

Frank O. Aylward, PhD

Curriculum Vitae

Assistant Professor
Department of Biological Sciences
Virginia Tech
Blacksburg, VA, 24061
faylward@vt.edu
www.aylwardlab.com

EDUCATION

- 2008-2013 PhD in *Microbiology*, Microbiology Doctoral Training Program, **University of Wisconsin-Madison**, Madison, WI. Awarded in August 2013.
- 2004-2008 B.Sc., double-major in *Biochemistry and Molecular Biophysics* and *Molecular and Cellular Biology*, **University of Arizona**, Tucson, Arizona.

ACADEMIC POSITIONS & RESEARCH EXPERIENCE

- 2017- **Assistant Professor.** Department of Biological Sciences, Virginia Tech, Blacksburg, VA.
- 2014-2017 **Postdoctoral Researcher.** Advisor: Edward F. DeLong, Center for Microbial Oceanography Research and Education, **University of Hawai'i at Mānoa**, Honolulu, HI.
- 2013-2014 **Postdoctoral Researcher.** Advisor: Edward F. DeLong, Department of Civil and Environmental Engineering, **Massachusetts Institute of Technology**, Cambridge, MA.
- 2008-2013 **PhD Candidate.** Advisor: Cameron Currie, Department of Bacteriology & Great Lakes Bioenergy Research Center (GLBRC), **University of Wisconsin-Madison**, Madison, WI.
- 2006-2008 **Undergraduate Researcher.** Advisor: Howard Ochman, Department of Biochemistry and Molecular Biophysics, **University of Arizona**, Tucson, AZ.
- 2005-2006 **Undergraduate Researcher.** Advisor: Rick Michod, Department of Ecology and Evolutionary Biology, **University of Arizona**, Tucson, AZ.

ACADEMIC HONORS, AWARDS, & SCHOLARSHIPS

- 2019 Luther and Alice Hamlett Endowed Junior Faculty Fellowship
- 2019 Outstanding Research Award, Department of Biological Sciences, Virginia Tech
- 2019 Simons Foundation Early Career Award in Marine Microbial Ecology and Evolution
- 2018 Alfred P. Sloan Research Fellowship in Ocean Sciences
- 2012 International Society for Microbial Ecology Travel Grant (Copenhagen, DK)
- 2012 Wisconsin Distinguished Graduate Fellowship, University of Wisconsin-Madison
- 2011 Hopkins Microbiology Course Fellowship (Pacific Grove, CA)
- 2009 Honorable mention, Graduate Research Fellowship Program, NSF
- 2007 Van de Velde Undergraduate Research Scholarship, University of Arizona
- 2006 Galileo Circle Undergraduate Research Scholarship, University of Arizona

GRANTS, CONTRACTS, & RESEARCH FELLOWSHIPS

- 2019-2022 PI, **NSF Infrastructure Innovation for Biological Research**, with co-I Liqing Zhang (\$555,496) “Innovative Software and Databases to Leverage RNA Polymerase as a Phylogenetic Marker in Metagenomic Data”.
- 2019-2022 PI, **Simons Foundation Early Career Award in Marine Microbial Ecology and Evolution** (\$540,000). “Revealing the Tempo and Mode of Prokaryotic Genome Evolution in the Ocean”.
- 2018-2020 PI, **Alfred P. Sloan Research Fellowship in Ocean Sciences** (\$65,000).
- 2018-2020 PI, **Virginia Tech ICTAS Junior Faculty Award**, with co-I Liqing Zhang (\$80,000) “Leveraging Metagenomic ‘Big Data’ for the Discovery of Novel Microbial Diversity in the Biosphere”.

PUBLICATIONS (reverse chronological order by section)

Full citation information can be found on [Google Scholar](#)

* Co-first author; # Graduate or Undergraduate mentee; ± Corresponding author.

