

# Andrew D. Mullen

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## EDUCATION

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2018	Ph.D.	Electrical Engineering	University of California San Diego
2015	M.S.	Oceanography	University of California San Diego, Scripps Inst. of Oceanography
2011	B.S.	Civil Engineering	University of Notre Dame, <i>Magna Cum Laude</i>

## PROFESSIONAL EXPERIENCE

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2022-Present	Senior Research Engineer	Cornell University
2018-2022	Postdoctoral Fellow	Georgia Institute of Technology, NASA Postdoctoral Program
2021, Fall	Visiting Researcher	University of Otago, New Zealand
2019, Summer	Visiting Researcher	NASA Jet Propulsion Lab

## SUMMARY

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- Engineer with over 10 years of experience on NASA and NSF projects developing technology for exploration.
- Designed and built scientific tools integrating optics, computing, electrical engineering, and mechanical design.
- Member of interdisciplinary teams operating these instruments in extreme polar and marine environments.

## AWARDS & HONORS

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2021	Antarctic Service Medal
2018	NASA Postdoctoral Program (NPP) Fellowship
2017	Microscopy Today Innovation Award
2014	Link Ocean Engineering Ph.D. Fellowship
2013	BSF Rahamimoff Travel Grant
2013	SIO Student Excellence Travel Award
2012	NSF Graduate Research Fellowship Program (GRFP)
2011	University of California Regents Fellowship
2009	NOAA Hollings Scholarship

## ENGINEERING & RESEARCH EXPERIENCE

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### NASA Postdoctoral Fellow, Georgia Institute of Technology (Supervisor: Dr. Britney Schmidt)

- *Icefin ROV*: Engineer on three Antarctic campaigns deploying custom underwater robot 'Icefin'. Optimized mechanical operations, coordinated vehicle launches, and troubleshoot system issues. Team surveyed previously inaccessible sub-glacial ocean environments providing critical measurements for modeling sea level rise.
- *Digital Holographic Microscope (DHM)*: Led collaboration with Georgia Tech & NASA JPL developing a submersible DHM for the Icefin ROV. Instrument integrates optical, mechanical, electrical, and embedded computing elements. DHM observed microbial life in Antarctica an analog for future "ocean world" exploration.
- *Subsurface Science & Search for Life on Ocean Worlds*: Co-led design conceptual payload for future NASA mission to the moon Europa. Coordinated 10+ member team, surveying state-of-the-art technologies from earth and space science. Presented framework for integrating tools into multi-sensor life-detection package.

### Doctoral Student, UC San Diego (Advisor: Dr. Jules Jaffe)

- *Benthic Underwater Microscope*: Jointly developed, first system to image seafloor subjects such as corals underwater at micron-scale. Payload integrates optics, illumination, focus tunable lens, and electronics into a submersible package. Applied system to study coral behavior and bleaching in natural environments.
- *Micro-Particle Tracking Velocimetry*: Enhanced underwater microscope to measure micro-scale fluid dynamics. Implemented dark-field illumination with precision timing, and developed particle tracking code. Measured viscous boundary layer surrounding coral polyps and perform Fourier analysis of fluctuating velocity fields.

- *Towed Microscope*: Engineering lead on integration and deployment of towed microscopic imaging system. Deployed system to investigate the transport and dispersion of eggs following mass Grouper spawning.

## Undergraduate Research

- *Groundwater Hydrology, Benin Africa*: Conducted hydrology measurements at remote field sites to study coastal saltwater intrusion. Lead small international team in field work, taught sampling methods, designed low-cost hydraulic field instruments, analyzed groundwater models. (Advisor: Dr. Stephen Silliman)
- *NOAA Hollings Scholar, University of Alaska Fairbanks*: Prepared and deployed ocean gliders and HF radars collecting data for pollution spill models in Arctic Ocean. (Advisor: Dr. Tom Weingartner)

