Sounds Like Research: Graduate Student Stories

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Acoustic behavior of metamaterials. Oceanic stratification characterization. Foraging behavior of whales. These are just a few of the many research areas explored by our fellow and former members of the Acoustical Society of America (ASA) Student Council (see bit.ly/3GF5jPr). In this essay, we highlight several of our peers who inspire us, all of whom are either nearing graduation or recently graduated. See other *Acoustics Today* essays about students and the Student Council in "*AT* Collections" at bit.ly/3m5kMyP.

Colby Cushing

(see bit.ly/3NOjvYz) graduated in August 2021 with a PhD in mechanical engineering from the University of Texas (UT) at Austin where he is now working as a postdoctoral fellow in the Applied Research Laboratories. He first learned about acoustics as a possible career path from a counselor at Penn State University (University Park, Pennsylvania) who identified acoustics as a connector between Colby's undergraduate major in aerospace engineering and his passion for music. A conversation with Preston S. Wilson at an Acoustical Society of America (ASA) meeting resulted in Colby becoming a graduate student at UT Austin, where he found that his relationships with others in the acoustics program were crucial to his graduate experience. He explains his research as motivated by acoustic metamaterials.

> "My PhD research was focused on the characterization of underwater acoustic metamaterials (AMMs). One method of predicting the necessary material properties needed in exotic devices such as underwater acoustic cloaks is spatial transformations (transformation acoustics). These properties can be impossible to realize with standard materials. A metamaterial, with the Greek prefix *meta-* meaning beyond, is one whose dynamic performance goes beyond that of existing materials. The effective properties of AMMs exceed what is typically possible with standard mixing laws of composite materials by leveraging both subwavelength structures and composition and can be used to physically realize the material properties predicted by transformation acoustics. However, there are often complex geometries that can require state-of-the-art fabrication techniques (e.g., additively manufactured metal structures) and are especially difficult to experimentally characterize for underwater applications. In my work, I used new and existing experimental apparatuses to characterize specific underwater AMMs. I also explored the relationships between homogenization, numerical simulation, and fabrication methods."

Colby's current research uses the fundamental ideas in his work with metamaterials to examine the substructures present within seagrass leaves and their acoustic effects in underwater environments.

Lucy Ruoqian Cheng

(see lucyrc.github.io) will be graduating with a PhD in linguistics from the University of Kansas (Lawrence) this year. Lucy's undergraduate degree in the Chinese language from Fudan University (Shanghai, China) was only the start of her scholarship in linguistics, with her research now spanning colloquial Beijing, Mandarin, English, and Eastern Min (Fuzhou) languages. Lucy was drawn to acoustics while studying ongoing sound change across speakers, and she explores the effect of age on speech perception in her dissertation.

> "The way listeners process speech sounds changes across the life span, even when the hearing acuity has not yet started to decline. A better understanding of the aging effect in its early stage (55-65 years old) contributes to the advancement of speech technology (e.g., hearing aids and voice/user interfaces) to better fulfill the needs of an aging population. My doctoral dissertation investigated the influence of aging on speech perception by comparing speech perception

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and auditory perceptual plasticity in older versus younger adults with normal hearing. The experiments investigated the listeners' use of the acoustic signal and contextual information and tested how listeners adapt to ambiguity in speech sounds. Younger listeners exhibited greater perceptual plasticity than older listeners when adjusting their acoustic cue weighting, whereas both younger and older listeners demonstrated good use of contextual information."

In addition to her research, Lucy's care for people and language has led her to volunteer on a project developing Audio Speech Recognition training data and models for Eastern Min, her native tongue.

Hilary Kates Varghese

graduated with a PhD in oceanography from the University of New Hampshire (Durham) in December 2021. Her journey into bioacoustics began on an undergraduate field trip where she learned that whales sang in the New York, NY, harbor and that these whales were studied by scientists. She knew then that she wanted to be one of those scientists! After completing her degree in biological sciences at Cornell University (Ithaca, New York) and taking advantage of undergraduate research opportunities along the way, Hilary gained real-world work experience at an algal biofuel company while getting a master's degree in applied mathematics at Florida Gulf Coast University (Fort Myers). This provided her with the critical thinking and quantitative analysis skills needed to pursue her interests in understanding how human-generated sound affects marine life.

