SETAC Annual Meeting, November 11-15, 1990, Arlington, VA (with P.C. Darby).

The mutagenicity of Black Rock Harbor sediments in the *Salmonella*/microsome assay: a comparison of the metabolic capability of the liver S9 fraction of rat and channel catfish. SETAC Annual Meeting, November 11-15, 1990, Arlington, VA (with J.S. Volosin, D.A. Pagano, and F.W. Kari).

Use of depleting agents in studies of glutathione turnover, subcellular distribution, and detoxification of chlorothalonil in channel catfish. SETAC Annual Meeting, November 11-15, 1990, Arlington, VA (with E.P. Gallagher).

1989

Biochemical and peroxisomal proliferating effects of bleached kraft pulp and paper mill effluent in channel catfish. SOT Annual Meeting, February 26 - March 1, Atlanta, GA (with E. Mather-Mihaich). *Toxicologist* 9:65 (Abstr.).

Phase I and phase II biotransformation enzyme activities in channel catfish exposed to contaminated sediments. SOT Annual Meeting, February 26 - March 1, Atlanta, GA (with C. Habig and T. Wolfe). *Toxicologist* 9:43 (Abstr.).

Oxyradicals and antioxidant defenses: an environmental perspective. Invited paper for the Annual Biomedical Sciences Symposium, Wright State University, Dayton, OH, May 19; Interdepartmental Plant Physiology Seminar Series, Virginia Tech, Blacksburg, VA, April 13; and Ecotoxicology Mini-symposium on Environmental Pollutants and Biomarkers, Duke University, May 17.

Biochemical characteristics of cholinesterases in aquatic organisms. Invited paper, SETAC Annual Meeting, October 29 - November 2, 1989, Toronto, Ontario (with C. Habig).

Effects of 2,4-D and picloram on monooxygenase, glutathione s-transferase, and peroxisomal enzyme activities in channel catfish liver. SETAC Annual Meeting, October 29 - November 2, 1989, Toronto, Ontario (with E.P. Gallagher).

Peroxisomal enzyme, mixed-function oxidase and oxidant-mediated responses of chlorinated phenolics and resin acids in channel catfish. SETAC Annual Meeting, October 29 - November 2, 1989, Toronto, Ontario (with E. Mather-Mihaich).

Oxidant-mediated responses as indices for environmental contamination. Invited paper, Pacificchem (The 1989 International Chemical Congress of Pacific Basin Societies), December 17-22, Honolulu, HI.

1988

Redox cycling and oxidative stress in aquatic animals. Invited paper, Southeastern Regional Chapter, Society of Toxicology, June 24-25, Knoxville, TN.

Free radical-mediated effects in channel catfish exposed to contaminated sediments. SETAC Annual Meeting, November 13-17, 1988, Arlington, VA. (with C. Habig).

1987

Mixed function oxidase activity in brown bullhead from a contaminated Neuse River estuary. SOT Annual Meeting, February 23-27, Washington, D.C. (with E.P. Gallagher). Toxicologist 7:149 (Abstr.)

Nitroaromatic catalysis of superoxide generation in three species of freshwater fish. SOT Annual Meeting, February 23-27, Washington, D.C. (with P.C. Washburn). Toxicologist 7:19 (Abstr.)

Effects of paraquat on microsomal oxygen reduction and antioxidant enzymes in the hepatopancreas of two mid-Atlantic bivalve molluscs. SOT Annual Meeting, February 23-27, Washington, D.C. (with R.J. Wenning). Toxicologist 7:149 (Abstr.).

In vivo and in vitro effects of the cotton defoliant DEF on catfish acetylcholinesterase. SOT Annual Meeting, February 23-27, Washington, D.C. (with C. Habig). Toxicologist 7:19 (Abstr.).

Toxicity of paraquat in the chicken embryo. SOT Annual Meeting, February 23-27, Washington, D.C. (with H.T. Williams). Toxicologist 7:1 (Abstr.).

