Conversation with a Colleague: Jennifer Cooper

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Meet Jennifer Cooper

Jennifer Cooper is the next acoustician in our "Sound Perspectives" series "Conversation with a Colleague." Dr. Cooper is currently a program scientist at the Johns Hopkins Applied Physics Laboratory (APL), Laurel, Maryland, and was a member of the Executive Council of the Acoustical Society of America (ASA). Jennifer received her BS from the University of North Texas, Denton, with a major in physics. She received her MS and PhD from The Pennsylvania State University, University Park, in acoustics. We asked Dr. Cooper to give us her elevator pitch and then to elaborate on her inspirations, contributions, and hopes for the future.

Give your "elevator speech" about the thrust(s) of your scholarly work over your career.

Light and other electromagnetic waves tend to not travel very far underwater due to a variety of environmental and sensor limitations, but sound does. As a result, hydrophones (underwater microphones) provide an excellent sensing system for all things emanating sound into the ocean. The Navy uses SOund NAvigation and Ranging (SONAR) to extend their sensing capabilities beyond those possible with electromagnetic and electro-optic systems to maintain their operational situational awareness. There are multiple acoustic signals in the ocean that we can observe, including marine mammals and other biologics along with man-made vessels and wind, rain, and seismic phenomena. By using arrays of hydrophones, we can break up that noise into smaller subsets based on the direction that each signal is coming from and hopefully separate out the signal we are interested in from the others. My work over the past 15 years largely centers around the research, design, testing, and employment optimization of sonar systems used by the Navy. This differs somewhat from the arrays used purely for research because longevity, cost, reliability, manufacturability, and usability in real time by a crew without advanced acoustics degrees all come into the equation. For example, we may be concerned about the precise relative calibration between hydrophones in an array and how that calibration changes with time, temperature, or depth. Ultimately, it's my job to predict how those variations will impact system performance.

What inspired you to work in this area of scholarship?

Like many acousticians, I was interested in both music and science in school and attempted to double major in jazz and physics. I briefly thought that perhaps I would someday design concert halls and then perform in them. Of course, that is extremely difficult within the constraints of financial aid limits on the number of course hours, and I ended up not completing the music degree. But it led to a work-study assignment helping to teach labs for the Musical Acoustics course that was designed to meet the lab science requirement for musicians. From there, I learned about other areas of acoustics and decided to go to graduate school. Playing in big bands gave me many opportunities to practice leading from the middle without a formal leadership role.

My first graduate research project at Penn State, with Jiri Tichy, focused on computational models of active noise cancellation. My PhD research, with Dave Swanson, focused on computational models of the long-range propagation of sound in the atmosphere over a complicated terrain. Those topics were appealing to me because

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the approach started from fundamental principles and was worked through by adding more complexity. We can use simulation to build an intuition of what to expect in a given situation. Because we can "turn all the knobs," we can assess sensitivity to each parameter independently, even when those parameters do not vary independently in real life. During graduate school, my research was primarily independent, with guidance from my advisors. Working through the problem sets for the courses was a good exposure to the benefits of working with a team from different backgrounds; my classmates with electrical engineering backgrounds helped me understand signal-processing problems and I helped with some of the math problems.

When I came to APL, my focus shifted to modeling the even longer range propagation of sound underwater and how that is affected by oceanographic variables, including mesoscale eddies, as well as how our predictions of propagation are influenced by imperfect knowledge of the environment. More recently, I've been leading teams working on the development of new sonar arrays, which makes use of our understanding of the properties of both signal and noise.

As much as I enjoy working with a team of dedicated colleagues, as an introvert, I feel most productive when diving deep into the weeds alone; I need to block out the distractions and listen to some good music. Increases in workplace flexibility over the past few decades, accelerated by Covid, make it easier to shift my schedule to tend to personal things in the early morning (when many of my coworkers work the best) and then stay a bit later in the evening when I focus best and the others have gone home. Computational acoustics is an area that lends itself well to lots of alone time.

Of all your contributions during your career, which are you most proud of and why?

