The newsletter of
The Acoustical Society of America

ECHOES

Volume 23, Number 3
Summer 2013

Studying the Sea with Sound

Stan E. Dosso and Jan Dettmer

The study of underwater sound may seem obscure but is of immense scientific and practical importance. Since seawater is electrically conductive, electromagnetic waves are strongly attenuated while sound propagates efficiently to long (in some cases global) ranges. Hence, scientists and engineers have devised many ingenious methods to use sound underwater in place of light, radio, or microwaves, including applications in remote sensing and control, communications, detection/localization, navigation, and in studying the sea itself (including the seabed). This article presents a brief, semi-historical overview of the acoustical study of the ocean culminating in recent work in geoacoustic inversion.

Among the earliest scientific investigations in underwater acoustics, Colladon and Sturm (1826) measured the speed of sound in Lake Geneva using an ingenious experiment. The sound source was a bell suspended in the lake from a row boat. The bell was struck with a hammer operated by Sturm using a lever which was connected by a pulley to a candle, such that at the instant the bell was struck the flame ignited a pan of gun powder, producing a simultaneous underwater tone and above-water flash. Colladon, in a second boat 16-km distant, listened with an underwater ear-trumpet and noted the time difference between the flash and tone. From this they estimated sound speed in fresh water to be 1435 m/s, remarkably close to modern measurements of 1438 m/s.

The 1912 sinking of the RMS Titanic due to a night-time ice-berg collision provided strong impetus for the development of underwater acoustic detection and ranging. That same year, Canadian Reginald Fessenden designed a moving-coil oscillator (transducer) which could produce and receive underwater signals at about 1 kHz. With this, Fessenden echo-located and ranged ice bergs to 3 km, representing one of the first applications of what came to be called sonar (sound navigation and ranging). The oscillator was later used to communicate underwater via Morse code and as a fathometer (echo depth-sounder), for which Fessenden won the Scientific American Gold Medal.

World War I provided intense motivation for sonar developments in anti-submarine warfare. Important instrumentation advances were based on the piezoelectric effect that some crystals develop an electric potential when subjected to mechanical pressure and the application of an electric field results in mechanical expansion/contraction of the crystal. Many modern hydrophones and acoustic sources are still based on piezoelectric transducers. Another advancement was the hydrophone array, typically a line of sensors which provides directional capabilities by steering the array response in angle through appropriate inter-sensor time delays as well as providing array gain.

After the War, echo-sounding was applied to mapping the ocean abysses. The first systematic acoustic survey of bathymetry (underwater topography) was carried out by the German ship Meteor, which traversed the Atlantic 13 times in 1925–27 resulting in 70,000 echo-soundings over 130,000 km (regularly checked against trusted but slow lead-line soundings). Large-scale bathymetric features, such as mid-

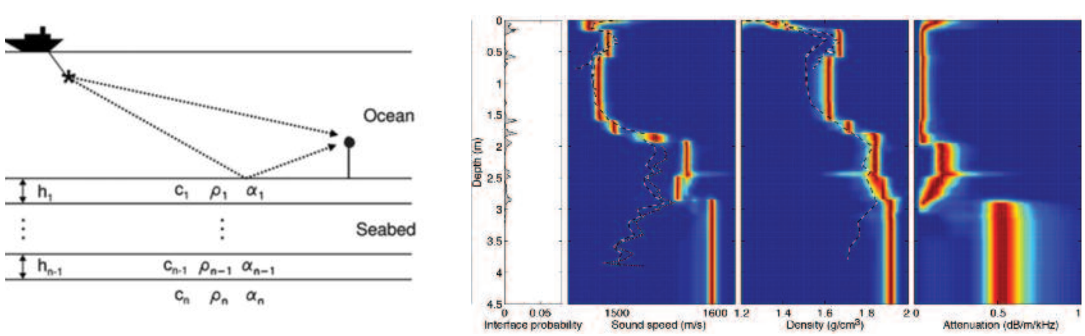


Figure 1 – Left: Reflection measurements with towed source and moored receiver. Right: probability profiles for geoacoustic parameters. Results for core measurements are also shown as dashed lines.

continued on page 3

We hear that . . .

