

PATRICK A. RAFTER

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EDUCATION / APPOINTMENTS / EMPLOYMENT

Keck Carbon Cycle Laboratory Scientist. UC Irvine. Apr 2014-present
Postdoctoral Research Associate & Associate Research Scholar. Princeton University. Oct 2009-April 2014
Ph.D. in Oceanography. Scripps Institution of Oceanography. Sept 2002-Sept 2009
B.S. Environmental Science & B.S. Marine Environmental Studies. Florida Institute of Technology. 2000

PUBLICATIONS

- Rafter**, P.A., A. Bagnell, D. Marconi, T. DeVries (Submitted) Global trends in nitrate N isotopes: insights from observations and neural network model results. *Biogeosciences Discussions*.
- Lund, D., P.A. **Rafter**, R. Anderson, et al. (In Review) Enhanced hydrothermal scavenging of ^{230}Th on the Southern East Pacific Rise during the last deglaciation. *Science Advances*.
- Robinson, R. S., P.A. **Rafter**, et al. (In Review) Contraction of the eastern equatorial Pacific high productivity zone across the Mid-Pleistocene Transition. *Geophysical Research Letters*.
15. Smart, S. [...], P.A. **Rafter**, D. Sigman, G. Haug (2018) Ground-truthing the planktic foraminifer-bound nitrogen isotope paleo-proxy in the Sargasso Sea. *Geochimica et Cosmochimica Acta*.
14. **Rafter**, P.A., J-C. Herguera, and J. R. Southon (2018) Extreme deglacial ^{14}C depletion observed in epifaunal and infaunal benthic foraminifera. *Climate of the Past Discussions*.
13. Lehmann, N., J. Granger, and P. A. **Rafter**, et al. (2018) Nitrate Isotope Evidence of the Origin of Subsurface Nitrate in the Western Equatorial Pacific. *JGR-Oceans*.
12. Marconi, D., P.A. **Rafter**, et al. (2017) Nitrate isotopic gradients in the North Atlantic Ocean and the nitrogen isotopic composition of sinking organic matter. *Global Biogeochemical Cycles*.
11. **Rafter**, P.A., D.M. Sigman, K.R.M. Mackey. (2017) New production requires recycled iron in the eastern equatorial Pacific. *Nature Communications*.
10. **Rafter**, P.A., S.C. Sanchez, E. Druffel, J. Southon and others. (2017) Eastern tropical North Pacific coral radiocarbon reveals North Pacific Gyre Oscillation variability. *Quaternary Science Reviews*.
9. Marconi, D., S. Kopf, P.A. **Rafter**, and D.M. Sigman. (2017) Aerobic respiration along isopycnals leads to overestimation of the isotope effect of denitrification in the ocean water column. *Geochimica et Cosmochimica Acta*.
8. **Rafter**, P.A. and D.M. Sigman. (2016) The spatial and temporal variation of upper equatorial Pacific nitrate utilization. *Limnology and Oceanography*.
7. Marconi, D., D.M. Sigman, P.A. **Rafter** and others. (2015) Nitrate isotope distributions on the US GEOTRACES North Atlantic cross-basin section. *Marine Chemistry*.
6. Fripiat, F., D.M. Sigman, S.E Fawcett, P.A. **Rafter**, and J.L. Tison. (2014) Sea Ice nitrogen biogeochemical dynamic from an isotopic perspective. *Global Biogeochemical Cycles*.
5. **Rafter**, P. A., P.J. DiFiore, and D. M. Sigman. (2013) Coupled nitrate nitrogen and oxygen isotopes and organic matter remineralization in the Southern and Pacific Oceans. *JGR-Oceans*.
4. DeVries, T., C. Deutsch, P. A. **Rafter**, and F. Primeau. (2013), Marine denitrification rates determined from a global 3-dimensional inverse model. *Biogeosciences*.
3. **Rafter**, P.A. and C.D. Charles. (2012) Pleistocene equatorial Pacific dynamics inferred from zonal gradients in nitrogen isotopes. *Paleoceanography*.
2. **Rafter**, P.A., C.D. Charles, D.M. Sigman, G.H. Haug and J. Kaiser. (2012) Subsurface tropical Pacific nitrogen isotopic composition of nitrate: biogeochemical signals and their transport. *Global Biogeochemical Cycles*.

