

# Emily L. Cardarelli

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Dr. Cardarelli is a molecular astrobiologist and research faculty at UCLA. She is a collaborator on the Mars 2020 RIMFAX, Mastcam-Z, and SHERLOC Instrument Teams who has led decision-making and target selection for remote and proximity science analysis since landing. She has led over 50 sols of Mars 2020 science and instrument operations as a Tactical Science Lead for Science Operations on the Mars 2020 Science Team. Using remote and sample-based studies, her research integrates microbial, geochemical, and geophysical techniques to illuminate subsurface organomineral interactions and martian regolith properties. She presently investigates water-rock interactions and the preservation potential of magnesium carbonates in Mars-analog environments, in pursuit of identifying signs of ancient life on Mars.

## EDUCATION

Ph.D. in Geomicrobiology, Earth System Science — Stanford University, Stanford, CA (2021)  
Thesis: The microbial ecology and biogeochemistry of alluvial subsurface systems

M.S. in Environmental Earth System Science — Stanford University, Stanford, CA (2015)

B.S. in Environmental Science — Tulane University, New Orleans, LA (2012)  
Geology Minor, *magna cum laude* with departmental honors  
Thesis: Seasonal impacts influencing denitrification in wetlands.

## *Additional training*

2016            Microbial Genomics and Metagenomics Course, Department of Energy-Joint  
Genome Institute, Walnut Creek, CA

2013            Microbial Diversity Course, Marine Biological Laboratory, Woods Hole, MA

## PROFESSIONAL EXPERIENCE

RIMFAX Instrument Engineer, Mars 2020 Perseverance, <i>UCLA</i>	2023-present
Research Scientist, <i>UCLA</i>	2023-present
Affiliate Research Scientist, <i>NASA-JPL</i>	2023-present
Planetary Terrain Building Workshop Invitee/Participant, <i>NASA-JPL &amp; ASU</i>	2023
Targeting Microhabitats for Life Detection KISS Study Invitee/Participant	2022-2023
Mastcam-Z Instrument Collaborator on Mars 2020 Perseverance, <i>NASA-JPL</i>	2022-present
Tactical Science Lead on Mars 2020 Science and Operations Team, <i>NASA-JPL</i>	2021-present
Tactical Science Support on Mars 2020 Science and Operations Team, <i>NASA-JPL</i>	2021-present
Instrument Interface in the Mars 2020 Project Science Office, <i>NASA-JPL</i>	2021-2022
Documentarian on Mars 2020 Science and Operations Team, <i>NASA-JPL</i>	2020-present
SHERLOC Instrument Collaborator on Mars 2020 Perseverance, <i>NASA-JPL</i>	2020-present
JPL Postdoctoral Fellow in Astrobiology and Ocean Worlds, <i>NASA-JPL</i>	2020-2023
Course Instructor for Diversity and Inclusion in the Geosciences, <i>Stanford University</i>	2019
Teaching Assistant for Hopkins Marine Microbiology Course, <i>Hopkins Marine Station</i>	2018
Teaching Assistant for Stanford Earth Young Investigators, <i>Stanford University</i>	2017
Teaching Assistant for Measurements in Earth Systems, <i>Stanford University</i>	2013
Graduate Research Assistant in Geomicrobiology, <i>Stanford University</i>	2012-2020
Undergraduate Research Assistant in Stable Isotope Geochemistry, <i>Tulane University</i>	2010-2012
Summer Research Analyst in Army Manpower and Reserve Affairs, <i>Pentagon</i>	2009-2011

## PEER-REVIEWED PUBLICATIONS

*In-prep & in-review manuscripts, available upon request.*

[27] 2024        **Cardarelli, E.L.**, K. Boye, V. Noël, J.R. Bargar, & C.A. Francis. Regional distance-decay relationships are water table driven in alluvial sediments of the Western USA.

- Journal of Geophysical Research: Biogeosciences*. Expected submission, March (draft available).
- [26] 2024 **Cardarelli, E.L.**, K. Boye, V. Noël, J.R. Bargar, & C.A. Francis. Seasonal flood disturbance destabilizes subsurface microbial and geochemical gradients and initiates microbial succession at Riverton, WY. *Nature Ecology & Evolution*. Expected submission, March (draft available).
- [25] 2024 **Cardarelli, E.L.**, T. Present, P. Vasconcelos, L. Kah, C. Swindle, S. Bhattacharjee, J. Eiler, K. Farley, J. Grotzinger, C. Li, E. Scheller, & K. Williford. Formation and alteration of pedogenic magnesite preserving organics from Kunwarara, Queensland, Australia. *AGU Advances*. Submitted, draft available.
- [24] 2024 Shoemaker, E.S., T.M. Casademont, L.M. Carter, P. Russell, S. Alwmark, B. Horgan, H. Dypvik, H.E.F. Amundsen, S. Eide, S.-E. Hamran, D. Paige, **E.L. Cardarelli**, T. Berger, and S. Brovoll. Observations of Continuous, Igneous Subsurface Stratigraphy Across the Jezero Crater Floor, Mars, using the RIMFAX Ground-Penetrating Radar Across the Jezero Crater, Floor. *Planetary Science Journal*. Submitted, manuscript number: AAS52365.
- [23] 2024 Scheller, E.L., T. Bosak, F.M. McCubbin, K. Williford, S. Silijeström, R.S. Jakubek, S.A. Eckley, R.V. Morris, S.V. Bykov, T. Kizovski, S. Asher, E. Berger, D. Bower, **E.L. Cardarelli**, B. Ehlmann, T. Fornaro, A. Fox, N. Haney, K. Hand, R. Roppel, S. Sharma, A. Steele, K. Uckert, A. Yanchilina, O. Beyssac, K. Farley, J. Henneke, C. Heirwegh, D. Pedersen, Y. Liu, M. Schmidt, M. Sephton, D. Shuster, B. Weiss. Inorganic Interpretation of Luminescent Materials Encountered by the Perseverance Rover on Mars. *Science Advances*. Submitted, manuscript: adm8241, draft available.
- [22] 2024 Swindle, C., Vasconcelos, P., Dalleska, N., **Cardarelli, E.L.**, Bhattacharjee, S., Dimarco, Z., Farley, K., Present, T. Determination of carbonate-specific trace element compositions in magnesite-bearing soils. *Chemical Geology*. Submitted, manuscript number: CHEMGE16521.
- [20] 2024 Broz, A., ..., **Cardarelli, E.L.**, et al. Diagenesis and biosignature preservation potential of sulfate-rich rocks at Hogwallow Flats, Jezero Crater, Mars. *Journal of Geophysical Research: Planets*. In revision, manuscript number: 2023JE008188.
- Published*
- [19] 2024 Garczynski, B., ..., **Cardarelli, E.L.**, et al. Rock Coatings as Evidence for Late Surface Alteration on the Floor of Jezero Crater, Mars. *Journal of Geophysical Research: Planets*. Submitted (pre-print published), manuscript number: 2023JE007961.
- [18] 2024 Barnes, R.T., Wolford, M.A., Almaraz, M., and **Cardarelli, E.L.** Not Enough: Efforts to Diversity Biogeosciences Benefit Limited Segment of Society. *Journal of Geophysical Research: Biogeosciences*. Invited submission, manuscript number: 2023JG007777. [Pre-print on ESS Open Archive](#).
- [18] 2024 Stack, K.M., ... **Cardarelli, E.L.**, et al. Sedimentology and Stratigraphy of the Shenandoah Formation, Western Fan, Jezero Crater, Mars. *Journal of Geophysical Research: Planets*. DOI: 10.1029/2023JE008187.
- [17] 2024 Siljeström, S., ..., **Cardarelli, E.L.**, et al. Evidence of Sulfate-Rich Fluid Alteration in Jezero Crater Floor, Mars. *Journal of Geophysical Research: Planets*. DOI: 10.1029/2023JE007989.
- [16] 2023 Wogsland, B., Minitt, M.E., Kah, L.C., Yingst, R.A., Abbey, W., Bhartia, R., Beegle, L., Bleefeld, B.L., **Cardarelli, E.L.**, Conrad, P.G., Edgett, K., Hickman-Lewis, K.,