## ENGINEERING & RESEARCH SKILLS

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### Technical Skills

- *Computing*: data analysis, image processing, computer vision, Fourier analysis [*Python, Matlab*]
- *Electrical*: PCB design, implementation of embedded computers and micro-controllers [*Eagle, Python*]
- *Mechanical*: mechanical design, pressure housing design, 3D printing [*Solid Works*]
- *Optical*: imaging systems, microscopy, holography, computational imaging
- *Fluidic*: particle tracking velocimetry observations, fluid dynamics, water sampling systems

### Engineering Design & Management

- *Management*: coordinated stakeholders, defined engineering requirements, managed timelines and budgets
- *Instrument Development*: performed design, procurement, fabrication, debugging, validation, and deployment
- *Systems Engineering*: integrated optical, electrical, mechanical, and software subsystems
- *Requirements*: designed systems for operation underwater, at low temperatures, in compact form factors
- *Communication*: wrote technology grant proposals, communicated results through technical papers and talks

### Field Operations & Logistics

- *Planning*: collaboratively developed field objectives, mission plans, team roles, and operating procedures
- *Logistics*: coordinated international shipping, identified and acquired field operational equipment
- *Teamwork*: performed tightly coordinated team operations in dynamic environments, experienced in both support and leadership roles, member of diverse international field teams of varying size (2-20+ members)
- *Settings*: conducted research in polar, marine, and wetland environments; including isolated settings
- *Platforms*: deployed instrumentation using ROVs, research vessels, SCUBA, and snow mobile

## PUBLICATIONS

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### Journal Publications

1. SE Silliman, BI Borum, M Boukari, N Yalo, S Orou-Oete, D McInnis, C Fertenbaugh, **AD Mullen**, "Issues of sustainability of coastal groundwater resources: Benin, West Africa", *Sustainability* 2, 2652–2675 (2010). <https://doi.org/10.3390/su2082652>
2. **AD Mullen**, T Treibitz, PLD Roberts, ELA Kelly, R Horwitz, JE Smith, JS Jaffe, "Underwater Microscopy for In Situ Studies of Benthic Ecosystems", *Nature Communications* 7, 12093 (2016). <https://doi.org/10.1038/ncomms12093>
3. JD Lawrence, **AD Mullen**, FE Bryson, CJ Chivers, AM Hanna, T Plattner, EM Spiers, JS Bowman, JJ Buffo, JL Burnett, CE Carr, DJ Dichek, KHG Hughson, W King, EG Lightsey, E Ingall, J McKaig, MR Meister, S Pierson, Y Tomar, BE Schmidt, "Subsurface Science and Search for Life in Ocean Worlds", *Planetary Science Journal* 4, 22 (2023). <https://doi.org/10.3847/PSJ/aca6ed>
4. BE Schmidt, PM Washam, PED Davis, KW Nicholls, DM Holland, JD Lawrence, KL Riverman, JA Smith, A Spears, DJG Dichek, **AD Mullen**, E Clyne, B Yeager, P Anker, MR Meister, BC Hurwitz, ES Quartini, FE Bryson, A Basinski, C Thomas, J Wake, DG Vaughan, S Anandakrishnan, E Rignot, J Paden, K Makinson, "Heterogeneous melting near the Thwaites Glacier grounding line", *Nature* 614, 471–478 (2023). <https://doi.org/10.1038/s41586-022-05691-0>
5. PED Davis, KW Nicholls, DM Holland, BE Schmidt, PM Washam, KL Riverman, RJ Arthern, I Vaňková, C Eayrs, JA Smith, PGD Anker, **AD Mullen**, DJ Dichek, JD Lawrence, MR Meister, E Clyne, A Basinski-Ferris, E Rignot, BY