Effects of atmospheric deposition on red spruce: a free radical-based approach. National Acid Precipitation Assessment Program Peer Review, March 8-13, Atlanta, GA (with C. J. Richardson).

Nitroaromatic stimulation of superoxide production in three species of freshwater fish. PRIMO 4, April 22-24, 1987, Woods Hole, MA (with P.C. Washburn).

The anticholinesterase effect of the cotton defoliant S, S, S tri-*n*-butyl phosphorotrithioate (DEF) on channel catfish. PRIMO 4, April 22-24, 1987, Woods Hole, MA (with C. Habig).

The effects of paraquat on microsomal oxygen reduction and antioxidant defenses in ribbed mussels (*Guekensia demissa*) and wedge clams (*Rangia cuneata*). PRIMO 4, April 22-24, 1987, Woods Hole, MA (with R. J. Wenning).

Isozymes of superoxide dismutase in red spruce and their importance in protecting against oxidative stress. US/FRG Symposium, "The Effects of Atmospheric Pollutants on the Spruce-Fir Forests of the Eastern United States and the Federal Republic of Germany", October 10-23, Burlington, VT (with N.E. Tandy and C.J. Richardson).

Biochemical responses in aquatic organisms: a review plus recent studies on oxidative stress. SETAC Annual Meeting, November 9-12, Pensacola, FL (with P.C. Washburn, R.J. Wenning, C.S. Jewell, and G.W. Winston).

Interactive effects of copper, iron and paraquat on in vitro lipid peroxidation in channel catfish liver. SETAC Annual Meeting, November 9-12, Pensacola, FL (with E. P. Gallagher).

Oxidant and mixed function oxidase mediated responses in channel catfish exposed to bleached kraft mill effluent. SETAC Annual Meeting, November 9-12, Pensacola, FL (with E. Mather-Mihaich).

Tissue distribution and depuration kinetics of the cotton defoliant DEF in channel catfish. SETAC Annual Meeting, November 9-12, Pensacola, FL (with C. Habig).

Inhibition of superoxide dismutase in red spruce by hydrogen peroxide: a possible factor in increased susceptibility to oxidative stress from pollutants. SETAC Annual Meeting, November 9-12, Pensacola, FL (with N.E. Tandy and C.J. Richardson).

1986

Heavy metals in peatland waters. Invited paper, North Carolina Section of the American Water Resources Association Annual Meeting, January 9, Durham, NC.

Nitroaromatic stimulation of superoxide production by channel catfish (*Ictalurus punctatus*) hepatic microsomes. SETAC Annual Meeting, November 2-6, Alexandria, VA (with P.C. Washburn).

Toxicity of paraquat in the chicken embryo. SETAC Annual Meeting, November 2-6, Alexandria, VA (with H.T. Williams).

Comparative effects of organophosphorous pesticides on catfish and blue crab acetylcholinesterase. SETAC Annual Meeting, November 2-6, Alexandria, VA (with C.R. Habig).

1985

Occurrence of heavy metals in wintering waterfowl and their toxicological significance. "Waterfowl in Winter", a conference sponsored by the Wildlife Management Institute. January 7-10, 1985, Galveston, TX.

Mechanistic studies in wildlife toxicology. Invited paper, SETAC Annual Meeting, November 10-13, St. Louis, MO.

Naphthoquinone-induced oxygen toxicity in channel catfish. SETAC Annual Meeting, November 10-13, St. Louis, MO (with A.A. Andaya).

Oxidant related effects of DEF and n-butyl mercaptan on channel catfish. SETAC Annual Meeting, November 10-13, St. Louis, MO (with E.L. Mather).

Inactivation and recovery of fish acetylcholinesterase. SETAC Annual Meeting, November 10-13, St. Louis, MO (with C.R. Habig).

Comparative effects of DEF on catfish and blue crabs. SETAC Annual Meeting, November 10-13, St. Louis, MO (with C.R. Habig).

Paraquat toxicity in the chicken embryo. North Carolina Society of Toxicology Annual Meeting, Research Triangle Park, NC, and SETAC, St. Louis, MO (with H.T. Williams).