Hugget, J., Imbeah, S., Kennedy, M.R., Lee, C., Nixon, B.E., Núñez, J.I., Pascuzzo, A., Robinson, M., Rodriguez Sanchez-Vahamonde, C., Scheller, E., Sharma, S., Silijeström, S., Steadman, K., Winchell, K., Ravine, M.A. Science and Science-Enabling Activities of the SHERLOC and WATSON Imaging Systems in Jezero Crater, Mars. *Earth and Space Science*. DOI: 10.1029/2022EA002544

- [15] 2023 Miner, K., Hollis, J., Miller, C., Uckert, K., Douglas, T., **Cardarelli, E.L.**, & Mackelprang, R.. Earth to Mars: A multiphasic protocol for characterizing permafrost microbes as an analog for extraplanetary exploration. *Astrobiology*. DOI: 10.1089/ast.2022.0155.
- [14] 2023 Sun, V., Hand, K., ... **Cardarelli, E.L.**, et al. Overview and Results from the Mars 2020 Perseverance Rover's First Science Campaign on the Jezero Crater Floor. *Journal of Geophysical Research: Planets*. DOI: 10.1029/2022JE007613.
- [13] 2023 Hausrath, L., Adcock, C.T., Bechtold, A., Beck, P., Benison, K., Brown, A., **Cardarelli, E.L.**, et al. An Examination of Soil Crusts on the Floor of Jezero crater, Mars. *Journal of Geophysical Research: Planets*. DOI: 10.1029/2022JE007433.
- [12] 2023 Sharma, S., ... **Cardarelli, E.L.** et al. Mapping organic-mineral associations in Jezero crater: Implications for Martian Organic Geochemistry. *Nature*. DOI: 10.1038/s41586-023-06143-z.

Media coverage: Picked up by 80 news outlets, including *The Washington Post* and *Popular Science*

- [11] 2023 Vaughan, A., Minitti, M., **Cardarelli, E.L.**, et al. Regolith of the crater floor units, Jezero crater, Mars: textures, composition and implications for provenance. *Journal of Geophysical Research: Planets*. DOI: [10.1029/2022JE007437](https://doi.org/10.1029/2022JE007437).
- [10] 2023 Corpolongo, A. ... **Cardarelli, E.L.**, et al. SHERLOC Raman mineral detections of the Mars 2020 Crater Floor Campaign. *Journal of Geophysical Research: Planets*. In press, DOI: [10.1029/2022JE007455](https://doi.org/10.1029/2022JE007455).
- [9] 2022 Scheller, E., Hollis, J., **Cardarelli, E.L.** et al. Aqueous alteration processes and implications for organic geochemistry in Jezero crater, Mars. *Science*. DOI: [10.1126/science.abo5204](https://doi.org/10.1126/science.abo5204)

Media coverage: Picked up by 80 news outlets, including *The Washington Post* and *Popular Science*

- [8] 2022 Liu, Y. ... **Cardarelli, E.L.**, et al. An olivine cumulate outcrop on the floor of Jezero crater, Mars. *Science*. DOI: [10.1126/science.abo2756](https://doi.org/10.1126/science.abo2756)

Media coverage: Picked up by 108 news outlets, including *U.S. News* and *News-break*

- [7] 2022 Farley, K. ... **Cardarelli, E.L.**, et al. Aqueously altered igneous rocks on the floor of Jezero crater, Mars. *Science*. DOI: [10.1126/science.abo2196](https://doi.org/10.1126/science.abo2196)

Media coverage: Picked up by 119 news outlets

- [6] 2022 Fries, M., ... **Cardarelli, E.L.**, et al. The SHERLOC Calibration Target on the Mars 2020 Perseverance Rover: Design, Operations, Outreach, and Future Human Exploration Functions. *Space Science Reviews*. DOI: [10.1007/s11214-022-00907-1](https://doi.org/10.1007/s11214-022-00907-1)
- [5] 2021 Reji, L.R., **Cardarelli, E.L.**, Bargar, J.R., & Francis, C.A. Diverse ecophysiological adaptations of subsurface *Thaumarchaeota* in floodplain sediments. *International Society for Microbial Ecology Journal*. DOI: [10.1038/s41396-021-01167-7](https://doi.org/10.1038/s41396-021-01167-7)
- [4] 2020 **Cardarelli, E.L.**, Bargar, J.R., & Francis, C.A. Diverse *Thaumarchaeota* dominate subsurface ammonia-oxidizing communities in semi-arid floodplains in the Western United States. *Microbial Ecology*. DOI: [10.1007/s00248-020-01534-5](https://doi.org/10.1007/s00248-020-01534-5)