- Queste, L Boehme, KJ Heywood, S Anandakrishnan, K Makinson, “Suppressed basal melting in the eastern Thwaites Glacier grounding zone”, *Nature* 614, 479–485 (2023). <https://doi.org/10.1038/s41586-022-05586-0>
6. JD Lawrence, PM Washam, C Stevens, C Hulbe, HJ Horgan, G Dunbar, T Calkin, C Stewart, N Robinson, **AD Mullen**, MR Meister, B Hurwitz, ES Quartini, DJ Dichek, A Spears, BE Schmidt, “Crevasse refreezing and signatures of retreat observed at Kamb Ice Stream grounding zone”, *Nature GeoSciences* (2023). <https://doi.org/10.1038/s41561-023-01129-y>
  7. (*Accepted*) FE Bryson, ED Ingall, AM Hanna, M Cardelino, T Plattner, MR Meister, JD Lawrence, **AD Mullen**, D Dichek, BE Schmidt, “Development of the Miniature Robotic Electrodialysis (MR ED) System for Small-Scale Desalting of Liquid Samples with Recovery of Organics”, *Earth and Space Science*.
  8. (*In Review*) BC Stock, **AD Mullen**, JS Jaffe, A Candelmo, SA Heppell, CV Pattengill-Semmens, CM McCoy, BC Johnson, BX Semmens, “Protected fish spawning aggregations as self-replenishing reservoirs for regional recovery”, *Proceedings of the Royal Society B*.
  9. (*In Review*) BE Schmidt, F Bryson, C Chivers, N Daniel, J Lawrence, S Pierson, A Hodges, B Wiley, S Rappaport, A Hanna, E Spiers, T Plattner, M Meister, **AD Mullen**, DJG Dichek, J Burnett, EG Lightsey, C Carr, K Hughson, Y Tomar, M Nassif, P Szot, W King, M Mohanalingam, R Ogilvie, J Buffo, J Bowman, C Walker, S Purkey, A Spears and the VERNE Team, “Vertical Entry Robot for Navigating Europa (VERNE): an ocean-profiling thermo-mechanical subsurface mission concept for searching for life”, *Planetary Science Journal*.
  10. (*In Prep*) P Washam, JD Lawrence, CL Stevens, CL Hulbe, HJ Horgan, NJ Robinson, CL Stewart, A Spears, ES Quartini, B Hurwitz, MR Meister, **AD Mullen**, DJ Dichek, F Bryson, BE Schmidt, “Ice-ocean interactions in an ice shelf crevasse”

## Conference Publications

1. **AD Mullen**, T Treibitz, PLD Roberts, JS Jaffe, “An Underwater Microscope for In Situ Imaging of Seafloor Organism”, *Optical Society of America, Novel Techniques in Microscopy 2017* (2017). <https://doi.org/10.1364/ntm.2017.ntu1c.1>
2. **AD Mullen**, DJG Dichek, JD Lawrence, MR Meister, FE Bryson, BC Hurwitz, AM Spears, PM Washam, E Quartini, BE Schmidt “A Robust Compact Water Sampler For Underwater Robotic Vehicles”, *IEEE Oceanic Engineering Society, Global OCEANS 2020* (2020). <https://doi.org/10.1109/ieeconf38699.2020.9389327>
3. M Meister, D Dichek, A Spears, B Hurwitz, F Bryson, **AD Mullen**, J Lawrence, P Washam, E Quartini, S Lopez, L Kassabian, P Anker, D Mandeno, BE Schmidt, “Antarctic Deep Field Deployments and Design of the Icefin ROV”, *IEEE Oceanic Engineering Society, Global OCEANS 2020* (2020). <https://doi.org/10.1109/ieeconf38699.2020.9389361>
4. B Hurwitz, M Thomas, JD Lawrence, P Washam, MR Meister, DJ Dichek, **AD Mullen**, AM Spears, K Haas, BE Schmidt, “CTD-on-a-Chip: High-Precision Polar In-situ Interfacial Data Collection”, *IEEE Oceanic Engineering Society, Global OCEANS 2020* (2020). <https://doi.org/10.1109/ieeconf38699.2020.9389175>
5. F Bryson, MR Meister, DJ Dichek, **AD Mullen**, BC Hurwitz, JD Lawrence, AM Spears, P Washam, ES Quartini, L Kassabian, S Lopez, BE Schmidt, “A Configurable Solid Sampling System for AUV/ROV Icefin”, *IEEE Oceanic Engineering Society, Global OCEANS 2020* (2020). <https://doi.org/10.1109/ieeconf38699.2020.9389075>
6. FE Bryson, M Nassif, PA Szot, CJ Chivers, N Daniel, BE Wiley, T Plattner, A Hanna, Y Tomar, S Rapoport, EM Spiers, S Pierson, A Hodges, J Lawrence, **AD Mullen**, D Dichek, K Hughson, MR Meister, EG Lightsey, BE Schmidt, “Vertical Entry Robot for Navigating Europa (VERNE) mission and system design”, *AIAA ASCEND 2020* pp. 4061 (2020). <https://doi.org/10.2514/6.2020-4061>
7. AJ Ramirez, BW Schierman, L Zheng, BM Dalporto, L Belvin, TP Burch, **AD Mullen**, JK Wallace, “A low-cost, submersible, digital holographic microscope for in situ microbial imaging”, *Optics and Photonics for Sensing the Environment*, JTu5A. 18, (2021). <https://doi.org/10.1364/AIS.2021.JTu5A.18>