1. **Rafter**, P.A., S.L. Jaccard, E.D. Galbraith, T. Kiefer, and M. Kienast. (2011) The nitrogen cycle in the ocean, past and present: 2nd NICOPP meeting report. *PAGES Newsletter*.

MANUSCRIPTS IN PREPARATION

- Rafter**, P.A., J-C. Herguera, J. Carriquiry, E. A. Solomon, and J. R. Southon. A deglacial carbon budget for the Gulf of California: potential influence of seafloor volcanism. *In prep.* (ms available).
- White, M.E., **P.A. Rafter**, L. Aluwihare. Recent increases in water column denitrification in the seasonally anoxic bottom waters of the Santa Barbara Basin. *In preparation* (ms available).
- Sato, M., **Rafter, P.A.** et al. The proteomics and geochemistry of the tropical Pacific oxygen minimum zone. *In preparation*.
- Demming, J., **P.A. Rafter, et al.** Ocean memory for a sea change in the ocean sciences. (*An invited 'Perspective' article for PNAS*).
- Rafter, P.A.**, A. Bagnell, T. DeVries, and J.J. Becker. Nitrate isotopes point to the subsurface source of upwelled water.
- Rafter, P.A.**, A. Martiny, and K. Moore. Global rates of limiting nutrient recycling. *In preparation*.
- Rafter, P.A.**, E. Druffel, J. Southon. Interannual variability of Gulf of California upwelling from coral radiocarbon.
- Rafter, P.A.**, A. Bagnell, T. DeVries. Deep-sea nitrate remineralization suggests efficient carbon export through oxygen deficient waters.

GRANTS/FELLOWSHIPS: Total Acquired: \$171,500

- UC-MEXUS. Is the Gulf of California a source of the greenhouse gas carbon dioxide to the atmosphere?: \$1,000. 2018. CURRENT.
- GEOTRACES / PAGES. Trace element and isotope proxies in paleoceanography: \$3,000. 2018.
- NSF MG&G Research Experience for Undergrads. \$15,000. 2018. CURRENT.
- UCI UNDERGRADUATE RESEARCH OPPORTUNITIES PROGRAM with Matthew Chan and Chassidy Manlapid. \$1,000. 2018. CURRENT.
- NSF OCE-16-36005. Analytical and modeling training program for paleo-pCO₂ reconstructions. \$1,500.
- COMER SCIENCE AND EDUCATION FOUNDATION. Searching for enhanced seafloor volcanism and carbon flux during the last deglaciation. \$14,000. 2017.
- NSF MG&G. Targeted equatorial Pacific foraminifera-bound N isotope measurements: implications for a rare record of nutrient dynamics and the El Niño-Southern Oscillation. \$99,000. CURRENT.
- UCI UNDERGRADUATE RESEARCH OPPORTUNITIES PROGRAM with Diana Nguyen. \$1,000. 2016.
- UCI UNDERGRADUATE RESEARCH OPPORTUNITIES PROGRAM with Gabrielle Lee. \$1,000. 2015.
- OCEAN DRILLING PROGRAM-Schlanger Fellowship (NSF-sponsored). \$30,000. 2005.
- CALIFORNIA SPACE INSTITUTE Fellowship (UC-sponsored). \$5,000. 2004.

PENDING: \$328,697

- NAT'L GEOGRAPHIC SOCIETY. Carbon and nutrient measurements in the Mexico's Gulf of CA 'set the scene' for extremophiles and other marine life. \$28,697.
- NSF MG&G. Collaborative Research: Multi-proxy investigation of deglacial ocean carbon chemistry with radiocarbon and boron isotopes. \$300,000. (To be submitted December 2018. Rafter PI.)

HONORS / AWARDS / INVITATIONS

- Plenary speaker for GEOTRACES/PAGES synthesis workshop on geochemical tracers used in paleoceanography. Aix, France. 2018.
- National Academies Keck Futures Initiative for Ocean Memory. Participant and Organizing Committee: 2017-to-2020.
- US CLIVAR Tropical Pacific Observing System 2020 workshop. Boulder, CO. 2018
- AGU Outstanding Reviewer for *GBC* and *GRL* (1 of 4 total awardees). 2017.