Peer-reviewed original research articles

1. ED Osburn, SG McBride, **FO Aylward**, BD Badgley, BD Strahm, JD Knoepp, JE Barrett. Soil bacterial and fungal communities exhibit distinct long-term responses to disturbance in temperate forests. **Frontiers in Microbiology**. In press.
2. CA Martinez-Gutierrez[#] & **FO Aylward**. Strong purifying selection is associated with genome streamlining in epipelagic *Marinimicrobia*. **Genome Biology and Evolution**, In press.
3. AM Linz, **FO Aylward**, S Bertilsson, KM McMahon. Time-series metatranscriptomes reveal conserved patterns between phototrophic and heterotrophic microbes in diverse freshwater systems. **Limnology and Oceanography**, In press.
4. BC Kolody, JP McCrow, L Zeigler Allen, **FO Aylward**, KM Fontanez, A Moustafa, M Moniruzzaman, FP Chavez, CA Scholin, EE Allen, AZ Worden, EF DeLong, AE Allen. Diel transcriptional response of a California Current plankton microbiome to light, low iron, and enduring viral infection. **ISME J**, In press.
5. MJ Harke, FR Frischkorn, ST Haley, **FO Aylward**, JP Zehr, ST Dyhrman. Periodic and coordinated gene expression between a diazotroph and its diatom host. **ISME J**, 2019, 13(1):118-131.
6. EW Getz, SS Tithi, L Zhang, **FO Aylward**[±]. Parallel Evolution of Genome Streamlining and Cellular Bioenergetics Across the Marine Radiation of a Bacterial Phylum. **mBio**, 2018, 9(5).
7. SS Tithi, **FO Aylward**, RJ Jensen, L Zhang. FastViromeExplorer: a pipeline for virus and phage identification and abundance profiling in metagenomics data. **PeerJ**, 2018, 12;6:e4227.
8. Luo E, **FO Aylward**, DR Mende, EF DeLong. Bacteriophage Distributions and Temporal Variability in the Ocean's Interior. **mBio**, 2017, 8(6):e01903-17.
9. **FO Aylward**, D Boeuf, DR Mende, EM Wood-Charlson, A Vislova, JM Eppley, AE Romano, EF DeLong. Diel Cycling and Long-Term Persistence of Viruses in the Ocean's Euphotic Zone. **Proceedings of the National Academy of Sciences, USA**, 2017, 114(43): 11446-11451.
10. DR Mende*, J Bryant*, **FO Aylward***, JM Eppley, TN Nielsen, DM Karl, EF DeLong. Environmental Drivers of a

Microbial Genomic Transition Zone in the Ocean's Interior. *Nature Microbiology*, 2017, 2(10): 1367.

