Acoustics Today

Winter 2019 Volume 15, Issue 4

ASA
ACOUSTICAL SOCIETY
OF AMERICA

An Acoustical Society of America publication

The Underwater Sounds of Glaciers

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Featured Articles

Sound Perspectives

Departments

About the Cover

Photograph of a tidewater glacier, from the article "The Underwater Sounds of Glaciers." Snowfall in the accumulation zone feeds the glacier that ends with its terminus in the fjord. Photograph by Dale Stokes.

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Acoustics Today (ISSN 1557-0215, coden ATCODK) Winter 2019, volume 15, issue 4, is published quarterly by the Acoustical Society of America, Suite 300,1305 Walt Whitman Rd., Melville, NY 11747-4300. Periodicals Postage rates are paid at Huntington Station, NY, and additional mailing offices. POSTMASTER: Send address changes to Acoustics Today, Acoustical Society of America, Suite 300, 1305 Walt Whitman Rd., Melville, NY 11747-4300.

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From the Editors

Arthur N. Popper and Micheal Dent

This "From the Editor" was written by both Arthur Popper (editor) and Micheal Dent (associate editor). We jointly wrote this piece because it arose from Micheal's question to Art about the lack of women as first authors of articles in some issues of *Acoustics Today* (*AT*). As a consequence of this question, we decided to review the distribution of articles by women in *AT* along with our overall goal to, over multiple issues of *AT*, ensure that articles reflect the technical committee (TC) diversity of the Acoustical Society of America (ASA).

What we realized as we started to analyze the articles is that we could do better in ensuring that we have women taking the lead in articles in *AT*. That is, other than in our special fall 2018 issue (see bit.ly/2m8eDpJ), Micheal was right in observing that a number of issues of *AT* have had few or no women as lead authors on articles. This is of considerable concern to us because the one thing that we have tried to do is to use *AT* to help increase the visibility and impact of women in acoustics in general and in the ASA in particular, not only through the special issue but also by having regular "Sound Perspectives" essays from our Women in Acoustics Committee.

So, we started to ask how we can rectify this situation. We quickly realized, however, that there are two issues that stand in the way of ensuring such diversity. First, women currently make up 18.6% of ASA members. This means that the pool of female ASA members that we can draw on to write articles for *AT* is small. Importantly, this also highlights the issue of ASA member diversity and inclusion, with *AT* authorship being only a small part.

Second, the majority of women in ASA are in three TCs: Animal Bioacoustics, Psychological and Physiological Acoustics, and Speech Communication. Combined, women make up 36% of the membership in these three TCs but average only 12.3% of the membership in all the other TCs. This means that the women we can call on to do articles is biased toward three TCs, thereby impacting a "prime directive" for *AT* that stipulates that we work to having a balance of articles across all TCs.

So, the question arises as to how to increase the number of women lead authors of *AT* articles without impinging (too much!) on our goal of having subject matter diversity. Adding to the immediate challenge is that the content of issues in *AT* is set 12-18 months in advance of an issue date to give authors sufficient time to fit writing articles into their already very busy schedules. And when we look at forthcoming issues, men are the preponderance of authors, so we have a lot of catching up to do.

Still, we want to address this problem by increasing the number of articles led by women as soon as we can. Therefore, with the strong support of ASA Editor in Chief Jim Lynch, we are going to increase the number of articles (assuming we can get authors) in many of the upcoming "filled" issues so that there is at least one, and better yet two, articles with women as lead authors in all issues. We have also already asked that TC chairs recommend women in their TCs who might write articles. And at the advice of several women leaders in the ASA to whom we have reached out, we will look outside the ASA membership to invite women in several technical areas to be lead authors on *AT* articles, with a secondary goal of introducing these women to the Society.

Finally, we are using this editorial to ask the general ASA membership for ideas on how we can increase diversity in *AT* authorship (and this request is not limited to gender!). In particular, we would very much value suggestions from individuals from groups underrepresented as *AT* authors who might potentially write articles for *AT*. If you have ideas, feel free to write either of us (apopper@umd.edu or mdent@buffalo.edu). We can promise that every suggestion will receive a thoughtful response and be given substantial consideration.

Now to this issue. In our first article, Grant Dean, Oskar Glowacki, Erin Pettit, and M. Dale Stokes discuss underwater sounds produced by glaciers. In this article, we learn that glacier sound provides long-range insight into changing conditions in polar regions. The second article, by David Dall'Osto, also deals with underwater sound propagation but for very different purposes. In his article, Dave discusses how underwater systems developed to monitor nuclear testing can also be used to understand other issues such as climate change.

In the third article, Psyche Loui provides insight into how the brain deals with music. In her article, we learn that music elicits complex neural activity and that this activity differs for different aspects of the musical experience. Our fourth article fits with our interests in learning about the history of research in acoustics. In his article, Kenneth Suslick presents a history of research in ultrasonics. He does this by introducing a number of fascinating individuals who did truly imaginative work in interesting places. And, in passing, Ken mentions the origin of the term used for men's formal wear!

The fifth article, by Aaron Thode, derives from a special session that Aaron organized at an ASA meeting. The topic, plant bioacoustics, is something most of us have never thought about. The article introduces us to the idea that plants not only influence sounds in their environment, but that sound may also play a role in plant biology.

Our final article, by Stephen Thompson, returns to the theme of history in a discussion of the first century of electroacoustics. As part of his discussion, Steve talks about the evolution.