"My PhD research looked at the potential interaction between 12-kHz deepwater multibeam ocean-mapping activity and Cuvier's beaked whale foraging behavior. To the best of current understanding, this scenario represents a potential worst case for the interaction of ocean-mapping sonar with marine life due to the overlap in the use of this sound in areas where these animals live as well as in the frequency overlap of the sound with beaked whale hearing. To assess the potential effect, I performed spatial and temporal analyses on the echolocation clicks of beaked whales, used as a proxy of their foraging behavior, collected from an array of hydrophones spanning an 1,800-square-kilometer area. Changes in foraging behavior were assessed before, during, and after two 12-kHz multibeam mapping surveys conducted over the array. The results of my research showed that beaked whales in the area did not stop foraging and did not leave the area during the two surveys, revealing that the mapping activity did not adversely affect beaked whale foraging."

Hilary always hoped that her research would influence marine policy and noise regulation in the ocean, and she strengthened her science communication skills during an internship with *Acoustics Today* (see bit.ly/3Q0OVgy). Now, in her role as a marine bioacoustician with the Bureau of Ocean Energy Management (a part of the US Department of the Interior), she is putting her expertise to use everyday.

Mark Langhirt

(see bit.ly/3t8txMw) graduated with a PhD from Penn State University (State College, Pennsylvania) this year. While working as a civilian on autonomous underwater robots with naval sonars, he became convinced that "acoustics is one of the best tools we have for studying the ecosystems and dynamics that shape the hidden world beneath the waves." This experience, combined with his undergraduate degree in physics, motivated Mark to gain a deeper theoretical understanding of underwater environments by studying acoustics at the graduate level. Mark focused his research on the following question: How can we construct an underwater acoustic propagation model that is less computationally expensive than the alternatives and capable of capturing primary effects we see in three-dimensionally inhomogeneous underwater environments?

"My research focuses on deriving and implementing 3D underwater acoustic propagation models based on energy conservation principles. The energy flux method integrates modal acoustic energy directly without solving for eigenvalues, and therefore takes significantly less time to execute compared to other propagation models. My contribution has been to extend the 2D energy flux theory and derive semi-coherent 3D energy flux models that capture horizontal refraction and focusing in underwater environments like shorelines and canyons. The models are verified by comparison with both analytical solutions and other

3D acoustic propagation models. As far as we are aware, these are the first semi-coherent 3D energy flux models that have been developed. These models could be beneficial in autonomous remote sensing networks with limited computational resources or in scenarios with uncertain acoustic environmental parameters."

After graduation, Mark hopes to continue working in ocean sciences research, with either an independent or government-affiliated research lab.

Elizabeth Weidner

(see bit.ly/3M5lXJb) graduated this summer with a joint PhD from the University of New Hampshire (Durham) and Stockholm University (Stockholm, Sweden). She first became "hooked" on acoustical oceanography when, as an undergraduate, she learned that "sound could provide observations of the deep ocean where light could not." As a geophysicist in the private sector, she used acoustic systems to map the water column and seafloor, developing an increasing interest in the impact of climate change on the Arctic Ocean. These experiences ultimately led Elizabeth to enroll as a graduate student at the Center for Coastal and Ocean Mapping (CCOM) at the University of New Hampshire where she asks: How can we leverage broadband acoustic data to better understand processes within the ocean water column (and seafloor)?

"My PhD research is focused on the acoustic analysis of oceanic density stratification structure utilizing broadband split-beam echo sounders. Stratification structure is a ubiquitous feature in the world's oceans and influences the vertical transport of heat and many dissolved constituents (e.g., nutrients, carbon, oxygen) in the water column. While scientists have been using acoustic systems to observe scattering from ocean structure for many decades, my work has leveraged the high SNR, vertical range resolution, and frequency-modulated scattering of broadband systems to move beyond just observation to tracking, analysis, and acoustic inversion for the estimations of physical water column properties. I hope my work will be used to better understand evolving spatiotemporal changes in ocean stratification from climate change."

After defending her dissertation in both New Hampshire and Stockholm, Elizabeth will work as a research scientist at the CCOM before starting a postdoc in early 2023.

Overview

Although these graduate students pursued very different research topics, they all credit participation in the ASA as contributing to their professional and personal success. Elizabeth identified service to the community as a "hugely important part of career development," an idea that Hilary echoed. They also discussed, along with Lucy and Mark, the value in attending ASA meetings, presenting your work, and meeting other researchers. Colby also reflected on how inspiring ASA meetings are, even as he noted the imposter syndrome that can sometimes come when you're surrounded by impressive researchers. He joined the ASA Student Council hoping "to help new students continue to feel welcomed in the Society but not overwhelmed by the gravity of the organization so that they can feel comfortable making an immediate positive impact." The impact of these individuals has certainly been felt on the ASA Student Council, and we look forward to seeing where their careers take them.

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