• **The Museum of Modern Art in New York has chosen sound as the subject of a major exhibition** "Soundings: A Contemporary Score: which will run from August 10 to November 3. The exhibition will feature work by 16 artists from the United States, Uruguay, Norway, Denmark, Britain, Germany, Australia, Japan, and Taiwan, according to a story in the April 5 issue of *The New York Times*.

Rose Mutiso

• The AIP-ASA Congressional Science and Engineering fellow for 2013-2014 will be **Rose Mutiso**. She will earn her PhD in materials science and engineering from the University of Pennsylvania in August 2013 and will begin her Fellowship in September.

• **Joseph A. Turner**, Department of Mechanical and Materials Engineering at the University of Nebraska-Lincoln has been named the recipient of a Friedrich Wilhelm Bessel Research Award from the Alexander von Humboldt Foundation in Germany.

• The **World Wide Web** celebrated its 20th birthday by restoring its first website at http://info.cern.ch/hypertext/WWW/TheProject.html. Included on the website is a history of the project led by Tim Berners-Lee, a scientist at CERN. He commented that "I realized that if everyone had the same informationn as me, my life would be easier."

From The Student Council:

Bonjour from Montreal! With over 600 preregistered students the Montreal meeting was a fantastic time for all involved. Approximately 100 students attended Monday night's student icebreaker, and well over 150 students attended Wednesday night's rooftop student reception. In addition we had over 50 students attend the new student orientation session.

The Student Council would like to thank our outgoing Chair, Eric Dieckman, for his service to the Society and all his hard work put into making the student council and it's events a great success. We look forward to working with our new Chair, Whitney Coyle.

Jennie Wylie

Looking towards San Francisco, all students are encouraged to attend the student events and to join us for the student outings. It's a great way to meet your fellow students and lean about the research they are doing. In addition, the Student Council will be hosting a special panel discussion on fellowships and grants, look for more details coming soon on the ASA Student Zone website at www.acosoc.org/student.

For all up to date news, especially during the meetings, subscribe to our twitter feed @ASAStudents and like us on facebook, facebook.com/asastudents.

Looking forward to seeing everyone in San Francisco!

Jennie Wylie

To the editor

Noise levels and impacts

I enjoy reading *Echoes* and find it informative and well-written in most cases. In the most recent issue, I was dismayed to find on p. 7 in the Spring 2013 issue of *Echoes*, the note about the 11 December NYT article in which there are misstatements about noise levels and impacts that "echo" those of the article, and which, in turn, were derived from an Oct. 2012 article also in the NYT. Some of ASA's membership found the two NYT articles sufficiently misleading to send concensus letters to the editors and authors of the articles (copied below). The use of inaccurate analogies about noise is an issue that ASA and its members are trying to address, publicly and scientifically, through talks, research, articles, and websites, like DOSITS. In particular, trying to get the public to appreciate the differences in decibels in air vs. water, differences in ability to impact for various signal types, differences in species susceptibility to noise is non-trivial. Therefore, I would hope that we could avoid repeating such misstatements as cargo vessels rivaling jets, etc. in our own newsletter, which make that process all the more difficult.

Respectfully,
Darlene Ketten
Senior scientist, Biology department
Woods Hole Oceanographic Institution

ECHOES ECHOES

Newsletter of the Acoustical Society of America

Provided as a benefit of membership to ASA members

The Acoustical Society of America was organized in 1929 to increase and diffuse the knowledge of acoustics and to promote its practical applications.

Echoes Editor . . . . .Thomas Rossing
ASA Editor-in-Chief .Allan Pierce
Advisors . . . . .Elaine Moran, Charles Schmid

Phone inquiries: 516-576-2360. Contributions, including Letters to the Editor, should be sent to Thomas Rossing, Stanford University, CCRMA Department of Music, Stanford, CA 94305 <rossing@ccrma.stanford.edu>

continued from page 1

ocean ridges and oceanic trenches, were mapped acoustically throughout the world's oceans in the 1920s–50s and played a key role in the development of plate tectonic theory in the 1960s. Depth-sounding technology has improved dramatically in recent decades, with modern multi-beam sonars efficiently mapping wide lateral swaths of seafloor and side-scan sonars imaging seafloor reflectors using backscatter from acoustic beams transmitted and received by a "tow-fish" flown near the bottom.