- [3] 2017 Noël, V., Boye, K., Kukkadapu, R. K., Bone, S., Lezama-Pacheco, J., **Cardarelli, E.**, Janot, N., Fendorf, S., & Bargar, J. R. Understanding controls on redox processes in floodplain sediments of the Upper Colorado River Basin. *Science of The Total Environment*. 603: 663-675. DOI: [10.1016/j.scitotenv.2017.01.109](https://doi.org/10.1016/j.scitotenv.2017.01.109)
- [2] 2017 Noël, V., Boye, K., Lezama-Pacheco, J., Bone, S., Janot, N., **Cardarelli, E.**, Williams, K., & Bargar, J. Redox controls over the stability of U(IV) in floodplains of the Upper Colorado River Basin. *Environmental Science and Technology*. 51: 10954-10964. DOI: [10.1021/acs.est.7b02203](https://doi.org/10.1021/acs.est.7b02203)
- [1] 2017 Peay, K., von Sperber, C., **Cardarelli, E.**, Toju, H., Francis, C., Chadwick, O., & Vitousek, P. Convergence and contrast in the community structure of Bacteria, Fungi and Archaea along a tropical elevation-climate gradient. *FEMS Microbiology Ecology*. 93. DOI: [10.1093/femsec/fix045](https://doi.org/10.1093/femsec/fix045)

*Internal publications*

- 2020 **Cardarelli, E.L.** and K. Gonzales. Cultivating diversity and normalizing inclusion within the Geosciences. Internal White Paper for Stanford University.
- 2013 **Cardarelli, E.L.** Unraveling the black box of aquaria biofilter function: FISHing for novel ammonia-oxidizing archaea associations. Online Publication, *Marine Biological Laboratory*, Woods' Hole, MA. **online:** [goo.gl/s1pAa7](https://www.mbl.edu/research/online-publication)

FIELD CAMPAIGNS AND MISSIONS*Sample Collection*

- 2021-present **Tactical Science Lead;** NASA Mars 2020 Perseverance Rover, 50+ sols led - including core collection (Pauls, Sol 300), abrasion patch selection (Berry Hollow, Sol 504), regolith core selection and collection (Atmo\_Mountain and Crosswind\_Lake, Sol 598), sample depot construction for Mars Sample Return (2 cores dropped).
- 2016 **Chief Scientist;** Riverton, WY, DOE-LM site formerly processed U- and V-ore, core collection.
- 2014-2016 **Lead Microbiologist** for 11 field campaigns; [1-5] R/V *Rachel Carson*, MBARI, Monterey Canyon, CA - water column monthly time-series sampling; [6] Rifle, CO, DOE-LM site formerly processed U-ore - core collection; [7] Grand Junction, CO, DOE-LM site formerly processed U-ore - core collection; [8] Naturita, CO, DOE-LM site formerly processed U-ore - core collection; [9] Shiprock, NM, DOE-LM site formerly processed U-ore - core collection; [10, 11] Riverton, WY, DOE-LM site formerly processed U-ore - core collection
- 2014 **Participating Microbiologist;** R/V *Questuary*, Sacramento River/San Francisco Bay, CA; water column sampling.
- 2013, 2014 **Chief Scientist;** Elkhorn Slough Estuary, CA; intact sediment coring for lab-based manipulations.
- 2011 **Chief Scientist;** Davis Pond River Diversion, Boutte, LA; seasonal water column/sediment and plant collection.

GRANTS

- [9] 2023 Submitted as Science PI/Co-I, “Sampling Microhabitat Areas with a Localizing Lancet”, Research & Technology Development Program, NASA Jet Propulsion Laboratory
- [8] 2022 Submitted as Science PI/Co-I, “Machine Learning Approach to Characterizing Clasts in Mars Rover and Orbital Imagery”, Mars Data Analysis Program, NASA

- [7] 2022 Raise the Bar Award (awarded: \$5,000), 3X Engineering and Science Directorate, NASA Jet Propulsion Laboratory
- [6] 2021 Raise the Bar Award (awarded: \$4,000), 3X Engineering and Science Directorate, NASA Jet Propulsion Laboratory
- [5] 2018-2021 Authored DE-SC0019119, “Response of Subsurface Nitrogen-Cycling Microbial Communities to Environmental Fluctuations” (awarded: \$539,400) PI: Chris Francis (E.L. Cardarelli, ghost PI), Stanford University
- [4] 2016 Authored Proposal 1927, “Metagenomic Characterization of Nitrogen-Cycling Microbial Communities Impacting Uranium Release in the Upper Colorado River Basin” (awarded: 16S rRNA gene sequencing (276 samples), metagenomic sequencing (50 samples), metatranscriptomic sequencing (10 samples)) PI: Chris Francis (E.L. Cardarelli, ghost PI), Stanford University; DOI: 10.25585/1488139
- [3] 2013, 2014 McGee/Levorsen Research Grant, Stanford University (awarded: \$2,060; \$3,940)
- [2] 2011-2012 Research Grant Proposal Author, Department of the U.S. Army (awarded: \$450,000) PI: Naomi Verdugo, Manpower and Reserve Affairs, U.S. Army
- [1] 2011 Undergraduate Research Opportunity Program Grant, NOAA Louisiana SeaGrant (awarded: \$2,500)

## MENTORING AND MANAGING EXPERIENCE

- 2021-present Denise Buckner; University of Florida, SHERLOC/Mars 2020
- 2017-2019 Lauren Abrahams; Stanford University, Enhancing Diversity in Graduate Education
- 2017, *Summer* Evan Baldonado; Stanford University ’23, Stanford Young Investigators Program
- 2017, *Summer* Rijul Amin; Thomas Jefferson High School ’18, University of Pittsburgh ’23
- 2017, *Summer* Natalie Wright; STEM teacher researcher, STAR Program
- 2017, *Summer* Alexandra Gutierrez; STEM teacher researcher, STAR Program
- 2016, *Summer* Kolyne DeJesus; STEM teacher researcher, STAR Program
- 2015-2016 Alan Wei; Stanford University ’18, Presently: Ph.D. student, Johns Hopkins Univ.
- 2015, *Summer* Madison Jackson; University of Miami ’17, UC Berkeley-UCSF ’18
- 2015, *Summer* Emilie Dirck; California State Monterey Bay ’17
- 2014, *Summer* Craig McLean; University of Arkansas ’16, Presently: Ph.D. student, MIT/WHOI
- 2014, *Spring* Angela Khov; Sequoia High School ’18, UC Davis ’22
- 2015-2018 Lab Manager for the Francis Lab