11. ST Wilson*, **FO Aylward***, F Ribalet, B Barone, JR Casey, PE Connell, JM Eppley, S Ferrón, JN Fitzsimmons, CT Hayes, AE Romano, KA Turk-Kubo, A Vislova, EV Armbrust, DA Caron, MJ Church, JP Zehr, DM Karl, EF DeLong. Coordinated Regulation of Growth, Activity and Transcription in Natural Populations of the Unicellular Nitrogen-Fixing Cyanobacterium *Crocospaera*. *Nature Microbiology*, 2017, 2(9): 118.
12. EA Gontang, **FO Aylward**, C Carlos, TG del Rio, M Chovatia, A Fern, C-C Lo, SA Malfatti, SG Tringe, CR Currie, R Kolter. Major changes in microbial diversity and community composition across gut sections of a juvenile *Panclora* cockroach. *PLOS ONE*, 2017, 12(5): e0177189.
13. DR Mende*, **FO Aylward***, JM Eppley, TN Nielsen, EF DeLong. Improving Environmental Genomes via Integration of Metagenomic and Single-Cell Assemblies. *Frontiers in Microbiology*, 2016, 7:e143.
14. JA Bryant, **FO Aylward**, JM Eppley, DM Karl, MJ Church, EF DeLong. The Influence of Wind and Solar Radiation on Microbial Community Diversity in the North Pacific Subtropical Gyre. *The ISME Journal*, 2016, 10(6):1308-1322.
15. **FO Aylward**, JM Eppley, JM Smith, FP Chavez, CA Scholin, EF DeLong. Microbial Community Transcriptional Network Dynamics are Conserved Across All Three Domains of Life at Ocean Basin Scales. *Proceedings of the National Academy of Sciences, USA*, 2015; 112(17): 5443-5448.
[Highlighted in a [PNAS commentary](#) by AF Haas and F Rohwer. A press release describing this work appeared in [EurekAlert](#), [Phys.org](#), and several other media outlets.]
16. MA Spero, **FO Aylward**, CR Currie, TJ Donohue. Phylogenomic Analysis and Predicted Physiological Role of the Proton-Translocating NADH:quinone Oxidoreductase (Complex I) Across Bacteria. *mBio*, 2015; 5(6): e02077-14.
17. **FO Aylward**[‡], L Khadempour, DM Tremmel[#], BR McDonald, CD Nicora, S Wu, RJ Moore, DJ Orton, ME Monroe, PD Piehowski, SO Purvine, RD Smith, MS Lipton, KE Burnum-Johnson, CR Currie. Enrichment and Broad Representation of Plant Biomass-Degrading Enzymes in the Specialized Hyphal Swellings of *Leucoagaricus gongylophorus*, the Fungal Symbiont of Leaf-Cutter Ants. *PLOS ONE*, 2015; 10(8): e0134752.
18. **FO Aylward**[‡], G Suen, PHW Biedermann, AS Adams, JJ Scott, SA Malfatti, T Glavina del Rio, SG Tringe, M Poulsen, KF Raffa, KD Klepzig, CR Currie. Convergent Bacterial Microbiotas in the Fungal Agricultural Systems of Insects. *mBio*, 2014; 5(6): e02077-14.
19. EL Huang*, **FO Aylward***, Y-M Kim, B-JM Webb-Robertson, CD Nicora, Z Hu, T Metz, MS Lipton, RD Smith, CR Currie, KE Burnum-Johnson. The Fungus Gardens of Leaf-cutter Ants Undergo a Distinct Physiological Transition During Biomass Degradation. *Environmental Microbiology Reports*, 2014; 6(4): 389-395.
20. **FO Aylward**, KE Burnum, SG Tringe, C Teiling, DM Tremmel[#], J Moeller, JJ Scott, KW Barry, CD Nicora, PD Piehowski, S Malfatti, SO Purvine, LA Goodwin, RD Smith, GM Weinstock, NM Gerardo, G Suen, MS Lipton, CR Currie. *Leucoagaricus gongylophorus* Produces Diverse Lignocellulases for the Degradation of Recalcitrant Plant Polymers in the Fungus Gardens of Leaf-cutter Ants. *Applied and Environmental Microbiology*, 2013; 79(12): 3770-3778.
[Cover Image for Issue 12, Vol. 79 in June 2013. A press release describing this article was featured in [Science Daily](#), and subsequent popular science coverage appeared in [The Scientist](#), [The Milwaukee Sentinel](#), [QUEST](#) (a collaboration involving Wisconsin Public Television), and [Biomass Magazine](#).]
21. **FO Aylward**, BR McDonald, SM Adams, A Valenzuela, RA Schmidt, LA Goodwin, T Woyke, CR Currie, G Suen, M Poulsen. Comparison of 26 Sphingomonad Genomes Reveals Diverse Environmental Adaptations and Biodegradative Capabilities. *Applied and Environmental Microbiology*, 2013; 79(12): 3724-3733.

22. AS Adams*, **FO Aylward***, SM Adams, N Erbilgin, BH Aukema, CR Currie, G Suen, and KF Raffa. Mountain Pine Beetles Colonizing Historical, Transitional, and Naïve Host Trees are Associated With a Community of Terpenoid-degrading Bacteria. *Applied and Environmental Microbiology*, 2013; 79(11): 3468-3475.
[Highlighted by the editors as an article of significant interest in Issue 11, Vol. 79]
23. MR Christopherson, G Suen, S Bramhacharya, KA Jewell, **FO Aylward**, D Mead, PJ Brumm. The Genome Sequences of *Cellulomonas fimi* and “*Cellvibrio gilvus*” Reveal the Cellulolytic Strategies of Two Facultative Anaerobes, Transfer of “*Cellvibrio gilvus*” to the Genus *Cellulomonas*, and Proposal of *Cellulomonas gilvus* sp. nov. *PLOS ONE*, 2013; 8(1): e53954.
24. **FO Aylward**, KE Burnum, JJ Scott, G Suen, SG Tringe, SM Adams, GJ Starrett[#], KJ Berry, LA Goodwin, MS Lipton, CR Currie. Metagenomic and Proteomic Insights into the Fungus Gardens of Leaf-cutter Ants. *The ISME Journal*, 2012; 6(9): 1688-1702.
[Included as a chapter in *The Social Biology of Microbial Communities, Workshop Summary, 2012*, presented by the Institute of Medicine of the National Academies. A press release describing this article was also featured in [Science Daily](#).]
25. G Suen, PJ Weimer, DM Stevenson, **FO Aylward**, J Boyum, J Deneke, C Drinkwater, NN Ivanova, N Mikhailova, O Chertkov, LA Goodwin, CR Currie, D Mead, PJ Brumm. The Complete Genome Sequence of the *Fibrobacter succinogenes* S85 reveals a Cellulolytic and Metabolic Specialist. *PLOS ONE*, 2011; 6(4): e18814.
26. G Suen, JJ Scott, **FO Aylward**, SM Adams, SG Tringe, A Pinto-Tomás, CE Foster, M Pauly, PJ Weimer, K Barry, LA Goodwin, P Bouffard, L Li, J Osterberger, TT Harkins, SC Slater, TJ Donohue, CR Currie. An Insect Herbivore Microbiome with High Plant Biomass-Degrading Capacity. *PLOS Genetics*, 2010; 6(9): e1001129.
[Featured Image for the September 2010 Issue of *PLoS Genetics*].
27. MD Herron, JD Hackett, **FO Aylward**, RE Michod. Triassic Origin and Early Radiation of Multicellular Volvocine Algae. *Proceedings of the National Academy Sciences, USA*, 2009; 106(9): 3254-8.