As usual, this issue includes an "Ask an Acoustician" essay. The piece here is about Adrian KC Lee. KC is well-known to many in the ASA as an active contributor to our Society and particularly for his contributions to ASA publications (see bit.ly/2kSQROr). So, it is a delight to learn more about KC as a scientist and as an individual.

Our second essay is by ASA Education and Outreach Coordinator L. Keeta Jones as part of her series in *AT* about both outreach and education. In her essay, Keeta focuses on the International Year of Sound (IYS), something ASA members will be hearing about over the coming year (2020) because, as Keeta points out, the ASA is strongly committed to its participation in the IYS.

In closing, we want again to ask ASA members to consider ways in which we can increase (all kinds of) diversity in *AT*. If you have ideas, or suggestions for authors and articles, please email either of us, or chat with us at any ASA meeting.

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Three-Dimensional Underwater Acoustics

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The Underwater Sounds of Glaciers

Grant B. Deane, Oskar Glowacki, M. Dale Stokes, and Erin C. Pettit

Introduction and Motivation

The stability of major ice sheets in polar regions are linked to sea level rise and the input of fresh meltwater into sensitive regions of the thermohaline circulation system (the oceanic salt and heat conveyor belt), two critical issues related to global change. Estimates of the future contributions to sea level rise from the melting of glaciers in Greenland alone range from 0.3 m to 3 m for the year 2100 (Berwyn, 2018). Moreover, the recent acceleration of mass loss from the Greenland ice sheet (GrIS), which quadrupled from 1992–2001 to 2002–2011 (**Figure 1**), led to a global mean sea level rise of 7-8 mm between 1992 and 2011 (Shepherd et al., 2012). Global glacier melt (small glaciers, ice caps, and ice sheets) currently contributes almost 1 mm/yr to the total sea level rise (Zemp et al., 2019). In addition to contributing to sea level rise, the freshening of surface waters affects global-scale heat transport by weakening the Atlantic meridional overturning circulation (Bamber et al., 2012). For these and other reasons, understanding the mass loss of glaciers is an important problem.

Here we focus on studying the behavior of tidewater glaciers using the various sounds they make in the ocean as they flow, melt, and break apart. However, before discussing the acoustics, we present some preliminaries about the glaciers themselves to introduce terminology and describe the processes that generate noise. Tidewater glaciers are valley glaciers flowing from their accumulation zones in the snowfields to the ocean over a journey that can take hundreds to thousands of years. Tidewater glaciers may flow short distances from local high mountain peaks (such as in Alaska) or from more distant ice fields and ice sheets (such as in Greenland or on the Antarctic peninsula). **Figure 2** is a photograph of the tidewater glacier Samarinvågen taken from a boat in Hornsund Fjord, southwestern Svalbard (an archipelago in the Arctic Ocean situated about midway between Norway and the North Pole). Snowfall in the mountainous accumulation zone feeds the glacier, which flows downhill and ends in the fjord. The ice cliff in the ocean is known as the glacier terminus.

- acoustic radiation pressures sufficient to support a weight of 150 g;
- the burning of skin or wood when pressed against an ultrasonically vibrating rod;
- numerous biological effects, including rupturing red blood cells, killing microbes, and harmful to lethal effects on small fish, frogs, and mice; and
- preliminary observations on the effects of ultrasound on crystallization.

The position and velocity of the glacier terminus are the net result of ice outflow, which drives the terminus onward, with melting and calving that erode it. Net mass loss of a glacier occurs when ablation (melting or calving) at the terminus exceeds the accumulation of new snow at high elevations. Any increase in the twin processes of melting and calving unbalanced by increases in snow accumulation will drive the retreat of the glacier terminus from the ocean toward land. The relative importance of melting and calving to glacial retreat is currently debated and is likely changeable, depending on ocean temperature; local winds and other atmospheric processes; and glacier flow dynamics. Models for glacial stability are sensitive to the roles of melting and calving in glacial ablation. Thus, quantifying models and understanding their responses to warming atmospheric and oceanic conditions are active areas of research.

There are no methods for the direct observation of submarine melt rates for tidewater glaciers. The terminus of a tidewater glacier or a floating sheet of ice is a dangerous place to work. This is because calving produces falling ice followed by a mini tsunami, both of which are hazardous, and so it is considered unsafe to get within a few hundred meters of the terminus of any glacier. Some glaciers are known to produce bigger calving events than others, and all glaciers should be approached with care. Moreover, the glacier surface is typically fractured by crevasses, making work on the ice surface dangerous or impossible as well. For these reasons, remote sensing techniques are primarily used to study terminus behavior.

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https://doi.org/10.1121/AT.2019.15.4.8

Figure 2. *Photograph of a tidewater glacier. Snowfall in the accumulation zone feeds the glacier that ends with its terminus in the fjord. Photograph by Dale Stokes.*

Many satellite and airborne remote sensing techniques produce reliable and accurate estimates of average bulk ice mass loss, but measuring the melt rate relative to the calving rate of a glacier terminus remains a challenging problem. Current techniques include estimates of underwater melt rates based on calculations of heat flux to the glacier or numerical models of circulation within the fjord. Calculations of heat flux require observations of water temperature, salinity, and velocity in front of the glacier on short timescales. In the absence of these data, which are challenging to obtain, assumptions must be made about the distributions of glacially modified seawater and the temperature, salinity, and flow of the seawater around the glacier terminus, including poorly understood turbulent processes.

For example, in Svalbard, there is typically a strong seasonality to the strength of the thermohaline circulation and also to glacier melting because the ocean temperatures can show large variations. In Alaska, such processes also occur in winter because there is not as much seasonality to ocean temperatures. In Antarctica, the warmth of the ocean water varies in different ways that are not necessarily seasonally linked and can also show a dependence on weather patterns and sea ice conditions. The bottom line is that models of melt rate based on measurements and models of thermohaline structure will likely have to accommodate a variable range of conditions depending on geographic region.