1984

Diquat induced free radical toxicity in bluegill sunfish (*Lepomis macrochirus*). SETAC Annual Meeting, November 4-7, Arlington, VA (with T. Mohin).

Free radical toxicity: potential basis for the assessment of the effects of complex effluents on aquatic organisms. Carolina Power and Light Company, Biology Seminar Series, November 21, 1984, Apex, NC.

1983

Physiological and ecological influences of heavy metals on wildlife. Pp. 121-129 in Kacmar, P., and J. Legath (eds.). Czechoslovak-American Symposium on Toxic Effects of Chemical Environmental Contaminants upon Production and Reproductive Ability in Free-living Animals. Strbske-Pleso, Czechoslovakia, October 2-4.

Effects of cadmium ingestion and food restriction on energy metabolism and tissue metal concentrations in mallard ducks (*Anas platyrhynchos*). SETAC Annual Meeting, November 6-9, Arlington, VA (with P.F. Scanlon).

1982

Heavy metals in Chesapeake Bay waterfowl. Wilson Ornithological Society, Blacksburg, VA (with P.F. Scanlon).

Heavy metals in benthos and sediments from the Chesapeake Bay region. Virginia Academy of Science, Blacksburg, VA (with J. van Montfrans and P.F. Scanlon).

1981

Studies in wildlife toxicology: interfacing field and laboratory approaches. SETAC Annual meeting, November 22-25, Arlington, VA (with R.J. Kendall and P.F. Scanlon).

Effects of cadmium ingestion and food restriction on energy metabolism and its endocrine control in Japanese quail. Virginia Journal of Science 32:90 (Abstr.). (with V.E. Kopf, P.F. Scanlon, and F.C. Gwazdauskas).

Heavy metal concentrations in tissues of ducks wintering in the lower Chesapeake Bay region. Transactions of the Northeast Section of the Wildlife Society 38:111-112 (Abstr.). (with P.F. Scanlon).

GRANTS

Previous:

Effects of Peatland Drainage on Mercury Dynamics in Eastern North Carolina. University of North Carolina Water Resources Research Institute. July 1, 1983 - June 30, 1984. \$35,840 (with D.W. Evans, Co-PI).

Mechanisms of Paraquat Toxicity in Avian Embryos. Duke University Research Council. July 1, 1983 - June 30, 1984. \$3,135.

An Ecotoxicology Research Program at Duke University. Andrew W. Mellon Foundation. July 1, 1984 - June 30, 1987. \$125,000 (with C.J. Richardson, Co-PI).

The Assessment of Impacts of Complex Effluents on Aquatic Organisms: An Oxygen Toxicity-Based Methodology. US-EPA. July 1, 1985 - June 30, 1987. \$60,267.

Oxidant/Free Radical Mediated Effects of Complex Effluents on the Bluegill (*Lepomis macrochirus*): A Preliminary Study with Pure Compounds. September 1, 1984 - June 30, 1986. University of North Carolina Water Resources Research Institute, \$4,800; Duke University Marine Biomedical Center, \$4,400; Duke University Research Council, \$6,200; North Carolina Office of Science and Technology, \$5,000.

Effects of Acid Precipitation and Associated Gases on Red Spruce: A Free Radical-Based Approach. US-EPA. January 1, 1986 - December 31, 1987. \$191,613 (with C.J. Richardson, Co-PI).

Effects of Gaseous Pollutants on Open-top Chamber Seedlings in Duke Forest: Physiology and Biochemistry. US-EPA and USDA. March 1, 1986 - February 28, 1988. \$168,202 (with C.J. Richardson, PI).

Comparative Neurobiology of Acetylcholinesterase in Channel Catfish and Blue Crabs. The Whitehall Foundation. November 1, 1986 - October 31, 1988. \$34,850.

Biochemical and Genotoxic Correlates of Carcinogenesis in Aquatic Organisms Exposed to Contaminated Sediments. Duke University Research Council, July 1, 1987 - June 30, 1988. \$5,000.