Peer-reviewed review articles

1. **FO Aylward**, CR Currie, G Suen. The Evolutionary Innovation of Nutritional Symbioses in Fungus-growing Ants. *Insects*, 2012; 3(1): 41-61.

Genome announcements (editorial review only)

1. **FO Aylward**, DM Tremmel[#], GJ Starrett[#], DC Bruce, P Chain, A Chen, KW Davenport, C Detter, CS Han, J Han, M Huntemann, NN Ivanova, NC Kypides, V Markowitz, K Mavrommatis, M Nolan, I Pagani, A Pati, S Pitluck, C-L Wei, LA Goodwin, T Woyke, CR Currie. Complete Genome of *Serratia* sp. Strain FGI 57, a Strain Associated with Leaf-cutter Ant Fungus Gardens. *Genome Announcements*, 2013; 1(2): e00239-12.
2. **FO Aylward**, DM Tremmel[#], DC Bruce, P Chain, A Chen, KW Davenport, C Detter, CS Han, J Han, M Huntemann, NN Ivanova, NC Kypides, V Markowitz, K Mavrommatis, M Nolan, I Pagani, A Pati, S Pitluck, C-L Wei, LA Goodwin, T Woyke, CR Currie. Complete Genome of *Enterobacteriaceae* Bacterium Strain FGI 57, a Strain Associated with Leaf-cutter Ant Fungus Gardens. *Genome Announcements*, 2013; 1(1): e00238-12.

Book chapters

1. G Suen, JJ Scott, **FO Aylward**, CR Currie. The Microbiome of Leaf-cutter Ant Fungus Gardens. In: de Bruin, F.J. ed., *Handbook of Molecular Microbial Ecology, Volume 2: Metagenomics in Different Habitats*, 2011, pp. 367-380. John Wiley and Sons, Inc., Hoboken, NJ, USA.

2. G Suen, **FO Aylward**, SC Slater, BS Goldman. From Genetics to Genomics. In: Maloy, S., Hughes, K.T., Casadesus, J. eds., *The Lure of Bacterial Genetics: A Tribute to John Roth*, 2010, pp. 257-266. American Society for Microbiology Press, Washington, D.C., USA.

Articles with undergraduate students (published in non-refereed undergraduate research compilations)

1. DP Delet[#], **FO Aylward**, CR Currie. Interactions Between Actinobacteria and Other Microorganisms Present in the Fungus Gardens of Leaf-cutter Ants. Integrated Biological Sciences Summer Research Program (IBS-SRP) Research Journal, 2010
2. JA Montalvo[#], **FO Aylward**, G Suen, A Valenzuela, CR Currie. Characterizing Lignocellulose-Degrading Microbes from the Fungus Gardens of Leaf-Cutting Ants. Integrated Biological Sciences Summer Research Program (IBS-SRP) Research Journal, 2009.