## PhD Thesis

- **AD Mullen**, “Underwater Microscopic Imaging & Velocimetry for In Situ Studies of Benthic Marine Environments”, University of California San Diego (2018). <https://escholarship.org/uc/item/1p03v5t1>

## White Papers

1. BE Schmidt, SS Johnson, T Hoehler, H Graham, J Bowman, S Som, L Barge, N Cabrol, A Pavlov, A Pontefract, A Stockton, B Orcutt, B Nunn, C Foreman, D Stillman, E Shock, F Kenig, G Love, K Bergmann, P Sobron, R Mathies,

R Hatzenpichler, S Yu, W Swingley, D Jones, J Lawrence, F Bryson, E Spiers, C Chivers, T Plattner, **A Mullen**, A Hanna, J Buffo, “Enabling progress towards life detection on NASA missions”, Whitepaper #260 *Planetary Science and Astrobiology Decadal Survey 2023-2032* (2020). <https://doi.org/10.3847/25c2cfef.77a5ad8e>

2. B Schmidt, K Craft, T Cwik, K Zacny, M Smith, V Singh, B Stone, F Bryson, C Chivers, S Pierson, J Lawrence, T Plattner, E Spiers, **A Mullen**, J Buffo, N Daniel, A Hanna, G Lightsey, M Meister, M Nassif, D Dichek, A Spears, “Dive, dive, dive: Accessing the Subsurface of Ocean Worlds”, Whitepaper #246 *Planetary Science and Astrobiology Decadal Survey 2023-2032* (2020). <https://doi.org/10.3847/25c2cfef.ffef076e>

## PROJECTS

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Engineer and/or operational member on the following project grants:

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| 2019-2022 | “Oceans Across Space & Time (OAST)”, NASA Astrobiology Program, Award 80NSSC18K1301, PI: BE Schmidt  |
| 2021-2022 | “Unravelling the Role of Subglacial Channels in Ice Stream Evolution”, NSF Office of Polar Programs grant, Award #2152742, PI: BE Schmidt  |
| 2021      | “Supercooling measurements under ice shelves”, New Zealand Marsden Fund grant, Award MFP-U001825 PI: I Smith, Co-I: BE Schmidt   |
| 2019-2021 | “Vertical Entry Robot for Navigating Europa (VERNE)”, NASA Scientific Exploration Subsurface Access Mechanism for Europa (SESAME) grant, Award 80NSSC19K0615, PI: BE Schmidt   |
| 2021      | “Pingo SubTerranean Aquifer Reconnaissance and Reconstruction (Pingo STARR)”, NASA Planetary Science and Technology from Analog Research (PSTAR) grant, PI: BE Schmidt   |
| 2019-2020 | “Melting at Thwaites Grounding Zone and its Control on Sea Level (THWAITES-MELT)”, NSF-NERC Office of Polar Programs grant, Award #1739003, (International Thwaites Glacier Collaboration [ITGC]), PI: D Holland, Co-I: BE Schmidt |
| 2018-2020 | “Ross Ice Shelf and Europa Underwater Probe (RISEUP)”, NASA Planetary Science and Technology from Analog Research (PSTAR) grant, Award NNX16AL07G, PI: BE Schmidt  |
| 2018-2020 | “Digital Holographic Microscopy on the Icefin Underwater Antarctic Vehicle: Technology & Science Development for Icy Worlds”, NASA Postdoctoral Program fellowship, Lead: AD Mullen, Advisor: BE Schmidt                           |
| 2014      | “A Novel In Situ Microscope for Studying Benthic Organisms”, Link Ocean Engineering & Instrumentation PhD Fellowship Program, Lead: AD Mullen, Advisor: JS Jaffe   |
| 2012-2016 | NSF Graduate Research Fellowship Program (GRFP) grant, Award DGE-1144086, Lead: AD Mullen, Advisor: JS Jaffe   |