Glutathione Metabolism and Utilization in the Channel Catfish, *Ictalurus punctatus*. Marine Biomedical Center, Duke University, June 1 - August 31, 1988. \$3,000.

Oxidative DNA Damage in Aquatic Animals: Biomarkers for Environmental Contamination. North Carolina Biotechnology Center. June 1, 1990 - November 30, 1991. \$24,973

Biomarkers for Redox-active Genotoxins in Contaminated Sediments: A Mechanistic Approach. U.S. Geological Survey and the University of North Carolina Water Resources Research Institute. July 15, 1990 - December 15, 1992. \$117,056.

Biomarkers for Sediment-Associated Genotoxins in Benthic Fish. U.S. EPA. August 1, 1990 - August 1, 1993. \$218,963. (L. Shugart and U. Varanasi, Co-PI's.)

Glutathione Metabolism and Utilization in the Channel Catfish, *Ictalurus punctatus*. U.S. EPA. October 1, 1990 - September 30, 1994. \$192,567

Biomarkers for Oxidative Stress in Aquatic Animals. U.S. EPA. October 1, 1990 - September 31, 1992. \$39,000.

Genotoxic Responses in Bottom-dwelling Fish Exposed to Nitrogen-substituted Aromatic Hydrocarbons (NSAHs). Exxon Corporation. July 1, 1992 - August 31, 1993. \$15,000.

Biomarkers for Bleached Kraft Mill Exposures and Effects in Aquatic Animals. September 1, 1992 - December 31, 1994. \$79,456. University of North Carolina Water Resources Research Institute.

Comparative Mechanisms of Polycyclic Aromatic Hydrocarbon Metabolism in the Channel Catfish and the Brown Bullhead. January 1 - December 31, 1994. \$30,000. Exxon Corporation.

In Vitro Methods for Screening and Evaluating Reproductive Impacts of Aquatic Pollutants on Fish. July 1, 1995 - December 31, 1996. \$39,935. University of North Carolina Water Resources Research Institute.

The Effects of Xenobiotics on Apoptosis and Development in *Fundulus heteroclitus*. June 1, 1996 - May 31, 1997. \$9,400. The Duke Marine and Freshwater Biomedical Center (with B. Toomey, PI).

Mechanisms of Adaptation in a Hydrocarbon-exposed Population of *Fundulus heteroclitus*. May 1, 1997 - April 30, 1998. \$14,000. Duke University Marine and Freshwater Biomedical Center.

Effects of Xenobiotics on Reproduction and Development in Aquatic Animals. January 1, 1995 - August 31, 1998. \$150,000. Exxon Corporation.

Comparative Mechanisms of Hydrocarbon Metabolism and Genotoxicity in Two Ictalurid Fishes. October 1, 1994 - September 30, 1998. \$290,973. U.S. EPA.

Comparative Mechanisms of Phase II Metabolism of Benzo[a]pyrene in Two Species of Ictalurid Catfish. May 1, 1998 – April 30, 1999. \$13,600. The Duke Marine and Freshwater Biomedical Center.

Reproductive Consequences to Fish of Exposure to Estrogenic Chemicals in the Environment. Unrestricted gift, effective July 1, 1997. \$35,000. Procter and Gamble Company.

Role of the Tumor Suppressor Gene p53 in PAH and Oxidant-mediated Liver Carcinogenesis in the Cancer Sensitive Brown Bullhead (*Ameiurus nebulosus*). April 1 – December 31, 2000. \$11,500. Duke Marine/Freshwater Biomedical Center.

Characterization of CYP1B1 Gene Activation in Fish for Use as a Possible Marker of Cancer Resistance. July 1, 2000 – December 31, 2001. \$40,000. North Carolina Biotechnology Center.

Collaborative Research Training in Environmental Toxicology. June 1, 1998 – May 31, 2001. \$1,206,394 (with E.D. Levin, PI, and T.A. Slotkin, Co-PI). U.S. EPA.