SERVICE

Ad Hoc Academic Reviewing

Journals: *Applied and Environmental Microbiology* [1], *Applied Microbiology and Biotechnology* [1], *Bioinformatics* [1], *BMC Genomics* [4], *Diversity* [1], *Ecological Entomology* [2], *Environmental Microbiology* [5], *Frontiers in Microbiology* [21], *Gut Microbes* [1], *The ISME Journal* [4], *Journal of Agricultural and Food Chemistry* [1], *Journal of Genetic Engineering and Biotechnology* [1], *Microbial Ecology* [3], *Microbiome* [1], *Microorganisms* [1], *Molecular Ecology* [2], *mSystems* [1], *Nature Communications* [2], *Nature Methods* [1], *PLOS Computational Biology* [1], *PLOS ONE* [1], *Proceedings of the National Academy of Sciences USA* [1], *Science Bulletin* [1], *Scientific Reports* [1], *Water Science and Technology* [1].

Grants: French National Research Agency [2], Czech Science Foundation [1], German Research Foundation [1], Israel Science Foundation [1], Kansas EPSCOR [1], National Science Foundation of China [1], Singapore National Research Foundation [1], Villum foundation (Denmark) [1], United States Army Research Office [1], USDA Agriculture and Food Research Initiative [1], US National Science Foundation Division of Environmental Biology [1].

Editorial Service

Review Editor: *Frontiers in Microbiology & Frontiers in Marine Science* (2015-).

Editorial Board Member: *Environmental Microbiology & Environmental Microbiology Reports* (2018-)

Conference Organization

Graduate Student Coordinator: Great Lakes Bioenergy Research Center annual retreat planning committee (May 2011).

PRESENTATIONS

November 4 th , 2019	Department of Microbiology seminar series, University of Tennessee at Knoxville
October 2 nd , 2019	Department of Biological Sciences seminar series, University of North Carolina-Greensboro
September 24 th , 2019	Department of Biological Sciences seminar series, University of Virginia.
July 18 th , 2018	Computer and Information Sciences Research Colloquium, Virginia Military Academy.
November 28 th , 2017	Microbiology Seminar series, Virginia Tech.
November 13 th , 2017	Biochemistry Department seminar series, Virginia Tech.

March 3 rd , 2017	American Society for Limnology and Oceanography (ASLO), Honolulu, HI.
December 1 st , 2016	Department of Biological Sciences, Virginia Tech.
September 12 th , 2016	Agricultural and Biosystems Engineering, University of Arizona.
June 18 th , 2016	ASM Microbe, Boston, MA.
April 20 th , 2016	Ecosystem Genomics Initiative, University of Arizona.
April 6 th , 2016	Molecular, Cellular, and Biomedical Sciences, University of New Hampshire.
March 3 rd , 2016	Department of Oceanography, University of Hawaii at Manoa.
February 9 th , 2016	Biology Department, Utah State University.
January 12 th , 2016	Marine, Earth, and Atmospheric Sciences, NC State University.
August 19 th , 2012	International Society for Microbial Ecology meeting, Copenhagen, Denmark.
May 17 th , 2011	Great Lakes Bioenergy Research Center annual retreat, South Bend, IN.

TEACHING

University Courses Taught at Virginia Tech

As primary instructor

Systems Biology 3035, Systems Biology of Genes and Proteins I	Fall 2019
Systems Biology 3036, Systems Biology of Genes and Proteins II	Spring 2018, 2019, 2020

As co-instructor

Microbial Community Analysis GRAD6895, Analysis of Microbiome Data	Spring 2019
Systems Biology 2025, Introduction to Systems Biology I	Fall 2017
Systems Biology 2026, Introduction to Systems Biology II	Spring 2019, 2020

Workshops

2016	<i>Instructor</i> , Oceanography and Geobiology Environmental 'Omics workshop sponsored by the NSF-funded EarthCube program. Topic: Introduction to metagenome assembly and analysis. Hosted by the University of Hawaii at Manoa.
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Guest lectures

2018	<i>Guest Lecturer</i> , Population Genomics, FREC 5164. Topic: Microbial Genomics.
2017	<i>Guest Lecturer</i> , Quantitative Ecology, BIOL 6004. Topic: Microbial Ecology.
2016	<i>Guest Lecturer</i> , Oceanography 750. Topic: Marine Microbiology. UH Manoa.
2011	<i>Guest Lecturer</i> , Microbiology 551. Topic: Ecological genomics. UW-Madison.
2010	<i>Guest Lecturer</i> , Agronomy 375. Topic: Microbial genomics. UW-Madison.