## FIELD EXPERIENCE

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### Certifications & Training

- SCUBA: AAUS Scientific Diver (2012), AAUS 100ft certification (2017); NAUI Advanced, Rescue, & Nitrox Diver (2012); over 150 total lifetime dives
- Antarctic Field Training (2018, 2019, 2021): Antarctic Field Safety, Sea Ice Safety, Field Plan Risk Assessment, Snowmobile Operations, Tracked Vehicle Operations, GPS, Communication

### Scientific Field Work

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| 2021 | Antarctic Field Season, Antarctica New Zealand (Oct-Jan): <ul style="list-style-type: none"> <li>▫ Kamb Ice Stream, K862 (5 wks, 1 Icefin ROV deployments) – Exploration of subglacial channel with ROV, genomic sampling of subglacial water, geophysical surveys, operations from remote field camp.</li> <li>▫ Scott Base, K750 (4 wks, 5 Icefin ROV deployments) – ROV hydrographic survey of Scott Base coast.</li> <li>▫ McMurdo Sound, K063 (3 wks, 8 Icefin ROV deployments) – Investigation of supercooling with ROV, deployment of submersible holographic microscope, operations from containerized sea ice camp.</li> </ul> |
| 2021 | Deadhorse, Alaska (3 wks) – Geophysical surveys of pingo ice formations using snow mobiles.   |
| 2019 | Antarctic Field Season, US Antarctic Program (Oct-Feb): <ul style="list-style-type: none"> <li>▫ Thwaites Glacier, C444 (4 wks, 5 Icefin ROV deployments) – Oceanographic exploration of Thwaites grounding zone, ROV deployments through 500m deep borehole, operations from remote field camp.</li> <li>▫ McMurdo Station, B041 (13 wks, 10 Icefin ROV deployments) – ROV surveys from sea ice.</li> </ul>  |
| 2018 | Antarctic Field Season, US Antarctic Program (Oct-Dec): <ul style="list-style-type: none"> <li>▫ McMurdo Station, B041 (9 wks, 22 Icefin ROV deployments) – ROV oceanographic exploration of</li> </ul>   |

- McMurdo Sound, testing of submersible water sample, operations from sea ice.
- 2018 Florida St. Coastal & Marine Lab (1 wk) – Icefin ROV ocean testing.
  - 2017 San Diego, California (winter quarter, 10 dives) – Teaching assistant for scientific dive course.
  - 2017 Cayman Islands (2 wks, 8 dives) – Small-boat deployment of towed microscope to study fish spawning.
  - 2016 Eilat, Israel (8 wks, 25 dives) – SCUBA study of coral micro-fluid dynamics using micro-PTV system.
  - 2016 San Diego (3 wks, 4 dives) – Small-boat deployments of towed microscope & smart drifters.
  - 2016 Cayman Islands (2 wks, 8 dives) – Small-boat deployments of towed microscope to study fish spawning.
  - 2015 Maui, Hawaii (2 wks, 11 dives) – SCUBA study of coral bleaching using Benthic Underwater Microscope.
  - 2014 San Diego, California (spring quarter, 17 dives) – SCUBA based ecology field course.
  - 2013 Eilat, Israel (9 wks, 38 dives) – SCUBA study of coral behavior using Benthic Underwater Microscope.
  - 2012 Palau (2012, 1 wk) - Deployment & recovery of ocean gliders via small-boat.
  - 2011-18 San Diego, California (> 6 day trips) – Research & course cruises aboard ocean research vessels.
  - 2011 South China Sea (2011, 3 wks) - Internal waves study aboard R/V Revelle using fast CTD casts.
  - 2010 Barrow & Wainwright, Alaska (2 wks) - Ocean glider and radar deployments on Arctic Ocean.
  - 2010 Death Valley, California (1 wk) - Geology field course.
  - 2009 Benin, West Africa (4 wks) – Collection of groundwater hydrology data in remote wetland field sites.
  - 2008 Benin, West Africa (4 wks) – Collection of groundwater hydrology data in remote wetland field sites.