From the first time I worked on trade-offs between different array design options for arrays that actually got built and tested at sea, I was hooked. It's very satisfying to be involved in a large team with people who have diverse skill sets (mechanical engineers, electrical engineers, oceanographers, Naval officers, acousticians, and the experienced ship's crew) all working together to design, build, deploy, and use a sonar system in a sea test. Getting the first data back that confirms your predictions (or not; sometimes we learn new things!) must be one of the most thrilling things I have ever been part of. I've been fortunate to be involved in the process at all stages, from ideation and research, to initial concept development, to setting requirements for a prototype to validate the concept, to testing the prototype and refining the requirements, and to ultimately testing a final production array and developing displays and training materials for the crews.

Along the way, I've learned a lot about how arrays in the real world can be vastly different from the simple models physicists are taught to use to start a problem. And that means we get to constantly increase the fidelity and complexity of the models to include things like sources that have complex directionality or range-dependent sound speed fields with internal waves, or even the idea that sharks or marine mammals might be so interested in the array that they investigate closely.

As with anything that exists in the real world, occasionally a test does not go as expected and the interdisciplinary team must work together to determine the cause. Is there a physical phenomenon unaccounted for in the model, are there some flukes in an electrical connection, or perhaps damage was sustained during deployment?

Because APL is doing new things that have not been done before, we constantly run into new challenges. In particular, when developing new sonar systems, I am often asking if the engineering or manufacturing teams can make a component with lower self-noise, lower power, rated to go deeper, or with a tighter relative calibration than has been required in the past simply because the prior systems were not trying to exploit the same signal. One area I have been looking at a great deal in recent years is that real arrays do not contain truly identical hydrophones nor are they in precisely the desired locations within the array, especially for an array moving through the water. There are always (hopefully small) differences in calibration from phone to phone as well as (again, hopefully small) deviations in array shape. The engineering team needs specifications about how large those imperfections can be, worded in a way that lends itself both to a measurement to verify that the specification was met and to guarantee the desired acoustic performance. It becomes an iterative process, where I describe what I think is needed and they reply with what they think is possible. And in the end, we work together to describe metrics that can actually be met and tested for a system that advances the state of the art.

What are some of the other areas in which you feel you made substantive contributions over your career?

I really enjoy mentoring early-career scientists and helping them develop their skills, background knowledge, and confidence to increase their impact. That includes coworkers and folks I meet at events like round-table discussions. Although I do not teach courses aside from an occasional guest lecture and do not work with students, I do get to interact with a variety of people, including sponsors and colleagues from interorganizational teams, and share with them specific problems they should be concerned about and why. Often that also means explaining why those will be hard problems.

I've been involved in the ASA since graduate school, and throughout the years, I've participated in a number of different committees. At one of the first meetings I attended (the fall 1999 meeting in Columbus, Ohio), I wound up at the Noise Technical Committee meeting and was, as one of the only students in the room, elected as their Student Council representative. Now, almost 25 years later, I'm finishing up a term on the Executive Council, having served alongside several of the other Student Council representatives with whom I first started. Along the way, I've been involved in Women in Acoustics and now Member Engagement and the Committee on Practitioners and Industry, working to increase diversity and representation in the Society. I helped with the push to make computational acoustics a full technical committee and have chaired sessions for computational acoustics, underwater acoustics, and physical acoustics. I've served in all the officer positions in the Washington, DC, regional chapter and am currently the treasurer. Because the ASA has always felt very welcoming to me, I want to make sure it feels welcoming to everyone.

What do you think are the most pressing open questions that you would like to focus on over the next 5-10 years?

Utilizing new sensors optimally requires aiding crews in understanding how the sensors work in different environments. Typically, this means lots of time-consuming performance model runs or using models that have been so simplified to improve speed that the results can be misleading. Climate change and increasing shipping contribute to the complexity because crews are unable to rely on prior performance or historical databases of model inputs (such as sound speed profile and wind speed) as indicators of what will happen now. So, there is a modeling aspect. But there is also work to be done in areas like automated signal processing and displays that help highlight where operators should look.

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