Comparative Mechanisms of Benzo[a]pyrene Metabolism and DNA Repair in Two Species of Ictalurid Catfish. October 1, 1998 – September 30, 2003. \$314,023. U.S. EPA.

Adaptation of a Population of *Fundulus heteroclitus* to a Creosote-contaminated Environment: Mechanisms, Genetic Consequences and Fitness Trade-offs. March 1, 2000 – February 28, 2004. \$321,447. Office of Naval Research.

Superfund Chemicals Impact on Reproduction and Development (a Superfund Basic Research Center). June 1, 2000 – March 31, 2005. \$6,531,856 (with T.A. Slotkin, Co-PI). National Institute of Environmental Health Sciences (NIEHS).

Markers for Chemical Mixtures in *Fundulus heteroclitus*. NIEHS (a project within the Superfund Basic Research Center, above). June 1, 2000 – March 31, 2005. \$801,983. NIEHS.

Emerging Molecular and Computational Approaches for Cross-Species Extrapolations. A Joint SETAC/SOT Workshop, July 18-23, 2004. Portland, OR. \$38,500. NIEHS.

Integrated Toxicology Program. July 1, 2001 – June 30, 2006. \$2,464,542. NIEHS.

Superfund Chemical Impacts on Development (Superfund Basic Research Center, second funding cycle – R. Di Giulio, PI and Center Director). April 1, 2005 – March 31, 2011. \$9,570,643. NIEHS. P42 ES-010356.

Developmental Effects of Superfund Hydrocarbon Mixtures in *Fundulus heteroclitus* (a project within the Superfund Basic Research Center, above). April 1, 2005 – March 31, 2011. \$1,479,036. NIEHS.

Administrative Core for the Superfund Basic Research Center. April 1, 2005 – March 31, 2011. \$432,762. NIEHS.

Research Translation Core for the Superfund Basic Research Center. April 1, 2005 – March 31, 2011. \$392,113. NIEHS (with ML Miranda, PI).

Center for the Comparative Biology of Vulnerable Populations (an Environmental Health Sciences Research Center) - R. Di Giulio, PI and Center Director. April 1, 2004 – March 31, 2011. \$2,447,138. NIEHS. P30-ES-01356.

Administrative Supplement, Center for the Comparative Biology of Vulnerable Populations - R. Di Giulio, PI and Center Director. October 1, 2009 – March 31, 2011. \$311,142. NIEHS. P30-ES-01356.

The Bioassay Network for Improved Assessments of Contaminated Sediments: A Superfund Research Program – U.S. EPA Collaboration. R. Di Giulio, PI. September 15, 2009 – March 31, 2011. NIEHS. \$75,272.

Mechanisms of Cancer-resistance in a Population of *Fundulus heteroclitus* Inhabiting a Superfund-impacted Estuary. R. Di Giulio, PI. September 15, 2009 – August 31, 2012. NIEHS. \$193,935.

Center for Environmental Implications of Nanomaterials. PI: M. Wiesner. R. Di Giulio: Co-PI and Theme Leader, Cellular and Organismal Responses. Other Co-PIs: M.F. Hochella, K.L. Jones, and G.V. Lowry. October 1, 2008 – September 30, 2013. NSF EF-0830093. \$14,375,003.

Influence of Chelating Ligands for the Aggregation, Dissolution and Bioavailability of Soluble Nanomaterials. H. Hsu-Kim, PI; R. Di Giulio and C. Matson, Co-PIs. May 1, 2011 – April 30, 2014. NSF CBET-1066781. \$337,419.

Environmental Impacts of Mountaintop Coal Mining in West Virginia. PI: R.T. Di Giulio. June 1, 2009 – May 31, 2015. Foundation for the Carolinas. \$1,650,000.

Risk Assessment for Manufactured Nanoparticles Used in Consumer Products. J. Zhang, Duke University, PI. July 1, 2010 – June 30, 2015. U.S. EPA (Joint US-UK Research Program). \$1,999,995; Duke subcontract - \$254,608 for July 1, 2013 – June 30, 2015.