## FELLOWSHIPS AND AWARDS

- 2023 **Mars 2020 SHERLOC Operations Team Award**, awarded by NASA-JPL for exceptional efforts to enable scientifically valuable SHERLOC data and analysis
- 2022 **NASA Group Achievement Award, Pre-Landing Strategic Science Group** awarded by NASA headquarters for the multi-faceted, multi-year effort that selected Perseverance’s landing site based on its scientific potential, prepared for M2020 surface science mission operations and meeting RSS goals in the context of a global pandemic that stressed the limits of remote work and team member participation. Novel tool-based solutions for collaborative strategic science planning and prioritization were pioneered to support this effort, some of which are being considered for adoption by future missions
- 2022 **NASA Group Achievement Award, SHERLOC Team**, NASA HQ
- 2022 **NASA Group Achievement Award, Mars 2020 Science Team**, NASA HQ
- 2021 **NASA Group Achievement Award, Mars 2020 Instrument Operations Development Team**, awarded by NASA Headquarters for outstanding achievement

- 2021 in the development of the Mars 2020 Instrument Operations Teams, tools, and systems enabling successful initial surface operations at Jezero Crater  
**Earth Service Award for DEI**, awarded in recognition for outstanding individual efforts and a long-term contribution to advancing DEI at Stanford Earth, Stanford University
- 2020 **Community Impact Award**, awarded for dedication and meaningful impact on the Stanford community, Stanford Alumni Association, Stanford University
- 2019 [\*\*Rising Environmental Leaders Fellow\*\*](#), Woods Institute for the Environment, Stanford University
- 2018 **Preparing Future Professor Fellow**, Vice Provost for Graduate Education, Stanford University
- 2016 **Outstanding Achievement in Mentoring Award (\$300)**, Stanford University
- 2015 **Student Travel Fellowship (\$2,000)**, Department of Energy, Office of Biological and Environmental Research, Environmental System Science Principal Investigator’s Meeting
- 2013, 2014 **Graduate Research Fellowship Honorable Mention Recipient in Geobiology**, National Science Foundation
- 2013 **Microbial Diversity Course Scholarship (\$6,180)**, National Science Foundation
- 2012 **Tulane 34 Award**, given for leadership, service, and academic contributions to the Tulane University community
- 2012 **Earth and Environmental Science Senior Honors’ Scholar**, awarded for top thesis in Earth and Environmental Science at Tulane University
- 2012 **Chairman’s Award**, awarded for high academic standing and research contributions in Earth and Environmental Science at Tulane University
- 2012 **Harold A. Vokes Award**, awarded for high academic standing in Environmental Science at Tulane University
- 2012 **The Under the Oaks Award**, awarded by the Newcomb Institute for advancing women’s education at Tulane University
- 2012 **Oak Wreath Award**, awarded by the Newcomb Institute for leadership in student activities and contributions to the Newcomb-Tulane community at Tulane University
- 2011 **Air and Waste Management Association Scholarship (\$2,000)**, Louisiana Section of the Air and Waste Management Association
- 2010 **Certificate of Achievement Award**, Department of the U.S. Army
- 2008-2011 **Dean’s List**, Dean of Students, Tulane University
- 2008-2012 **Tulane Presidential Scholars Award**, Tulane University

PROFESSIONAL EXPERIENCE (expanded roles & activities)

- 2023 **Planetary Terrain Building Workshop Participant**, Arizona State University and NASA Jet Propulsion Laboratory
  - Invited participant to foster the development of a multi-institution consortium that would create and host immersive 3D model datasets derived from planetary imagery, expanding current collaborative efforts from producing Mars 2020 data-based 3D visualizations for mission operations workflows to reach planetary data sources or educational/outreach contexts.
- 2022-2023 **Targeting Microhabitats for Life Detection KISS Study Participant**, Keck Institute for Space Studies, California Institute of Technology, Pasadena, CA.
  - Invited think-tank study participant (approximately 1 of 25) on advancing target selection and analysis of microhabitats for life detection within the subsurface, rocky planets, and icy worlds
- Dec. 2021- **Instrument Interface**, Mars 2020 Project Science, NASA-JPL, Pasadena, CA.
- Jul. 2022

- Initiated productive communications and leads interactions between Instrument Data Systems Operations and Mars 2020 Instrument Teams for on-time product deliveries to Planetary Data System, for public data releases 3 and 4.
- Led weekly team meeting with attendees from Instrument Data System Operations Instrument Operations Teams

Nov. 2020- **Mission Operations on Mars 2020**, NASA-JPL, Pasadena, CA.

- Mars 2020 Science Team Member, SHERLOC (deep UV Raman, native fluorescence) and Mastcam-Z Instrument Collaborator
- Over 100 shifts staffed to date (Sols 9-365); 9 teammates trained.
- Roles (5): Tactical Science Lead (led 50+ sols), Targeting Scientist, SHERLOC Spectroscopy Science Payload Uplink Lead, Documentarian
- Key contributor to the Regolith Working Group and Biosignatures

Sept. 2020- **JPL Postdoctoral Research Fellow**, NASA-JPL, Pasadena, CA.

- Analyzing regolith types, rock-regolith transitions, and organomineral associations with multiple on-board (Mars 2020) spectroscopic instruments
- Microscopy (SEM/EDS, petrography) and geochemical techniques (XRF, XRD) employed for spatial analyses conducted across scales, including (deep UV Raman, native fluorescence)
- Investigating Mars analog systems (Kunwarara, Australia and Arctic permafrost) for microbial biosignatures, specifically within an ancient magnesite precipitating environment and weathered ultramafics in Australia and related to age as well as species of carbon

2012-2020 **Graduate Research Assistant**, Stanford University, Stanford, CA

- Examined the size, structure, and potential geochemical controls of microbial communities belowground using molecular biology techniques (functional genes, qPCR, FISH, metagenomics), geochemical characterization techniques for solid-phase elemental analysis (EA, XRF, ICP-MS/OES, XAS) and multivariate statistics (nonparametric hypothesis testing, principal component analyses, regression analyses (ex. LASSO, Ridge, linear)) from >500 samples collected from 17 cores (2-10 m down) over five sites in the American West. \*XAS — for uranium, completed on ~20 samples
- Evaluated the size and diversity of nitrogen cycling communities at five sites and from the topsoil to 10 m below-ground; found AOA and AOB ecotypes within these terrestrial subsurface soils are primarily associated with conditions influenced by water table position, location of the naturally reduced zone, or both conditions.
- Elucidated microbial diversity, niche partitioning, and succession patterns in semi-arid terrestrial subsurface environments are shaped by hydrologic conditions and seasonal disturbances (i.e. drought to flood conditions)
- Determined native microbial communities *in-situ* limit uranium's movement from floodplain soils to water bodies

2010-2012 **Undergraduate Research Assistant**, Tulane University, New Orleans, LA.