Making long-term measurements of both calving and melting on the highly resolved timescales necessary for developing predictive models of retreat is an outstanding and difficult problem. Accomplishing this for multiple tidewater glaciers is even more difficult. In response to these monitoring challenges, in 2008, Wolfgang Berger and colleagues organized a workshop in Bremen, Germany, to propose the use of hydroacoustics to study tidewater glaciers, culminating in the publication of a correspondence note (see Schulz et al., 2008). They suggested that “Hydroacoustics could be used for passive listening — for example, to calving, iceberg collision, tidal flow, sediment transport and wind action — as well as active echo-sounding (for example Doppler detection of water and ice motions)” (Schulz et al., 2008). At the same time, some of the first measurements to record calving events were being made at Hansbreen Glacier in Svalbard (Tegowski et al., 2011) and the Meares Glacier, Prince William Sound, AK (Pettit, 2012).

Using Ambient Sound to Study Glaciers

The idea of using ambient sound to study the ocean and the things in it, sometimes called “passive acoustics,” has been around for awhile and has proven effective at providing information across a diverse range of phenomena including the study of breaking surface waves, monitoring reef ecology, studying marine animals (Mann, 2012), monitoring volcanoes (Matoza and Fee, 2018), and probing the ocean interior structure, to name a few. Active acoustics has a much longer history. Indeed, it is arguably the most important tool ever developed to probe the ocean interior and seafloor. However, the ideas that emerged from Schultz at el. (2008) and the initial measurements made an important contribution in pointing out that these powerful tools could be applied to a pressing and difficult measurement problem in polar regions: the monitoring of tidewater glaciers with hydroacoustics.

Hydroacoustics, more commonly referred to as underwater acoustics in North America, offers some practical advantages for monitoring tidewater glaciers over more traditional methods. Active acoustic sensing can provide data about the structure of a glacier terminus that would be virtually impossible to acquire otherwise (e.g., Sutherland and Straneo, 2012). This would include water motions in the glacier bay, which can be complicated by meltwater outflows and direct melting of the terminus interacting with tidally pumped circulation. The concept salinity, and other variables cannot surface in ice-covered regions to use the Global Navigation Satellite System (GNSS) to determine their position and to relay data back to shore, for example. Furthermore, measurements of sea surface height using satellite altimeters, which provide important constraints on the ocean circulation at lower latitudes, are not feasible when the ocean is covered with ice. Multipurpose acoustic systems can operate beneath the ice, however. Such systems provide acoustic remote sensing of ocean temperatures (ocean acoustic tomography), underwater navigation, and passive acoustic monitoring of natural and anthropogenic sounds. Thus, such systems have a special role to play in making measurements of the rapidly changing Arctic Ocean, complementing and supporting other in situ observations (Mikhalevsky et al., 2015; Howe et al., 2019).

At the same time, even as sound is used to help monitor the changes in the Arctic, the changes in the ice cover and stratification have affected acoustic propagation and ambient sound. As a consequence, what was learned about Arctic acoustics during the Cold War is now largely obsolete.

In this article, we describe a series of experiments that have been performed both to determine the effect of the changes in the Arctic on the acoustics and to use acoustic remote sensing as a tool to study the changing Arctic environment. The discussion of the experiments is preceded by a brief description of the extraordinary changes currently occurring in the Arctic and some background on Arctic acoustics. **Multipurpose Acoustic Systems in the Arctic Ocean Observing System** describes how multipurpose acoustic systems complement and support other in situ observations in ice-covered regions.

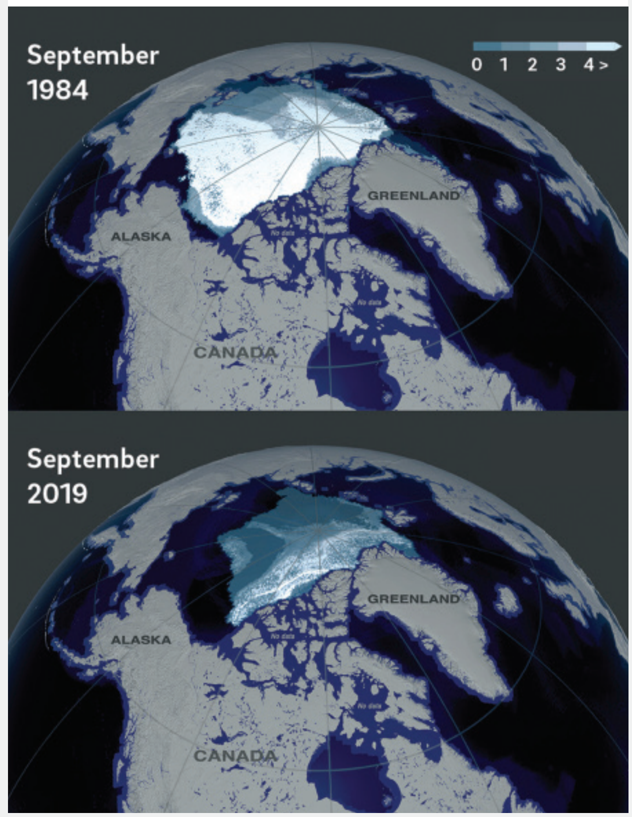
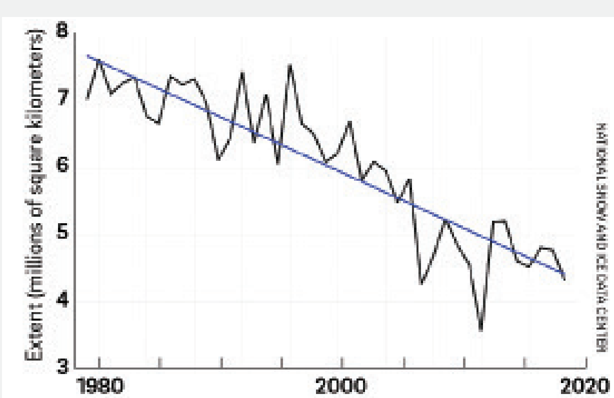