### **International Collaborators**

Conducted field work involving collaboration with international partners: Antarctica New Zealand (ANZ); British Antarctic Survey (BAS); International Thwaites Glacier Collaboration (ITGC); Inter-University Institute for Marine Sciences, Israel (IUI); Cayman Islands Department of the Environment; University of Abomey-Calavi, Benin

### **Complimentary Recreational Field Activities**

- Endurance Athletics: Ironman Arizona 2022 (12hr 47min), Half Ironman Santa Cruz 2022 (05hr 27min)
- Backpacking: section hiked over 750 miles of the Pacific Crest Trail 2021 (over approx. 7 weeks)
- Mountaineering: rope team & glacier travel; summits of Mt. Rainer 2019 (14,411'), Mt. Baker 2019 (10,786'), Mt. Whitney 2021 (14,505')
- Team Athletics: Univ. Notre Dame Rugby 4-year starter (2008-11), Univ. Western Australia Rugby (2009)

## **MENTORING & SERVICE**

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### **Teaching Assistant**

- SIO 130 Scientific Diving - classroom work & ocean SCUBA sessions
- SIO 60 Experiences in Ocean and Atmospheric Sciences - classroom, lab, and field sessions including boat work

### **Advising & Mentoring**

- Scripps Peer-Mentorship Program - founding team and leadership committee member, mentor for PhD students Ludovic Tenorio and Madeleine Harvey
- Univ. of San Diego Senior Engineering Capstone Project, “A low-cost, submersible, digital holographic microscope for in situ microbial imaging”, (2021)
- Carl Snyder (Portland St. PhD student), JPL summer intern, Holographic Microscopy, (2019)
- Adela DePavia (Yale undergraduate student), SIO Summer Intern, Fish Scale Microfluidics, (2017)
- Peer Mentor: Madeline Harvey & Ludovic Tenorio, 2014-2016

### **Service**

- Proposal reviewer: NASA PICASSO, NASA FINNEST
- Community Workshops: Future of the Search for Life (FoSL) Science and Engineering Workshop (2021)

## CONFERENCES & SEMINARS

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### Invited Talks

1. **AD Mullen**, "Microscopes for Life Detection And Exploration: From Oceans To Space", *Network for Life Detection (NFOLD) Seminar*, Virtual (Oct 2020).
2. **AD Mullen**, "Microscopes for Earth & Space Exploration" *Georgia Tech Planetary Science & Astrobiology Seminar*, Atlanta, Georgia (Sept 2020).
3. **AD Mullen**, "Adventures with Underwater Microscopes: From the Tropics to the Poles", *Crary Library*, McMurdo Station, Antarctica (Oct 2019).
4. **AD Mullen**, "Microscopic Imaging of Coral & Fluid Motions", *SIO/SDSU Coral Club*, San Diego, California (Apr 2018)
5. **AD Mullen**, JS Jaffe, "Adventures in Underwater Microscopy." *Optical Society of America, Applied Industrial Optics*, San Francisco, California (June 2017).
6. **AD Mullen**, T Treibitz, PLD Roberts, JS Jaffe, "An Underwater Microscope for In Situ Imaging of Seafloor Organism." *Optical Society of America, Novel Techniques in Microscopy*, San Diego, California (April 2017).
7. **AD Mullen**, "Benthic Underwater Microscope," *Scripps Institution of Oceanography*, La Jolla, California (May 14).
8. **AD Mullen**, "In Situ Coral Microscopy," *Interuniversity Institute of Marine Sciences*, Eilat, Israel (Jan 2014)