Legacy Impacts of Coal Combustion Residues on Freshwater Ecosystems in North Carolina. PI: R. Di Giulio; Co-PIs: E. Bernhardt, H. Hsu-Kim, and A. Vengosh. Water Resources Research Institute of the University of North Carolina System. March 1, 2015 – February 28, 2016. \$60,000.

PCBs in Game fish and Atlantic Killifish in the Elizabeth River system, Virginia: Sources, Spatial Distribution, Stakeholder Engagement, and implications for health and management. Administrative Supplement to the Duke Superfund Research Center. PI: R. Di Giulio. June 1, 2014 – May 31, 2016. NIEHS. \$163,622.

Developmental Toxicants: Mechanisms, Consequences and Remediation (Superfund Research Center, third funding cycle – R. Di Giulio, PI and Center Director). April 1, 2011 – March 31, 2017. NIEHS. \$12,899,235.

Developmental PAH exposures in fish: Mechanisms of toxicity, adaptation and later life consequences (a project within the Superfund Research Center, above). April 1, 2011 – March 31, 2017. NIEHS. NIEHS. \$2,217,135.

Administrative Core for the Superfund Basic Research Center. R. Di Giulio, PI. April 1, 2011 – March 31, 2017. NIEHS. \$1,009,222.

Current:

University Program in Environmental Health (a T-32 doctoral training grant). R. Di Giulio, PI, S. Patierno, Co-PI. July 1, 2013 – June 30, 2018. NIEHS. \$1,205,672.

Center for Environmental Implications of Nanomaterials. PI: M. Wiesner; Co-PIs: R.T. Di Giulio, M.F. Hochella, K.L. Jones, and G.V. Lowry. October 1, 2013 – September 30, 2018. NSF. \$15,000,000.

Chemical mixture toxicity of well water: investigating the potential role of pollutant mixtures in well water as a root cause for chronic kidney disease in Sri Lanka. Co-PIs: R.T. Di Giulio, N. Jayasundara, and T. Ostbye. January 15, 2017 – January 14, 2018. Duke Global Health Institute. \$25,000.

Progressive loss of chemical resistance in pollution-adapted Atlantic killifish.
Co-PI's: R.Di Giulio, C. Weinhouse, N. Jayasundara, S. Murphy, J. Meyer. March 1, 2017 – September 30, 2019. Triangle Center for Evolutionary Medicine. \$20,000.

Developmental Exposures: Mechanisms, Outcomes and Remediation (Superfund Research Center, fourth funding cycle – R. Di Giulio, PI and Center Director). April 1, 2017 – March 31, 2022. NIEHS. \$10,150,450.

Mechanisms and Consequences of Evolved Adaptation to Environmental Pollution (a project within the Superfund Research Center, above). April 1, 2017 – March 31, 2022. NIEHS. \$1,183,430.

Administrative Core for the Superfund Basic Research Center. R. Di Giulio, PI. April 1, 2017 – March 31, 2022. NIEHS. \$691,650.

Harnessing genomics for environmental toxicology: Exploring how a key anthropogenic pollutant impacts mitochondrial mutation in the model vertebrate, Atlantic killifish. Co-PIs: R. Di Giulio, J. Meyer, and J. Wernegreen. Duke Center for Genomic and Computational Biology. January 1 – December 31, 2018, \$50,000.

RAIS-Leon Goldberg Memorial Fellowships in Toxicology (Post-doctoral Research Associate support). R. Di Giulio, PI. September 1, 2018 – August 31, 2020. RAI Services Company. \$318,496.

Early life neurotoxic exposure effects on neurocognitive decline with aging. R. Di Giulio and E. Levin, PI's. September 1, 2018 – August 31, 2019. NIEHS. \$400,425.

In review:

University Program in Environmental Health (a T-32 doctoral training grant, renewal application). R. Di Giulio, PI, S. Patierno and H. Stapleton, Co-PIs. July 1, 2019 – June 30, 2024. NIEHS. \$1,326,240 requested.