Figure 3. *Arctic sea ice age in September 1984 (**top**) and September 2019 (**bottom**). **Dark blue,** younger sea ice, or first-year ice; **white,** ice that is four years old or older. From the National Aeronautics and Space Administration (NASA) Scientific Visualization Studio, 2019.*

Figure 2. *Average monthly September sea ice extent from 1979 to 2019. The straight line is a linear fit showing a decline of 12.9% per decade. From the National Snow and Ice Data Center, 2019*



The Rapidly Changing Arctic Ocean

Ice

Satellites with passive microwave sensors have made accurate measurements of the areal extent of sea ice (defined as the area of ocean with at least 15% sea ice) since 1979. The monthly average extent of ice in September, when it is at a minimum, declined from 7.5 million square kilometers in 1980 to 4.4 million square kilometers in 2019 (**Figure 2**). The minimum extent in the satellite record occurred on September 16, 2012, when there were 3.4 million square kilometers of ice. Although there is considerable year-to-year variability, a linear fit yields a decline of 12.9% per decade in the September monthly average from 1979 to 2019 (National Snow and Ice Data Center, 2019). The ice extent in winter is also declining, although more slowly.

The decrease in the observed Arctic sea ice area is directly correlated with anthropogenic CO_2 emissions (Stroeve and Notz, 2018). The ice loss per ton of anthropogenic CO_2 emission is about 3 square meters during summer and slightly above 1 square meter during winter. Extrapolating these relationships into the future, the Arctic will become ice free in the months of August and September when an additional roughly 800 ± 300 gigatons of anthropogenic CO_2 have been released. The emission rate today is about 40 gigatons of CO_2 per year. If this emission rate continues unchanged into the future, an additional 800 gigatons of CO_2 will have been released in about 20 years.

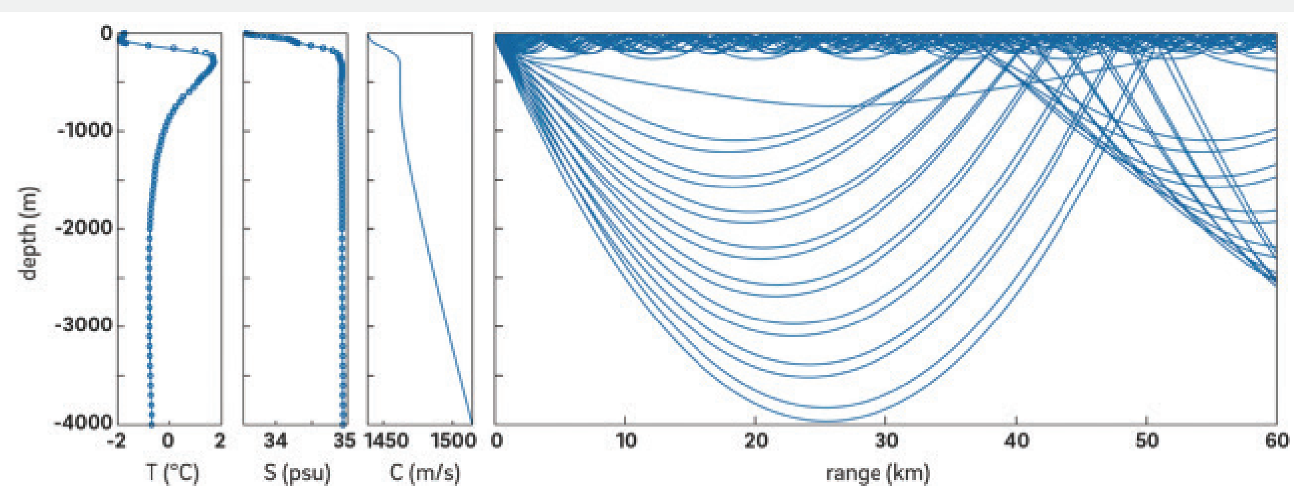
Ice thickness is more difficult to measure than ice extent (Kwok and Untersteiner, 2011). Thickness estimates are available from upward-looking sonars that measure ice draft (the distance from the ocean surface to the bottom of the ice) installed on submarines and moorings and from satellite altimeters (ICESat and CryoSat-2) that measure ice freeboard (the distance from the top of the ice to the ocean surface). Between the early submarine measurements (1958 to 1976) and the CryoSat-2 period (2011 to 2018), the average thickness over most of the deep-water portions of the Arctic at the end of the melt season decreased by 2.0 meters, or about 66% (Kwok, 2018). The most dramatic decrease has been at the North Pole where the average ice thickness at the end of the melt period decreased by about 2.9 meters, from 3.8 meters to 0.9 meter (Kwok, 2018).