### Conference Presentations & Abstracts

#### 2022

1. **AD Mullen**, C Snyder, B Schmidt, D Dichek, J Lawrence, MR Meister, Benjamin Hurwitz, E Quartini, FE Bryson, J Nadeau, JK Wallace, CA Lindensmith and Icefin Team, "Life Under Ice: Development and Application of a Submersible Holographic Microscope to Detect Microbial Motility in Antarctic Waters", *2022 Astrobiology Science Conference AGU* (2022).
2. BE Schmidt, FE Bryson, JD Lawrence, **AD Mullen**, CJ Chivers, N Daniel, E Spiers, SM Pierson, A Hodges, AM Hanna, BE Wiley, S Rapoport, TA Plattner, MR Meister, DJD Dichek, JR Burnett, EG Lightsey, CE Carr, KHG Hughson, and VERNE Team, "Vertical Entry Robot for Navigating Europa (VERNE): An ice- and ocean-profiling thermomechanical subsurface mission to search for life on Europa", *2022 Astrobiology Science Conference AGU* (2022). <https://agu.confex.com/agu/abscicon21/meetingapp.cgi/Paper/1032029>
3. FE Bryson, ED Ingall, AM Hanna, M Cardelino, T Plattner, MR Meister, JD Lawrence, **A Mullen**, D Dichek, BE Schmidt, "Development and Testing of a Miniature Robotic Electrodialysis (MR ED) System to Remove Salts for Ocean World Sampling", *2022 Astrobiology Science Conference AGU* (2022). <https://agu.confex.com/agu/abscicon21/meetingapp.cgi/Paper/1031618>

#### 2021

4. F Bryson, E Ingall, A Hanna, M Cardelino, T Plattner, M Meister, J Lawrence, **A Mullen**, D Dichek, B Schmidt, "Development and testing of a Miniature Robotic Electrodialysis (MR ED) system to remove salts for ocean world sampling", *AGU Fall Meeting Abstracts 2021*, P25E-2201 (2021). Bibcode: 2021AGUFM.P25E2201B
5. P Washam, B Schmidt, PED Davis, K Nicholls, D Holland, J Lawrence, K Riverman, J Smith, D Dichek, **A Mullen**, P Anker, M Meister, A Spears, B Hurwitz, E Quartini, F Bryson, E Clyne, B Yeager, A Basinski-Ferris, D Vaughan, S Anandakrishnan, E Rignot, J Paden, K Makinson, "Ice loss from asymmetric melting at Thwaites Glacier grounding zone", *AGU Fall Meeting Abstracts 2021*, C35A-0867 (2021). Bibcode: 2021AGUFM.C35A0867W
6. KHG Hughson, BE Schmidt, E Quartini, RJ Michaelides, MR Siegfried, **AD Mullen**, JH Bradford, A Swidinsky, HG Sizemore, "The Fool on the Hill: Chasing Pingos with Pingo STARR", *Workshop on Terrestrial Analogs for Planetary Exploration, LPI Contributions* 2595, 8061 (2021). Bibcode: 2021LPICo2595.8061H

#### 2020

7. BE Schmidt, P Washam, PED Davis, KWW, J Lawrence, J Smith, KL Riverman, D Dichek, **AD Mullen**, D Holland, A Basinski-Ferris, P Anker, MR Meister, A Spears, B Hurwitz, E Quartini, FE Bryson, W Rose Clyne, C Thomas, J Wake, D Glyn Vaughan, S Anandakrishnan, J Drysdale Paden, E J Rignot, B Yeager, K Makinson, "Melting at the Grounding Zone of Thwaites Glacier Observed by Icefin", *AGU Fall Meeting 2020*, C057-04 (2020). Bibcode: 2020AGUFMC057-04S