- Developed a new area of research centered on nitrogen cycling within the Rosenheim Lab through an undergraduate research grant funded in full (\$2,500) by the Louisiana SeaGrant Program, NOAA
- Utilized natural abundance carbon and nitrogen isotope measurements made by elemental analysis isotope ratio mass spectrometry (EA-irMS) to evaluate spatiotemporal particulate organic carbon and nitrogen transformation trends within the water column of a newly constructed wetland

2009-2011 **Summer Research Analyst**, Department of the U.S. Army, Pentagon, Washington, D.C.

- Authored a research proposal (funded for \$450,000) to examine the lifecycle of behavioral healthcare providers in the private and public sectors
- Prepared reports to the Secretary of the Army on recruiting and retention of behavioral healthcare professionals and bonus incentives' effectivity for attracting/retaining different demographics

## LEADERSHIP ROLES AND PROFESSIONAL AFFILIATIONS

### *Departmental/Institutional Service and Leadership*

Since 2021 Founding Chair, American Geophysical Union Biogeosciences DEI Committee

- Lead of the B-DEI Steering Committee (a dozen scientists selected for committee development and to generate feedback to AGU's Biogeosciences Executive Committee) and guide of participation into focus areas to advance progress on DEI activities.
- Lead of the B-DEI Working Group, facilitating initiatives including: a DEI Travel Grant program (administered \$6,000 and enabled 8 early career scientists to attend the Fall Meeting), founded the GEOspire program connecting scientists to K-12 teachers within the Fall Meeting host city, and redefining the Sulzman Award to be open to all early- to mid-career scientists independent of sex or gender, with an emphasis on acknowledging an educator and mentor furthering diversity in the Earth Sciences.
- Raised over \$1000 for programming at the AGU Fall 2022 Meeting.

Since 2021 Biogeosciences Section Executive Committee, American Geophysical Union  
2020-2021 Steering Committee, Asian Americans and Pacific Islanders in the Geosciences  
2019-2021 Chief Strategy Officer and Horse Manager, Stanford Polo Club, Stanford University  
2017-2019 Chair, ESS Student-Invited Seminar Committee, Stanford University  
2014-2015 Vice-President, Graduate Student Advisory Council, Stanford University  
2013-2014 Secretary, Graduate Student Advisory Council, Stanford University  
2013-2014 Student Liaison to Faculty, ESS Geobiology Faculty Search Committee

### *Academic service & Affiliations*

Since 2024 Panelist, NASA  
Since 2022 Reviewer, Astrobiology  
Since 2022 Reviewer, Advances in Space Research  
Since 2022 Reviewer, Acta Astronautica  
Since 2021 Member, Geological Society of America  
Since 2021 Member, Veterans of Foreign Wars Auxiliary  
Since 2019 Member, United States Polo Association  
Since 2017 Reviewer, Journal of Geophysical Research: Biogeosciences  
Since 2016 Member, International Society of Microbial Ecology  
Since 2013 Member, American Geophysical Union

## CONFERENCE/INVITED PRESENTATIONS

### *Oral,*

- [29] 2023 **Cardarelli, E.L.** In-situ regolith observations on the Delta Front and Crater Floor of Jezero crater, Mars. California State University San Bernardino, San Bernardino, CA. **[Invited Speaker]**
- [28] 2023 **Cardarelli, E.L.** and A. Williams. In, On, and Around Jezero Delta. Lunar and Planetary Science Conference. The Woodlands, TX. **[Session Chair]**
- [27] 2023 **Cardarelli, E.L.,** A. Vaughan, S. Siljeström, M.E. Minitti, G. Paar, D.K. Buckner, E.M. Hausrath, J.R. Johnson, M. Wu, K. Uckert, R. Bhartia, K. Hand, J.F. Bell III, P. Conrad, L. Panossian, R. Burgos. The first in-situ regolith observations on the Delta