NSF Expert Witness Training Academy. 2014.
NSF Marine Geoscience Leadership Symposium. 2013.
NSF Ocean Leadership Early Career Geoscience Symposium. 2011.

INVITED PRESENTATIONS

UC Santa Cruz. *Rethinking iron fertilization & the marine biological pump on seasonal to ice age timescales*. 2019.

GEOTRACES/PAGES workshop (Aix, France). **PLENARY LECTURE**. *Rethinking iron fertilization & the marine biological pump on seasonal to ice age timescales*. 2018.

University of South Florida. *Rethinking iron fertilization & the marine biological pump on seasonal to ice age timescales*. 2018.

University of Washington. *Rethinking iron fertilization & the marine biological pump on seasonal to ice age timescales*. 2018.

University of Southern California. *Rethinking iron fertilization & the marine biological pump on seasonal to ice age timescales*. 2018.

Oregon State University. *Iron recycling is critical for new primary production in all nitrate-rich, iron-limited ocean regions*. 2018.

Changelings / Comer Foundation Climate Conference. *A song of Ice and Fire and CO₂: linking seafloor volcanism and CO₂ efflux during the deglaciation*. 2017.

Gordon Chemical Oceanography. *Iron recycling fuels nitrate consumption, new primary production, and the biological pump in most HNLC regions*. 2017.

Rutgers University. *A song of Ice and Fire and CO₂: linking seafloor volcanism and CO₂ efflux during the deglaciation*. 2017.

Pomona College. *A song of Ice and Fire and CO₂: linking seafloor volcanism and CO₂ efflux during the deglaciation*. 2017.

CICESE (Centro de Investigación Científica y Educación Superior de Ensenada) *A song of Ice and Fire and CO₂: linking seafloor volcanism and CO₂ efflux during the deglaciation*. 2017.

UCSD-Scripps Institution of Oceanography. *Iron recycling drives New Production in HNLC region*. 2017.

UC Riverside. *The future of ENSO from Plio-Pleistocene sediments*. 2016.

California Institute of Technology. *Iron recycling drives New Production in HNLC region*.

Stanford University. *How to survive a High Nutrient-Low Chlorophyll region: insight to the internal cycling of iron and nitrogen*. 2015.

UC Santa Barbara. *How to survive a High Nutrient-Low Chlorophyll region: insight to the internal cycling of iron and nitrogen*. 2015.

University of Southern California. *Building a new view of the Plio-Pleistocene tropical climate*. 2015.

Richard Stockton State University of NJ. *The past and future of El Niño*. 2014.

UCSD-Scripps Institution of Oceanography. *South Pacific respiration and the dual isotopic composition of nitrate*. 2014.

California Institute of Technology. *3-Myr history of equatorial Pacific upwelling and Permanent El Niño*. 2014.

UC Irvine. *3-Myr history of equatorial Pacific upwelling and Permanent El Niño*. 2014.

Ocean Sciences. *A 3-Myr history of equatorial Pacific upwelling, Permanent El Niño, and a summary of the session's results*. 2014.

Columbia University-Lamont Doherty Earth Observatory. *3-Myr history of equatorial Pacific upwelling and Permanent El Niño*. 2014.

Yale University. *3-Myr history of eq. Pacific upwelling and Permanent El Niño*. 2013.

Woods Hole Oceanographic Institution. *South Pacific respiration and the dual isotopic composition of nitrate*. 2013.

Goldschmidt Conference. Florence, Italy. *South Pacific respiration and the dual isotopic composition of nitrate*. 2013.