World War II provided another impetus in ocean acoustics. In addition to sonar developments, acoustic studies advanced knowledge of the ocean. For example, investigation into sonar operators' observations of diffuse, variable-depth echoes lead to the discovery of the deep scattering layer, prevalent worldwide, which consists of a population of marine organisms (zooplankton, krill, small fish) which rise to the surface at night to feed on phytoplankton (and each other) and descend during daylight to avoid larger predators. Another example is the deep sound channel (DSC), which provides the mechanism for long-range propagation. Sound speed initially decreases with depth due to decreasing water temperature through a layer known as the thermocline, then increases with depth due to increasing pressure in deep isothermal water. The result is the DSC with a minimum (axis) at the base of the thermocline, which varies from ~1000 m in the tropics to the surface near the poles. Sound in the DSC is refracted downward above the channel axis and upward below the axis, propagating without lossy boundary interactions. DSC propagation was exploited in WWII to locate airmen downed at sea: An explosive source was dropped from the life raft, detonated at the DSC axis, and was detected at widely-spaced coastal stations allowing triangulation of the source location to within 10–20 km.

In the 1970s, Walter Munk proposed measuring ocean properties via acoustic tomography, analogous to X-ray medical scans used to image the human body. In ocean-acoustic tomography, acoustic travel-times are measured between a series of sources and receivers and inverted for a model of the sound-speed distribution. Since sound speed depends on temperature, tomographic results may be interpreted in terms of the temperature distribution, from which different water masses can often be identified. The Acoustic Thermometry of Ocean Climate program is based on acoustic tomography at an ocean-basin scale to average out mesoscale variability and provide a stable measure of ocean temperature which can be monitored over time as an indicator of climate change. Measurements made from 1996–2006 in the North Pacific provided ocean temperatures along mega-meter propagation paths with uncertainties much smaller than from other approaches of this scale. The Trans-Arctic Propagation experiment considered warming in the Arctic basin by inverting acoustic measurements made in 1994 and comparing results to direct sound-speed measurements from 1970–1980. By considering the change in travel-times of propagating modes concentrated at various depths, it was concluded that a 0.4°C warming had occurred in Atlantic intermediate water flowing into the Arctic at depth, a result verified by temperature measurements along icebreaker transits.

Recent years have seen great advancements in underwater acoustics which have furthered our understanding of the oceans. Of many diverse developments, the final topic considered here is remote sensing of seabed sub-bottom geoacoustic properties, which provides a convenient in-situ alternative to direct sampling (coring). Remote sensing of a physical system (e.g., the seabed) is a ubiquitous problem in science: A signal interacts with the system under investigation and is altered such that observations of the signal (data) provide information regarding system properties. The process is described by a model which specifies the physical theory, an appropriate parameterization for the system, and a statistical representation of errors. Bayesian inversion treats model parameters as random variables constrained by data and prior information, with the goal of quantifying the posterior probability density (PPD) providing parameter estimates and

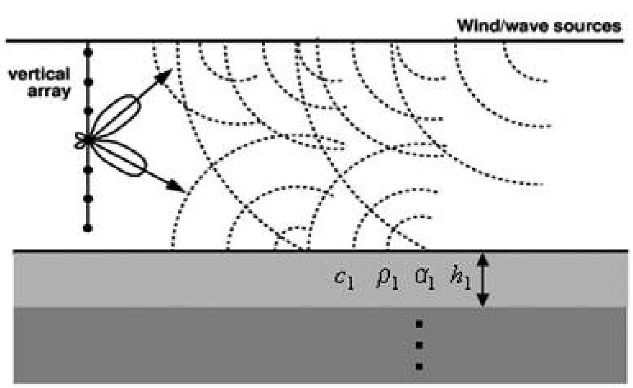
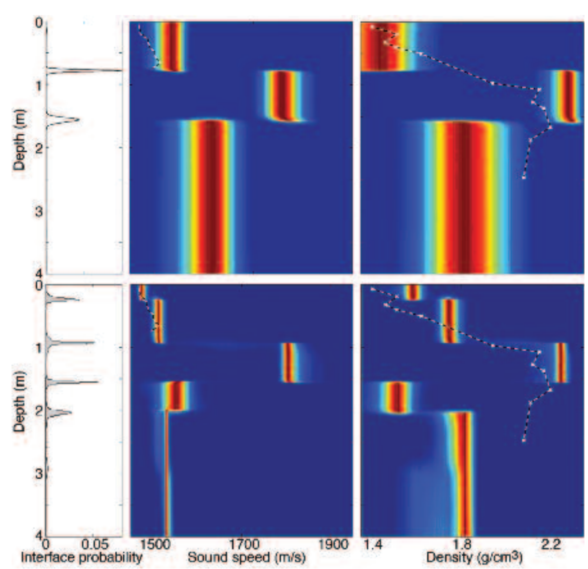