- Front of Jezero crater, Mars characterized by the Mars 2020 SHERLOC & Mastcam-Z investigations. Lunar and Planetary Science Conference. The Woodlands, TX.
- [26] 2023 Siljeström, S., A.D. Czaja, A. Corpolongo, E.L. Berger, **E.L. Cardarelli**, R. Bhartia, S. Bykov, S. Sharma, A. Steele, P. Conrad, R. Roppel, R. Jaubeck, A.Y. Li, E. Scheller, J. Razzell Hollis, R. Morris, T. Fornaro, S. Asher, K. Moore, Y. Liu, N. Randazzo, K. Steadman, A. Fox, L. DeFlores, A. Yanchilina, W. Abbey, C. Lee, C. Rodriguez, M. Wu, K. Winchell, S. Imbeah, B. Bleefeld, and M. Minitti. Sulfate alteration in the Crater Floor of Jezero Crater, Mars as observed by SHERLOC and PIXL Instruments. Lunar and Planetary Science Conference. The Woodlands, TX.
- [25] 2023 **Cardarelli, E.L.** Expanding diversity, equity, and inclusion in the Geoscience and Astrobiology. Georgia Institute of Technology, Atlanta, GA. **[Invited Speaker]**
- [24] 2022 **Cardarelli, E.L.** Advancing Diversity, Equity, and Inclusion (DEI) in the Biogeosciences. RUBISCO Project and Working Group Meeting at the American Geophysical Union Fall Meeting, Chicago, IL. **[Invited Speaker]**
- [23] 2022 **Cardarelli, E.L.** Toward Increasing Justice, Equity, Diversity, and Inclusion (JEDI) and Community Engagement in Climate Research: Challenges, Opportunities, and Successes in Scientific Publishing — AGU Biogeosciences Section. American Geophysical Union Fall Meeting, Chicago, IL. **[Invited Speaker]**
- [22] 2022 **Cardarelli, E.L.** 500+ Sols on Perseverance: The Mars 2020 Perseverance Rover Mission in Jezero crater, Mars. The Open University School of Physical Sciences, Kents Hill, England. **[Invited Seminar]**
- [21] 2022 **Cardarelli, E.L.,** Willis, P.A., Mayhew, L.E., Fornaro, T., Tuite, M.L., Williams, A.J., Astrobiology Investigations Enabled by the NASA Mars 2020 Mission and Sample Return. Astrobiology Conference, Atlanta, GA. **[Session Chair and Convener]**
- [20] 2022 **Cardarelli, E.L.** Assessing Organic Preservation and the Implications for Potential Biosignatures in the Bastide Member of the Séítah Formation, Jezero Crater. Astrobiology Conference, Atlanta, GA.
- [19] 2022 **Cardarelli, E.L.** ‘Seeing with SHERLOC’: from the rocks to the regolith in Jezero. After Dark Series: Mars! Exploratorium, San Francisco, CA. **[Invited Speaker]**
- [18] 2022 **Cardarelli, E.L.** 300+ Sols on Perseverance: The Mars 2020 Perseverance Rover Mission in Jezero crater, Mars. After Dark Series: Mars! Exploratorium, San Francisco, CA. **[Invited Speaker]**
- [17] 2022 **Cardarelli, E.L.,** S. Sharma, A.E. Murphy, J. Tarnas, C. Lee, R. Bhartia, L.W. Beegle. Assessing the biosignature preservation potential of the Bastide Member in the Séítah Formation, Jezero crater. American Geophysical Union Astrobiology Science Conference, Atlanta, GA.
- [16] 2022 **Cardarelli, E.L.,** A. Vaughan, M.E. Minitti, L. Beegle, M. Rice, J.R. Johnson, B. Horgan, A. Cousin, L.C. Kah, E.M. Hausrath, and S. Siljeström. Regolith at Jezero crater, Mars: spectral diversity, textures, and implications for provenance. Lunar and Planetary Science Conference. The Woodlands, TX.
- [15] 2022 **Cardarelli, E.L.** From the rocks to the regolith of Jezero crater: the first 300 sols on the Mars 2020 rover. University of Nevada-Las Vegas Department of Geosciences, Las Vegas, NV. **[Invited]**
- [14] 2021 **Cardarelli, E.L.,** K.H. Williford, C. Lee, E.L. Berger, A. Cousin, K.S. Edgett, M.R. Kennedy, S. Shkolyar, L.P. DeFlores, W. Abbey, R. Bhartia, R.C. Wiens and L.W.

- Beegle. Exploring rock-regolith interfaces in Jezero crater with Mars 2020 SHERLOC. American Geophysical Union Fall Meeting, New Orleans, LA.
- [13] 2021 Hausrath, E., A.J. Brown, **E.L. Cardarelli**, A. Cousin, F. Gomez, Y. Goreva, J. Lasue, C. Legett, J. Manuel Madariaga, L. Mandon, G. Martinez, J. Martinez-Frías, T.H. McConnochie, P. Meslin, M. Zorzano, S. Siljeström, S. Schröder, S.K. Sharma, A. Steele, R.J. Sullivan Jr, A. Udry, R.C. Wiens, S. Shkolyar, the SuperCam Team and the Regolith Working Group. Examining Soil Surface Processes at Jezero crater, Mars. American Geophysical Union Fall Meeting, New Orleans, LA.
- [12] 2021 Beegle, L.W., L.P. DeFlores, R. Bhartia, W. Abbey, J.J. Razzell Hollis, K. Uckert, B. Zachary, K.S. Edgett, M.R. Kennedy, C. Lee, S.A. Asher, E.L. Berger, A. Burton, S. Bykov, **E.L. Cardarelli**, et al. An overview of SHERLOC Raman and fluorescence spectroscopy results obtained during Perseverance's Green Zone Campaign at Jezero crater, Mars. American Geophysical Union Fall Meeting, New Orleans, LA.
- [11] 2021 **Cardarelli, E.L.** Microbe-mineral interactions and possible biosignatures within semiarid alluvial deposits of the Western United States and beyond. Georgia Institute of Technology Astrobiology and Planetary Science Seminar, Atlanta, GA. **[Invited, seminar recorded]**
- [10] 2021 **Cardarelli, E.L.**, J. Tarnas, and M. Rice. The Mars 2020 Perseverance Rover in Jezero Crater. Geological Society of America Annual Meeting, Portland, OR. **[Invited Keynote]**
- [9] 2021 **Cardarelli, E.L.**, E. Hausrath, R. Sullivan, J. Johnson, S. Siljeström, J. Manuel Madariaga, P. Meslin, L. Mandon, A. Cousin, K. Williford. Insights into Jezero Crater geology from rock-regolith interfaces. Geological Society of America Annual Meeting, Portland, OR.
- [8] 2021 **Cardarelli, E.L.** Microbe-mineral interactions and possible biosignatures within semiarid alluvial deposits of the Western United States and beyond. Johns Hopkins Osher Lifelong Learning Institute at Johns Hopkins University, Baltimore, MD. **[Invited Seminar]**
- [7] 2020 **Cardarelli, E.L.** Illuminating the microbial ecology, biogeochemistry, and possible biosignatures within semiarid alluvial deposits of the Western United States and beyond. Caltech GPS Division 'Geoclub' Seminar, Pasadena, CA. **[Invited Seminar]**
- [6] 2019 **Cardarelli, E.L.**, Bargar, J.R., and C.A. Francis. Microbes in the American West: subsurface spatiotemporal dynamics reveal depth-specific metabolic strategies and critical water cycle interactions. American Geophysical Union Fall Meeting, San Francisco, CA
- [5] 2019 **Cardarelli, E.L.** and K. Gonzales. Cultivating a Cohort of Change Agents: Launching Diversity and Inclusion in the Geosciences Curricula at Stanford University. American Geophysical Union Fall Meeting, San Francisco, CA.
- [4] 2019 **Cardarelli, E.L.** Microbes in the American West: subsurface spatiotemporal dynamics reveal new taxa and critical water cycle interactions. Caltech GPS Division 'Geoclub' Seminar, Pasadena, CA. **[Invited Seminar]**
- [3] 2018 **Cardarelli, E.L.**, J.R. Bargar, and C.A. Francis. Microbes of the West: niche partitioning and new phyla in the depths of the terrestrial subsurface. Southern California Geobiology Symposium, Riverside, CA.
- [2] 2016 **Cardarelli, E.L.**, V. Noël, J.R. Bargar, K. Williams, W. Dam, and C.A. Francis. Biogeochemical constraints on uranium cycling in redox active floodplain sediments. American Geophysical Union Fall Meeting, San Francisco, CA.