Woods Hole Oceanographic Institution. Nitrate isotopes as a pseudo-sediment trap. 2013.
 Middle Township High School. *Science is NOT boring: isotopes and the ice ages*. 2013.
 UNC-Wilmington. *Science from the Sea Surface through the Seafloor*. 2013.
 Coastal Carolina University. *Science from the Sea Surface through the Seafloor*. 2013.
 Dalhousie University. Nitrogen Cycle in the Ocean, Past and Present Workshop. 2011.
 Rutgers University. *Tropical reign? A 1.2 million year record of nutrient dynamics in the eastern equatorial Pacific*. 2010.
 CICESE (Centro de Investigación Científica y Educación Superior de Ensenada) (Ensenada, Mexico). *A 1.2-Myr record of eastern equatorial Pacific thermocline depth from sediment nitrogen isotopes*. 2010.
 UCLA. *New insight to tropical Pacific circulation using isotopic tracers*. 2009.
 University of Southern California. *Tropical Pacific nutrient dynamics of the past 1-Myr*. 2008.

TEACHING / MENTOR EXPERIENCE

Mentor: Jazmin Amanda Sanchez. Undergraduate research. 2018.
 Mentor: Matthew Chan. Undergraduate research. 2018.
 Mentor: Chassidy Manlapid. Undergraduate research. 2018.
 Guest Lecture for K. Johnson at UCI: "Isotope Geochemistry". 2018.
 Guest Lecture for J. Ferguson at UCI: "The Ocean and Atmosphere". 2018.
 Mentor: Matthew Chan. Undergraduate research. 2017.
 Mentor: Alyssa Mariah de la Rosa. Undergraduate research. 2017.
 Mentor: Juan Manuel Troncoso. Undergraduate research. 2017.
 Mentor: Diana Nguyen. Undergraduate research and UCI Senior Thesis. 2016.
 Mentor: Abigail Ambriz. UCI undergraduate research experience. 2016.
 Mentor: Abigail Ambriz. UCI undergraduate research experience. 2015.
 Mentor: Stephanie Silva. UCI undergraduate research experience. 2016.
 Mentor: Stephanie Silva. UCI undergraduate research experience. 2015.
 Guest Lectures for Kathleen Johnson at UCI: "Introduction to Paleoclimatology". 2015.
 Mentor: Annalysha Lafferty. UCI undergraduate research experience. 2015.
 Mentor: Mina Nada. UCI undergraduate research experience. 2015.
 Mentor: Philip Andre Nazareta. UCI undergraduate research experience. 2015.
 Mentor: Franloie Cruz. UCI undergraduate research experience. 2015.
 Mentor: Ian Kamus. UCI undergraduate research experience. 2015.
 Mentor: Gabriella Lee. Undergraduate research and UCI Senior Thesis. 2015.
 Mentor: Gabriella Lee. Undergraduate research and UCI Senior Thesis. 2014.
 Mentor: Araceli Serrano. UCI undergraduate research experience. 2015.
 Mentor: Araceli Serrano. UCI undergraduate research experience. 2014.
 Mentor: Rachel Coons. UCI undergraduate research experience. 2014.
 Mentor: Johann Lopez. UCI undergraduate research experience. 2014.
 Guest Lecture for Jorge Sarmiento at Princeton University: "Ocean Biogeochemistry". 2012.
 Mentor: Tyler Tamasi Princeton University, summer internship. 2012.
 Mentor: Samantha Csik Northeastern University, summer internship. 2012.
 Mentor (w/Daniel Sigman): Lydia Rudnick Princeton University, junior thesis. 2011.
 Mentor (w/Daniel Sigman): Jacob Kim Princeton University, summer internship. 2010.
 Mentor (w/Lihini Aluwihare): Ulisses Barraza (SD Ocean Discovery Institute). 2008.
 Teaching Assistant for Chris Charles, Intro. Environmental Systems, SIO, UCSD. 2008.
 Teaching Assistant, Lihini Aluwihare, CA Coastal Oceanography, SIO, UCSD. 2007.
 Teaching Assistant, Chris Charles, Intro. to Environmental Systems, SIO, UCSD. 2007.
 Teaching Assistant, Lynne Talley, Intro. to Environmental Systems, SIO, UCSD. 2006.
 Teaching Assistant, Gabi Laske, EARTH/SIO 10: Natural Disasters, SIO, UCSD. 2005.
 Teaching Assistant, Gabi Laske, EARTH/SIO 10: The Earth, SIO, UCSD. 2004.