The presence of multiyear ice (i.e., ice that survives the summer melt season) is closely related to ice thickness and volume. Sea ice age can be estimated using a combination of satellite passive-microwave data and drifting buoys to derive the formation, movement, persistence, and disappearance of sea ice (Maslanik et al., 2011). The area covered by sea ice that was four years of age or older declined from 2,687,000 square kilometers in September 1984 (week 38) to 53,000 square kilometers in September 2019 (week 38; **Figure 3**; National Snow and Ice Data Center, 2019). The disappearance of multiyear ice has affected not only the average ice thickness but also the pressure ridges and associated ice keels formed when ice floes collide. Old multiyear ice has larger pressure ridges than first-year ice, with ice keels that can extend down tens of meters. These deep keels are disappearing together with the multiyear ice.

Ocean Stratification

Warm, salty water from the Atlantic Ocean enters the Arctic through Fram Strait between Greenland and Svalbard and through the Barents Sea. This water sinks

Figure 4. Left three: *temperature (T), salinity (S), and sound speed (C) profiles at 84°N, 28°E in the eastern Arctic Ocean from the 2013 World Ocean Atlas. The temperature maximum at about 300 meters is associated with the Atlantic layer.* ***Right:*** *geometric ray paths for an acoustic source at a 60-meter depth. Rays with positive (**upward**) and negative (**downward**) launch angles of the same magnitude give rise to the closely spaced ray pairs. The ray with a positive launch angle reflects from the surface before starting downward.*



of passive listening is also attractive because it provides an opportunity to monitor ice-ocean interactions on long timescales with robust and cost-effective technology and without introducing artificial signals into the ocean. Although it may not be immediately obvious that hydrophones can survive for extended periods in a glacial bay, which is subject to the passage of icebergs that may extend from the sea surface to the seafloor and is often covered with sea ice during the winter months, several groups have now demonstrated that year-long recordings of ambient noise are possible.

The subject of polar underwater acoustics, both active and passive, is a large and important field with a history dating well back into the last century. The breadth and scope of it lie well beyond our reach in this article. However, here we offer some highlights from the new and developing field of tidewater glacier acoustics along with some interesting results from a closely related topic, iceberg acoustics.

The Underwater Soundscape Near a Glacier Terminus

The bays of tidewater glaciers are one of the noisiest places in the ocean (Pettit et al., 2015). Calving icebergs, wave-iceberg interactions, freshwater outflows and melting glacier ice all contribute to the underwater soundscape (see bit.ly/347NuVF). The variability of sound sources, in both frequency and time, are prominent features of the soundscape.

Figure 3 gives an overview of noise sources in the bay of a tidewater glacier terminus and boundary and waveguide effects influencing sound propagation (note that the spectrogram in **Figure 3**, ***inset***, is from the video referenced above). The noise of iceberg calving is mostly evident in the sub-500-Hz band and persists for several seconds, whereas the noise of melting glacier ice dominates the noise from around 1 kHz to several tens of kilohertz or higher and is generated without interruption. Other intermittent noise sources include breaking waves on the fjord shoreline, marine mammal vocalizations, rain, wave-iceberg interactions, and the sounds of iceberg disintegration. Noise from freshwater outflows from the glacier terminus is thought to generate sound at frequencies below 100 Hz, but not much is known about this source of sound at the present time. Anthropogenic noise from cruise ships, small transport vehicles, and acoustic sensors such as echo sounders and acoustic Doppler profilers can also be present.

The mechanical and acoustical properties of glacier ice play an important role in determining the character of the underwater soundscape in the bay of a glacier terminus. Ice mechanical properties, combined with ocean temperature and other factors such as rain, control how frequently calving events occur, the range of iceberg sizes produced, and the integrity of the ice block as it impacts the sea surface. All these parameters influence the underwater sound of calving.

Remarkably, most glacier ice contains numerous, small bubbles of compressed air (see **Figure 3**). Ice mechanical properties, combined with ocean temperature and other factors such as rain, control how frequently calving events occur, the range of iceberg sizes produced, and the integrity of the ice block as it impacts the sea surface. All these parameters influence the underwater sound of calving.

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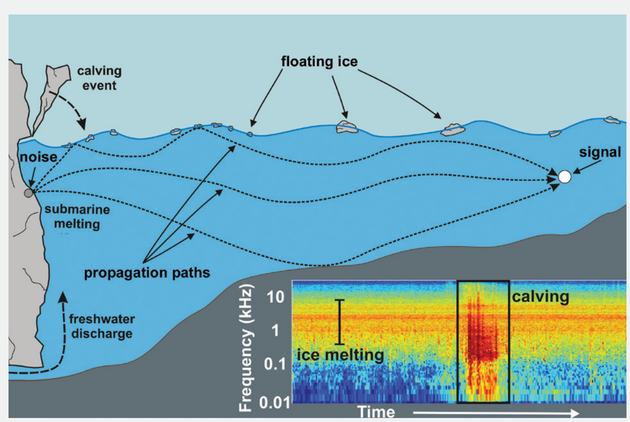
Figure 3. *Noise sources and propagation effects shaping the soundscape around the terminus of a tidewater glacier.* ***Inset:*** *spectrogram of sound versus frequency (in kHz on a log scale) and time (total duration of 1 minute) showing a calving event and noise radiated by melting glacier ice in the bay of Hansbreen Glacier.*



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BioSketches

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Erin Pettit studies the dynamics of glaciers and ice sheets to better predict the impact of glacier change on land and ocean environments. Her research currently focuses on ice-ocean interactions and the stability of marine-terminating glaciers and ice shelves in Greenland, Antarctica, and Alaska. She is an associate professor at Oregon State University (Corvallis), founder and director of Inspiring Girls Expeditions, a fellow of Wings WorldQuest, and an emerging explorer with National Geographic. She has a BSc in mechanical engineering from Brown University (Providence, RI) and a PhD in geophysics from the University of Washington (Seattle).