- [1] 2015 **Cardarelli, E.L.**, J.R. Bargar, K. Williams, W. Dam, and C.A. Francis. Subsurface nitrogen-cycling microbial communities at uranium contaminated sites in the Colorado River Basin. American Geophysical Union Fall Meeting, San Francisco, CA. **online:** [goo.gl/URuhMx](https://goo.gl/URuhMx)
- Poster, \*\* — indicates led by mentee*
- [23] 2023 Connell, S.A., R.C. Wiens, **E.L. Cardarelli**, R. Deen, L. Mandon, S. Sharma, O. Beyssac, E. Clavé, S. Silijeström, A. Czaja, P. Pilleri, O. Gasnault, G. Lopez-Reyes, J.R. Johnson, R. Bhartia, S. Maurice. Analysis of co-located SuperCam and SHERLOC observations on abrasion patches in Jezero Crater. Lunar and Planetary Science Conference, The Woodlands, TX.
- [22] 2023 Hausrath, E.M., R. Sullivan, Y. Goreva, M.P. Zorzano, **E. Cardarelli**, A. Vaughan, A. Cousin, S. Siljeström, A. Shumway, S. VanBommel, G. Martinez, J. Johnson, A. Bechtold, G. Paar, F. Poulet, C.D.K. Herd, K. Benison, M. Sephton, J.M. Madariaga, J. Lasue, R.C. Wiens, J. Martinez-Frias, J.F. Bell III, A.D. Czaja, C.T. Adcock, N. Randazzo. The first regolith samples from Mars. Lunar and Planetary Science Conference, The Woodlands, TX.
- [21] 2022 **Cardarelli, E.L.** and Maya Almaraz. Establishing the American Geophysical Union Biogeosciences Section's Diversity, Equity, and Inclusion Committee. American Geophysical Union Fall Meeting, Chicago, IL. **[Invited Abstract]**
- [20] 2021 **Cardarelli, E.L.** and M.B. Wilhelm. Microbe-mineral interactions preserved across scales. American Geophysical Union Fall Meeting, New Orleans, LA. **[Session Chair and Convener]**
- [19] 2021 **\*\*Abrahams, L.S., \*\*S.J. Tumber-Davila, E.L. Cardarelli.** Diversity and Inclusion in the Geosciences (DIG): a student-led initiative empowering trainees to make institutional change. American Geophysical Union Fall Meeting, New Orleans, LA.
- [18] 2021 Cousin, A., P. Meslin, E. Hausrath, J. Lasue, **E.L. Cardarelli**, O. Beyssac, O. Forni, E. Dehouck, L. Mandon, O. Gasnault, C. Quantin Nataf, S. Schröder, S.M. Clegg, R.B. Anderson, P. Pilleri, A.J. Brown, S. Maurice, R.C. Wiens and SuperCam Team. Fine-grained regolith on Mars: Comparison between Gale and Jezero craters using ChemCam and SuperCam LIBS data. American Geophysical Union Fall Meeting, New Orleans, LA.
- [17] 2021 Lee, C., T.G. Graff, M. Fries, V.D. Tran, R.H. Weiner, M.J. Calaway, D.H. Garrison, R.S. Jakubek, R.S. Harrington, K. Davis, E.L. Berger, A. Burton, F. McCubbin, A.J. Ross, A. Fox, C.L. Smith, R. Bhartia, L.W. Beegle, L.P. DeFlores, W. Abbey, K. Uckert, J.J. Razzell Hollis, **E.L. Cardarelli**, M.R. Kennedy, A. Werynski, K. Winchell and K.S. Edgett. Calibration and validation of the SHERLOC instrument operating in Jezero crater, Mars. American Geophysical Union Fall Meeting, New Orleans, LA.
- [16] 2019 **Cardarelli, E.L.**, J.R. Bargar, and C.A. Francis. Microbes in the American West: comparative metagenomics of subsurface communities reveals depth-specific metabolic strategies and potential water cycle interactions. Department of Energy Joint Genome Institute User Meeting, San Francisco, CA.
- [15] 2019 **Cardarelli, E.L.**, J.R. Bargar, and C.A. Francis. Comparative metagenomics below-ground and potential water cycle interactions in the American West. Southern California Geobiology Symposium, Pasadena, CA.