8. PED Davis, KW Nicholls, DM Holland, BE Schmidt, P Anker, JA Smith, D Dichek, AD Mullen, KL Riverman, A Basinski-Ferris, ER Clyne, "Oceanographic Conditions in the Grounding Zone Region of Thwaites Glacier", *AGU Fall Meeting Abstracts 2020*, C057-05 (2020). Bibcode: 2020AGUFMC057-05D
9. P Washam, B Schmidt, JD Lawrence, MR Meister, A Spears, KW Nicholls, PED Davis, C Stevens, **AD Mullen**, D Dichek, E Quartini, B Hurwitz, FE Bryson, HJ Horgan, CL Hulbe, D Holland, "A synthesis of ice-ocean boundary observations from the underwater vehicle Icefin", *AGU Fall Meeting 2020*, C022-0001 (2020). Bibcode: 2020AGUFMC022.0001W
10. EM Spiers, FE Bryson, **AD Mullen**, C Chivers, AM Hanna, K Hughson, JD Lawrence, T Plattner, ED Ingall, CE Carr, MR Meister, EG Lightsey, BE Schmidt, "VERNE Sample Intake and Processing (SIP): Investigation and Development of Liquid Water Sampling for Subsurface Probe on Europa", *AGU Fall Meeting 2020*, P044-0013 (2020). Bibcode: 2020AGUFMP044.0013S
11. **AD Mullen**, C Snyder, B Schmidt, D Dichek, JD Lawrence, MR Meister, FE Bryson, JL Nadeau, JK Wallace, CA Lindensmith. "A Submersible Digital Holographic Microscope for In Situ Microbial Imaging" *AGU Fall Meeting 2020*, P044-0011 (2020). Virtual Poster. Bibcode: 2020AGUFMP044.0011M
12. J Lawrence, B Schmidt, P Washam, CL Hulbe, HJ Horgan, C Stevens, GB Dunbar, MR Meister, B Hurwitz, E Quartini, D Dichek, A Spears, **AD Mullen**, FE Bryson, "ROV Icefin at Ross Ice Shelf Grounding Zone: 5 km of ice, ocean, seafloor, and crevasse exploration", *AGU Fall Meeting 2020*, C019-07 (2020). Bibcode: 2020AGUFMC019-07L
13. F. E. Bryson, M. R. Meister, J. Burnett, C. Chivers, B. Colón, N. Daniel, D. Dichek, A. M. Hanna, A. L. Hodges, K. Hughson, B. Hurwitz, J. D. Lawrence, **A. D. Mullen**, M. Nassif, S. Pierson, T. Plattner, S. Rapoport, A. Spears, E. Marie Spiers, P. Szot, Y. Tomar, B. Wiley, E. G. Lightsey, B. E. Schmidt, "Vertical Entry Robot for Navigating Europa (VERNE) - A Mission Concept and Identification of Technologies Needed to Access Europa's Ocean", *AGU Fall Meeting 2020*, P052-04 (2020). Bibcode: 2020AGUFMP052-04B
14. KL Riverman, S Anandakrishnan, ER Clyne, B Schmidt, P Washam, KW Nicholls, PED Davis, D Holland, A Basinski-Ferris, P Anker, J Smith, D Dichek, **A Mullen**, "Geometry of the eastern Thwaites ice shelf cavity and implications for continued grounding zone retreat", *AGU Fall Meeting Abstracts 2020*, C052-01 (2020). Bibcode: 2020AGUFMC052-01R
15. B Schmidt, K Nicholls, P Davis, J Smith, K Riverman, D Holland, D Dichek, **A Mullen**, J Lawrence, P Washam, A Basinski-ferris, P Anker, M Meister, A Spears, B Hurwitz, E Quartini, E Clyne, C Thomas, J Wake, D Vaughn, "The grounding zone of Thwaites Glacier explored by Icefin", *22nd EGU General Assembly*, id.20512 (2020). <https://doi.org/10.5194/egusphere-egu2020-20512>
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