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multicenter study in collaboration with colleagues at the University of Iowa and the University of North Carolina at Chapel Hill. This work demonstrated the impact of early hearing aid fitting and use on linguistic and academic development over a 10-year period in a large group of children who were hard of hearing compared with normal-hearing age-mates (Moeller and Tomblin, 2015; Tomblin et al., 2015; see ochlstudy.org).

The BTNRH faculty have also made important contributions to research on cochlear implants as well as basic research on psychoacoustics and on speech perception. Work on cochlear implants was begun by Robert Shannon (Shannon, 1989) and continued by Michelle Hughes (Hughes and Stille, 2009) and Monita Chatterjee and Adam Bosen (Bosen and Chatterjee, 2016). Much of this work relied on methodology developed in the psychoacoustics literature. Examples of BTNRH contributions in that area include work by Stelmachowicz on the growth of masking in listeners with hearing loss (Stelmachowicz et al., 1987), by Neff on informational masking (Neff, 1995; Leibold and Neff, 2007), and by Huanping Dai on pitch perception (Dai, 2000). The author has worked on a number of psychoacoustics topics ranging from forward masking (Jesteadt et al., 1982) to loudness summation (Jesteadt et al., 2019). BTNRH publications on speech perception have ranged from work by Susan Nittrouer (2001) on phonetics to more recent work by Buss, Leibold, and colleagues (2017) on the effects of masking on speech perception by children.

Recent Developments

Many people contributed to the BTNRH research program over the years, but by 2010, there was concern that several members of the long-term core group would be retiring at about the same time, without obvious replacements available for key leadership positions. The BTNRH had always been most successful at recruiting people early in their careers, and many of those people had moved to positions in universities. We had not recruited an established, midlevel researcher since Keefe joined the staff in 1995. Several of our more recently recruited early-career people were not successful in obtaining external support for their research programs, and it was also unclear who would eventually replace the BTNRH founding director, Patrick Brookhouser, or how that transition would be handled.

Much of this uncertainty was resolved over the next few years. Pat Brookhouser died unexpectedly in the fall of 2011 and was replaced by our long-term hospital administrator who continued the strong institutional commitment to the research program. Monita Chatterjee moved her well-established cochlear implant research program to the BTNRH in 2012, attracted by the availability of cochlear implant patients and freedom from teaching and other university duties, the same factors that drew scientists to the BTNRH in its early years of development. In 2014, the BTNRH received NIH funding for a center of excellence in research related to perception and communication in children. The new funding provided support for several of our early-career investigators and a mechanism for recruiting and supporting additional scientists over the coming years with the goal of expanding the research program into new areas. In 2015, we were able to recruit Lori Leibold, a former BTNRH postdoctoral fellow, to return as director of the NIH-funded center as well as of our Center for Hearing Research. Her interests in auditory development (Leibold et al., 2019) made her an excellent fit for both positions. In 2017, Ryan McCreery, who had established an independent research program at the BTNRH in 2011, was appointed as director of research. McCreery in turn led the effort to recruit Karla McGregor as a successor to Mary Pat Moeller, with the goal of developing a program in developmental language disorders, with six additional positions to be filled over the next few years. In 2019, G. Christopher Stecker moved his spatial hearing research program to the BTNRH and is in the process of equipping a new anechoic chamber that will be an important core resource for the hearing research program.

Because we now have a better understanding of the peripheral auditory system than we did in the early days of the BTNRH, the emphasis in the recent expansion of the research program has shifted to work on perception in more complex auditory environments (e.g., Leibold et al., 2019) and the contributions of memory and executive function to development of speech and language. This is now one of the few programs to have NIH-funded research on both peripheral and central mechanisms, evaluating both hearing aids and cochlear implants, in both children and adults. After 48 years, the BTNRH research program in hearing, speech, and language to grow and to have a major impact on the diagnosis and treatment of communication disorders in children.

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BioSketch

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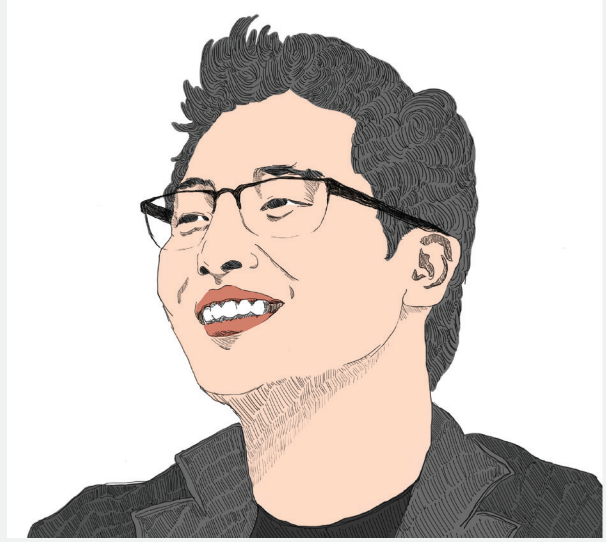
Walt Jesteadt is a senior scientist at the Boys Town National Research Hospital in Omaha, Nebraska. He served as Director of Research at the BTNRH from 1986 to 2016. Before coming to Boys Town in 1976, he received a BA in psychology from Johns Hopkins University (Baltimore, MD) and a PhD in psychology from the University of Pittsburgh (PA), followed by postdoctoral training with Robert Bilger at Eye and Ear Hospital in Pittsburgh and with David Green at Harvard University (Cambridge, MA). He is a Fellow of the Acoustical Society of America, the Association for Psychological Science, and the American Association for the Advancement of Science.