- [14] 2018 **Cardarelli, E.L.**, J.R. Bargar, W. Dam, and C.A. Francis. Microbial niche partitioning at the soil-groundwater interface in transiently reduced floodplains. Department of Energy Earth System Science PI Meeting, Potomac, MD. **online:** [goo.gl/4y5Rz4](https://goo.gl/4y5Rz4)
- [13] 2018 **Cardarelli, E.L.**, J.R. Bargar, and C.A. Francis. Hydrologic perturbations support niche partitioning at the soil-groundwater interface and reveal new phyla in the West. Department of Energy Joint Genome Institute User Meeting, San Francisco, CA.
- [12] 2017 **Cardarelli, E.L.**, J.R. Bargar, W. Dam, and C.A. Francis. Effects of microbial communities on uranium oxidation and mobilization in the presence of nitrate, nitrite, and oxygen. Department of Energy SSRL/LCLS Users' Meeting, Menlo Park, CA. **online:** [goo.gl/PM4ZKG](https://goo.gl/PM4ZKG)
- [11] 2017 **Cardarelli, E.L.**, J.R. Bargar, W. Dam, and C.A. Francis. Effects of microbial communities on uranium oxidation and mobilization in the presence of nitrate, nitrite, and oxygen. Department of Energy Environmental System Science PI Meeting, Potomac, MD.
- [10] 2017 **Cardarelli, E.L.**, J.R. Bargar, and C.A. Francis. Subsurface microbial communities involved in nitrogen cycling with implications for uranium release in the Upper Colorado River Basin. Department of Energy Joint Genome Institute User Meeting, Walnut Creek, MD.
- [9] 2016 **Cardarelli, E.L.**, C.A. Francis, K. Boye, S. Bone, V. Noël, J. Lezama-Pacheco, W. Dam, R.H. Johnson, K.H. Williams, and J.R. Bargar. Diversity and biogeography of subsurface nitrogen-cycling communities at uranium contaminated DOE-LM sites in the Upper Colorado River Basin. Department of Energy Environmental System Science PI Meeting, Potomac, MD. **online:** [goo.gl/gSWNfq](https://goo.gl/gSWNfq)
- [8] 2016 **Cardarelli, E.L.**, J.R. Bargar, and C.A. Francis. Subsurface microbial communities involved in nitrogen cycling with implications for uranium release in the Upper Colorado River Basin. Department of Energy Joint Genome Institute User Meeting, Walnut Creek, MD.
- [7] 2016 **Cardarelli, E.L.**, J.R. Bargar, W. Dam, and C.A. Francis. Characterization of nitrogen-cycling microbial communities impacting uranium release in the Colorado River Basin. International Society for Microbial Ecology Meeting, Montreal, QC, Canada.
- [6] 2016 **\*\*Jackson, M.B., M.M. Mills, K.R. Arrigo, C. Francis, and E. Cardarelli.** Nitrifier diversity and distribution controls in the Chukchi Sea Shelf sediments. American Geophysical Union Fall Meeting, San Francisco, CA.
- [5] 2015 Noël, V., P. Lefebvre, K. Boye, J. Bargar, K. Maher, J. Lezama-Pacheco, **E.L. Cardarelli**, S. Bone, W.L. Dam, and R.H. Johnson. Combining U speciation and U isotope fractionation to evaluate the importance of naturally reduced sediments in controlling the mobility of uranium in the upper Colorado River Basin American Geophysical Union Fall Meeting, San Francisco, CA.
- [4] 2015 **Cardarelli, E.L.**, J.R. Bargar, K.H. Williams, and C.A. Francis. Subsurface microbial nitrogen-cycling communities of uranium contaminated sites. Department of Energy Environmental System Science PI Meeting, Potomac, M.D.
- [3] 2014 **Cardarelli, E.L.** and C.A. Francis. The abundance and activity of nitrate-reducing microbial populations in estuarine sediments. American Geophysical Union Fall Meeting, San Francisco, CA.

- [2] 2014      **\*\*McLean, C., E.L. Cardarelli, J.A. Lee, and C.A. Francis.** The Impact of Salinity on the Diversity of Microbial Sediment Communities. American Geophysical Union Fall Meeting, San Francisco, CA.
- [1] 2013      **Cardarelli, E.L.** and C.A. Francis. The relative importance of microbial nitrate reduction processes in an agriculturally-impacted estuary. American Geophysical Union Fall Meeting, San Francisco, CA

## UNIVERSITY TEACHING

- 2019      **Instructor & Course Developer;** EARTH 203: Diversity and Inclusion in the Geosciences, Stanford University, Stanford, CA
- Developed and taught a new course for students in the earth sciences on the value of diversity and inclusion for fostering innovative and interdisciplinary research, now offered annually and the centerpiece of DEI education in the Stanford School of Earth. Through experiential learning, class discussions, and written reflections, students evaluated current practices and identified interventions for broadening participation and improving inclusion. Imagining an initiative an individual could implement that would improve inclusion in the earth sciences, possibly at every level of higher education, the students developed these achievable solutions over the course of the quarter.
  - EARTH 203 culminated in a school-wide symposium where students share their projects, which imagine and detail initiatives for current students that improve diversity and inclusion at Stanford and beyond, with their peers.
  - **Media coverage:** ‘Cultivating diverse communities’, <https://earth.stanford.edu/spotlights/cultivating-diverse-communities#gs.s0p42l>
- 2018      **Teaching Assistant;** ESS 253: Hopkins Microbiology Course, Hopkins Marine Station of Stanford University, Pacific Grove, CA
- Designed new content and laboratory tutorials for an experiential graduate microbiology class focused on applying multivariate statistics to microbial data and environmental metadata.
  - Introduced basic coding skills and statistics and taught students how to manipulate existing R programs commonly used to analyze microbial and environmental data concurrently. Integrated student-generated observations from the environment and led enrichment modules for culturing/isolating purple non-sulfur bacteria, among others.
- 2017      **Guest Lecturer;** Geology 015: Physical Geology, San Jose Community College, San Jose, CA
- Engaged students by integrating their prior knowledge on the Water Cycle in California with figures from scientific papers and figures from my own research and fostered student-guided discussions on ecosystem processes that spatially scale from microbes ( $\mu\text{m}$ ) to watersheds (km) as well as water in the American West.
- 2017      **Teaching Assistant;** Stanford Earth Young Investigators, Stanford University, Stanford, CA
- Mentored and assisted 17 incoming undergraduate and high school students from diverse backgrounds beginning research in the Earth Sciences.
- 2013      **Teaching Assistant;** ESS 212: Measurements in Earth Systems, Stanford University, Stanford, CA
- Team-taught incoming interdisciplinary graduate students field-sampling techniques for marine, freshwater, and terrestrial environments. Incorporated microbial and geochemical analytical techniques including DNA/RNA isolation, PCR, and solid-/aqueous-phase chemical characterization using elemental analysis and x-ray techniques.

## OUTREACH ACTIVITIES

- 2023      NASA-JPL Volunteer, Yuri’s Night, The California Science Center, Los Angeles, CA

- 2023 Panelist, You've Got Perseverance, NASA-JPL, Pasadena, CA
- Since 2021 AGU Local Science Partners Ambassador, inaugural cohort of scientists building sustainable partnerships with policymakers, American Geophysical Union.  
Media coverage: 'AGU welcomes first cohort of Local Science Partners', <https://thebridge.agu.org/2021/12/10/agu-welcomes-first-cohort-of-local-science-partners/>
- 2021-2023 Guest Coach, Stanford Polo Team, Stanford University, Stanford, CA.
- 2020-2021 Speaker (monthly), Para Los Ninos Middle School, Los Angeles, CA (100 students)
- 2018 Floodplain dynamics Lab, University of San Francisco (12 undergraduate students)
- 2015, 2016 Host and Guide of Stanford University, Hillsdale High School (20 students)
- 2012-2016 Instructor, GeoKids (1,000 children per year), Stanford University
- 2009 Intern, Mayor's Office of Recovery and Development, City of New Orleans, LA (developed urban soil science curricula for 24 middle school students)
- 2009 Volunteer, Gulf Restoration Network, New Orleans, LA