Teaching Assistant, Sam Iacobellis, The Atmosphere, SIO, UCSD. 2003.

RESEARCH FIELD EXPERIENCE (Select)

Project director. Sargasso Sea. CTD, plankton tows, *in-situ* filtering and more (November BATS cruise). 7 days on *RV Atlantic Explorer*. 2013.

Project director. Sargasso Sea. CTD, plankton tows, *in-situ* filtering and more (April BATS cruise). 7 days on *RV Atlantic Explorer*. 2013.

Project director. Sargasso Sea. CTD, plankton tows, *in-situ* filtering and more (November BATS cruise). 5 days on *RV Atlantic Explorer*. 2012.

Project director. Sargasso Sea. CTD, plankton tows, *in-situ* filtering and more (July BATS cruise). 5 days on *RV Atlantic Explorer*. 2012.

Project director. Sargasso Sea. CTD, plankton tows, *in-situ* filtering and more (April Bermuda Atlantics Time Series (BATS) cruise). 5 days on *RV Atlantic Explorer*. 2012.

Multi-coring, box-coring, seawater sampling in the Santa Barbara Basin. 5 days on the *RV Sproul*. 2008.

Gravity-coring, dredge recovery, seawater sampling in the Arabian Sea. 21 days on the *RV Roger Revelle*. 2007.

Lacustrine sediment freeze-coring on Swamp Lake, Yosemite National Park. 4 days remote field-work. 2006.

CTD technician, seawater sampling in the eastern tropical Pacific. 40 days on the *RV Ka'imimoana*. 2005.

Sediment pore-water and seawater preparation. 8 days on the *RV Atlantis*. 2002.

TEACHING & INCLUSIVE EXCELLENCE TRAINING

Improving Student Learning Outcomes Assessment: Diversity, Efficiency, and Effectiveness. Workshop Participant. 2018

Inclusive Teaching for Non-Native English Speakers and International Students. Workshop Participant. 2017.

Helping Promote Academic Success for First Generation Undocumented Students. Workshop Participant. 2017.

UC Irvine First Generation Faculty Initiative. Member. 2017.

UCSD Center for Teaching Development Training. Participant 2003.

PROFESSIONAL SERVICE

Chair: Ocean Sciences 2018: *Building biogeochemical bonds: Identifying the influence of macro and micro-nutrient cycling on marine carbon and nitrogen*

Chair: AGU 2017: *Linking the fluid and solid Earth: The role of terrestrial and submarine volcanism in the Plio-Pleistocene ice ages*

Chair: Goldschmidt 2016: Goldschmidt Geochemistry: *Marine Biogeochemistry at a Range of Scales: The Global Ocean and Polar Atmosphere-Sea Ice-Ocean Systems*.

Chair: Ocean Sciences 2016: *Mode and Intermediate Waters: Their Contributions to Physical, Biological, Chemical, and Climate Processes*.

Chair: Goldschmidt 2013 (17c: Changing ocean oxygen: Past, present, future)

Reviewer: AGU-Geophysical Research Letters (>15), AGU-Global Biogeochemical Cycles (>10), AGU-Journal of Geophysical Research-Oceans (>5), AGU-Paleoceanography (>10), Deep Sea Research (2), Earth and Planetary Science Letters (2), EGU-Biogeosciences (2), Limnology and Oceanography (>5), Marine Chemistry (2), National Geographic Society (1), National Research Foundation-South Africa (2), Nature Geoscience (1), NSF OCE-Marine Geology and Geochemistry (>10), NSF OCE-Chemical Oceanography (>5), NSF-International Ocean Discovery Program (2), Philosophical Transactions of the Royal Society A (1). Nature Geoscience (2).

MEDIA

Environmental Monitor (March 7, 2018). *Iron Hoarding and Recycling by Aquatic Plants in the Pacific*
Geochemical News (Feb 20, 2018). Top Story: *Oceanographers solve mystery of phytoplankton survival in nutrient-poor Pacific*
UC Irvine News (Feb 14, 2018). *UCI oceanographers solve mystery of phytoplankton survival in nutrient-poor Pacific; Essential iron is hoarded and recycled by the climate-regulating aquatic plants*