Ask an Acoustician: Adrian KC Lee

Adrian KC Lee and Micheal L. Dent



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Preparing for the International Year of Sound 2020

L. Keeta Jones

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https://doi.org/10.1121/AT.2019.15.4.18

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How do you handle rejection?

With a nip of rye! For a long time, we had a laboratory tradition to gather around and celebrate everyone's success and rejection alliteratively, with success scotch or rejection rye depending on the occasion. Now with me wanting to get home by 6 p.m. sharp (and many laboratory members having their own families as well), these gatherings have become less frequent and less organized. I find that nowadays I internalize rejection more. But after I recover from that punch-in-the-gut disappointment, I remind myself that this is work and that paper/grant rejection is not a rejection of me as a person. I then go and hang out with my friends and family and remind myself what makes me happy. Finally, I turn back to the rejected work and determine how to learn professionally and make improvements on it. But I do sometimes miss those cathartic rye gatherings.

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When I was 16, I went to a high-school engineering camp hosted by The University of Wollongong (just outside Sydney, NSW, Australia) and saw how sound can be represented both in time and in frequency; it was a Hollywood clip showing how forensic acoustics is used to solve crimes (viz., a spectrogram). I was hooked. That led me to study electrical engineering for my bachelor’s degree at the University of New South Wales (Sydney, NSW, Australia), with a major concentration in signal processing. In my junior year, a book by Graeme Clark entitled *Sounds of Silence*, an autobiographical journey of cochlear implant research in Australia, inspired me to do my undergraduate thesis at the Bionic (Ear) Institute under the tutelage of Hugh McDermott. At that time, my signal-processing professor encouraged me to apply to graduate school in the United States. By the process of elimination (viz., which applications did not require me to take a GRE), I applied to MIT and was accepted to what was then the Harvard-MIT Speech and Hearing Biosciences and Technology (SHBT) program but without guaranteed funding as a foreign student. (I was lucky that my parents encouraged me to accept their admission offer and could afford to let me take the financial risk.) Once I arrived there, I knocked on every professor’s door to see whether I could volunteer in their laboratory and try to prove that eventually I would be worth funding as their research assistant, with little luck. Fortunately, before I left Sydney, Simon Carlile recommended that I look up Barbara Shinn-Cunningham when I got to Boston because she was a preceptor in the SHBT program. When I emailed Barb and mentioned Simon, she welcomed me with open arms. That led me to study auditory attention and steered my path away from my original plans to continue my work in cochlear implant research. After obtaining my doctorate with Barb, I briefly stepped away from hearing science and joined Massachusetts General Hospital, first in the Department of Psychiatry, then in Radiology, to learn neuroimaging techniques. During my time there, I was fortunate to receive a National Institutes of Health (NIH) Pathway to Independence Award (K99/R00). To celebrate, I planned a trip to the West Coast to visit some friends. During a stop in Seattle, Cara Stepp, who was then a postdoc at the University of Washington, decided to arrange meetings for me during my one-day visit, even though I was just planning to visit the Space Needle! Seeing that I would end up spending my day at the university instead, I decided to craft an email to Patricia Kuhl to see whether I could meet with her as well because I found out that a magnetoencephalography (MEG) center was being built at her institute. Pat replied within five minutes and said that unfortunately she’d be in Finland at a conference (with Barb) but forwarded a job advertisement and asked if I would be interested in a tenure-track job. Well, today I remain in Seattle, describing my career path after joining the Department of Speech and Hearing Sciences in 2011. I know this is a long-winded personal story, but I always find it fascinating that my career path has really been shaped by a series of lucky chance encounters with a number of kind people, peppered with different spur-of-the-moment decisions.

What is a typical day for you?

It depends whether it is a "research" day or a "teaching and administrative" day. I have two corresponding offices and with them being a 15-minute walk apart helps me partition my time. If I go to my research office, I generally spend time meeting with my students and postdocs, and occasionally, I have time to read and write. If I go to my teaching office, I prepare for class, teach, host office hours, and also work on my administrative duties for the department. With two young kids at home, I am in charge of drop-off duties so I generally try not to schedule meetings before 9:30 a.m. I set a goal to finish work by 5 p.m. so that I can spend time with my family after an hour-long commute. In the past few years as a *JASA* CE, I also spend about 15-30 minutes/day to take care of editorial duties. In the past few years as a *JASA* CE, I also spend about 15-30 minutes/day to take care of editorial duties.

How do you feel when experiments/projects do not work out the way you expected them to?

First, disappointment. Then, after the grieving period is over, you remind yourself that data are data and you find a way to learn from it. Sometimes, you find unexpected explanations that would lead to new discoveries or avenues of research. But there are plenty of times when you realize what stupid mistakes you have made and then you learn from those. It is humbling to admit that this is the norm rather than the exception, having to learn through one's frequent mistakes.

Do you feel like you have solved the work-life balance problem? Was it always this way?

My wife has been really good at conditioning me to keep a good work-life balance. She knows that I hate losing bets, so she made a bet with me that I could not be home before 6 p.m. sharp in time for family dinner. Just to prove her wrong, I decided to leave work earlier and earlier so that I could make that deadline. Eventually, it became my routine. On the other hand, leaving my smartphone alone at home so that I can be present with my family remains a work in progress. Things were entirely different before I had kids; I would get to work before 9 a.m., leave after 6 p.m., and respond almost immediately to work-related emails in between. At the time, I thought I already had a work-life balance, at least compared with my postdoc hours in Boston. Now, I make a conscious effort to encourage our postdocs to strive for a real work-life balance such that they can have flexible hours to attend to their personal and family needs.