Teaching Assistantships

2010-11, '13	<i>Teaching Assistant</i> , Microbiology 450, UW-Madison
2009	<i>Teaching Assistant</i> , Microbiology 301 Laboratory, UW-Madison

OUTREACH & MENTORSHIP

Mentorship

2018-	Thesis advisor to students Carolina Martinez and Alaina Weinheimer, both PhD students in the Virginia Tech Biological Sciences Graduate Program.
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- 2018- Thesis advisor to Nitin Nair, student in the Electrical and Computer Engineering MS program at Virginia Tech.
- 2018- Research advisor to Meagan Todd, Gavin Mucker, and Ashleen Harris, undergraduate students in the Systems Biology undergraduate program at Virginia Tech.
- 2010-2013 Mentor to two undergraduate Microbiology majors, Daniel Tremmel and Gabriel Starrett, who have subsequently appeared as co-authors on peer-reviewed journal articles (*see Publications section*). Both students are currently in PhD programs.
- 2010 Mentor for Thiruvankadam Shanmugam, a participant in the Khorana Program for Scholars, hosted by UW-Madison and New Delhi University. Thiru is currently in a PhD program at Myongji University in the Republic of South Korea.
- 2009, 2010 Mentor for David Pagan-Declet and Jorge Montalvo ('09 and '10, respectively), students in the Integrated Biological Science Summer Research Program (IBS-SRP), Great Lakes Bioenergy Research Center. Both students were undergraduates at the University of Puerto Rico and subsequently published their work in undergraduate research journals (*see Publications section*).
- 2009 Mentor to Rhonda Knapp, a participant in the Research Experience for Teachers Program hosted by the Great Lakes Bioenergy Research Center. This program provided research experience to elementary school teachers in the greater Madison area. I assisted in developing a bioenergy-related research project and the design of curricula for middle-school science classes.
- 2009 Mentor to Microbiology undergraduate Austin Lynch on a two-semester project integrating computational and wet-lab methods.
- 2007, 2008 Peer Mentors Program, Department of Biochemistry, University of Arizona, Tucson, Arizona. In this program I mentored freshmen Biochemistry majors for one year.

Outreach

- 2018 Guest speaker at the Blacksburg High School College Research event, where I gave several presentations on the Systems Biology program at Virginia Tech.
- 2017- I have posted > 30 open-access bioinformatics tutorials on the Protocols.IO website in an effort to make these teaching materials more broadly available.
Link: <https://www.protocols.io/researchers/frank-aylward>
- 2010 Speaker at the Monona Grove Energy Fair, held on May 22. This was a program supported by the Wisconsin Bioenergy Institute intended to broaden public knowledge of bioenergy research.
- 2010 Speaker for the UW-Madison People Program. This program exposes high school students to research in university labs.
- 2010 Speaker for the UW-Madison, Department of Bacteriology undergraduate Microbiology Club.
- 2010 Speaker in the Biological Sciences Preview Weekend at UW-Madison, held from October 21st-24th. The purpose of this program was to allow under-represented minorities in college to explore research opportunities at UW-Madison.
- 2006-2008 Ambassadors program, Department of Biochemistry, University of Arizona, Tucson, Arizona. In this program I participated in outreach activities spreading awareness of scientific careers and opportunities to high school students.

FIELD WORK & OCEANOGRAPHIC CRUISES

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| 2015 | Hawaii Ocean Experiment (HOE) Legacy II, R/V <i>Kilo Moana</i> , July 24 th -August 6 th . <i>Diel whole-community transcriptomic sample collection, transcriptome profiling across depths.</i> |
| 2015 | Hawaii Ocean Experiment (HOE) Legacy I, R/V <i>Kilo Moana</i> , April 6 th -10 th . <i>Diel whole-community transcriptomic sample collection.</i> |
| 2015 | Research at the Natural Energy Laboratory of Hawaii Authority (NELHA) in Kona, the Big Island, Hawaii, March 2 nd -16 th . <i>Dissolved organic matter (DOM) filtration and processing.</i> |
| 2010 | Research with the Smithsonian Tropic Research Institute, Panama City & Gamboa, Panama, April 20 th -May 20 th . <i>Leaf-cutter ant collection and experimentation.</i> |