What makes you a good acoustician?

I find this to be a strange question. I would say that I am an inquisitive person and I happen to appreciate sound itself. Does that make me a good acoustician? I think an easier question to answer is what makes one a good mentor and by extension a good mentor in the field of

NEWS FROM THE ACOUSTICAL SOCIETY FOUNDATION FUND

I appreciate the opportunity to inform the membership and friends of the Acoustical Society of America (ASA) about the Acoustical Society Foundation Fund. The Fund supports ASA scholarships, grants, fellowships, and other special programs from tax-deductible gifts. As I mentioned in the summer 2019 issue of Acoustics Today, I am featuring winners of ASA awards and prizes and how they benefited from the support the Society provided.

The Medwin Prize in Acoustical Oceanography was established in 2000 from a generous gift made to the Acoustical Society Foundation by Herman and Eileen Medwin to recognize a person for the effective use of sound in the discovery and understanding of physical and biological parameters and processes in the sea. The prize includes a cash award of $2,000, a certificate, and the opportunity to present the Acoustical Oceanography Prize Lecture. Jennifer Miksis-Olds of the University of New Hampshire (Durham) is a recent prize winner and writes, "In preparing for the prize lecture, I reflected on the past and the pillars upon which my research has been built. I looked into the future to envision where the field of ocean sound may be in a decade. The prize helped me to appreciate the diverse applications of sounds in the sea."

James H. Miller
Chair, Acoustical Society Foundation Board
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Mission of the Acoustical Society Foundation Board:
To support the mission of the ASA by developing financial resources for strategic initiatives and special purposes.

For more information, contact James H. Miller at miller@uri.edu

Obituary | William J. Cavanaugh, 1929–2019

K. Anthony Hoover

William J. Cavanaugh, pioneering architectural acoustician, passed away of natural causes on July 14, 2019, at the age of 90. Bill changed the world as we hear it; he was at the forefront of a broad spectrum of research and consulting in architectural acoustics for over 60 years. His service and contributions to the science and art of acoustics have been deep and pervasive.

Bill earned his architecture degree from the Massachusetts Institute of Technology (MIT; Cambridge) in 1951 and was then ordered to active duty in the US Army Corps of Engineers in 1953. After his service, Bill joined the acoustical consulting firm of Bolt Beranek and Newman (BBN) in 1954 and began teaching acoustics classes at the MIT School of Architecture and other institutions. He and Greg Tocci started the acoustical consulting firm of Cavanaugh Tocci Associates, near Boston, in 1977.

Bill consulted on thousands of projects of all building types, requiring skillful interaction with architects, engineers, and clients as well as the public. Insights and research based on his projects have been the source of most of his contributions to the acoustical community at large.

Areas of Bill's contributions to acoustics and their practical application that are worth special consideration include masking, outdoor venue sound propagation, cinema sound quality, professional societies, and teaching and mentoring.

Bill was the lead author on the seminal paper (Cavanaugh et al., 1962) that had the daring and the scientific evidence to suggest that adding appropriate background sound could improve acoustical privacy, leading to the entire industry of masking systems and making open plan offices viable. Speech privacy remains a high priority, especially with recent federal mandates for healthcare facilities.

Bill's interest in the challenges of neighbors' complaints of sound from outdoor amphitheaters led to and has continued to influence the entire field of concert sound-monitoring systems, associated methods for improved community relations, and the development of acoustic criteria for outdoor concert venues.

Bill helped found and grow the National Council of Acoustical Consultants (NCAC) and the Institute of Noise Control Engineering (INCE) and served as president of each. He was awarded the NCAC C. Paul Boner Medal for Distinguished Contributions to the Acoustical Consulting Profession in 1983 and the inaugural NCAC/INCE Laymon N. Miller Award for Excellence in Acoustical Consulting in 2015.

Bill's inspirational teaching at various college architectural programs led many students to become future clients, and some even became acousticians. He originated the series of ASA books that began with *Halls for Music Performance* and contributed to many other publications.

Bill's service to the ASA included as a member of the Executive Council, chair of the Technical Committee on Architectural Acoustics, and work on other committees.

Ginny, his loving wife of 57 years who passed in 2010, his five children, and his grandchildren and great-grandchildren were the loves of his life.

The NCAC Newsletter published a Bill Cavanaugh tribute issue, available at ncac.com/resources/bill-cavanaugh.

Selected Publications by William J. Cavanaugh

Cavanaugh, W., Farrell, W., Hirtle, P., and Watters, B. (1962). Speech privacy in buildings. *The Journal of the Acoustical Society of America* 34, 475-492.

Cavanaugh, W., Talaske, R., and Wetherill, E. (Eds). (1982). *Halls for Music Performance: Two Decades of Experience, 1962–1982.* American Institute of Physics for The Acoustical Society of America, New York.

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Book Announcements | ASA Press

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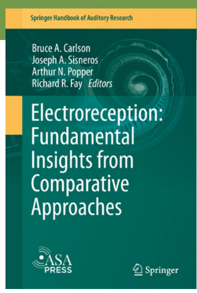

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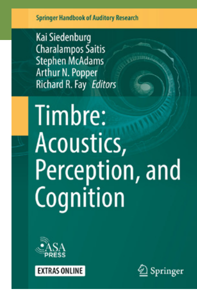

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