Figure 2 – Above: Ambient-noise measurements involving vertical array recordings beamformed into up- and down-looking beams. Right: geoacoustic probability profiles from ambient-noise inversion (top) and controlled-source inversion (bottom). Core measurements indicated by white dotted lines.



continued on page 4

Desalination and Water Remediation by Hydrodynamic Cavitation

Larry Crum, Michael Skinner, and Scott Zellinger

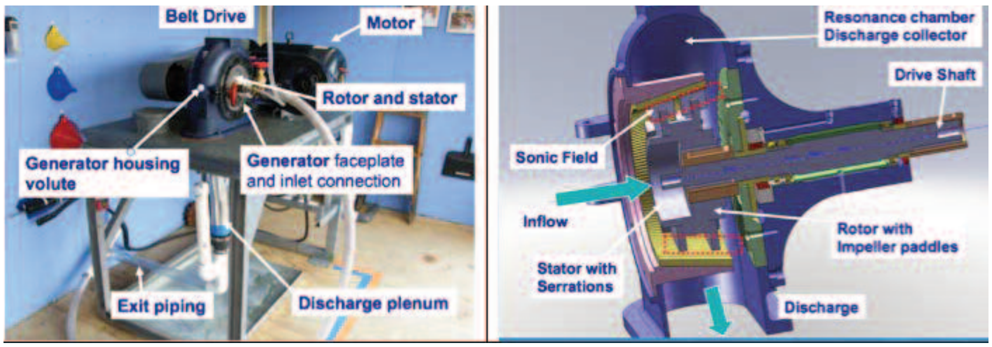


Fig. 1. (Left). General view of the hydrodynamic cavitation system. (Right) Expanded view of the rotor-stator cavitation generation region.

Cavitation is a phenomenon that results in an extraordinary concentration of mechanical energy. This is because cavitation involves the collapse of (often spherical) gas bubbles with volume reduction factors of over 109. Most of the energy generated by growing the bubble to macroscopic sizes is converted into mechanical energy during the final states of collapse. The collapse of the bubble causes a subsequence creation of high velocity liquid jets, intense shock waves, pressures on the order of kilobars, and temperatures in the thou-

continued on page 5

Studying our Sea with Sound... *continued from page 3*

uncertainties. Nonlinear inversions require numerical sampling of the PPD, which can be computationally intensive. Subjective assumptions are sometimes made for the model parameterization (e.g., the number of seabed layers) in inverse problems. However, in the general case where an appropriate parameterization is not known, it can (and should) be included in the inversion, i.e., be estimated from the data. Trans-dimensional (trans-D) inversion methods sample probabilistically over a range of parameterizations in a manner that favors simple models consistent with the data resolution. This approach also has the advantage that the uncertainty in the parameterization is quantified and included in the uncertainty of the solution.

An example of geoacoustic inversion is given in Fig. 1. Acoustic reflection-coefficient data (ratio of seabed-reflected to direct-path energy) were collected on the Malta Plateau in the Mediterranean Sea using a moored hydrophone and ship-towed impulsive source (0.5–5 kHz). In the inversion the data are modeled using spherical-wave reflection theory and a poro-elastic model. Spherical-wave calculations were carried out using a graphics processing unit which sped up computations by ~200 times. Since the number of seabed layers is unknown, trans-D inversion is applied, and error variances at each frequency are included as unknowns. Figure 1 shows inversion results as probability profiles for seabed sound speed, density, and attenuation, which are in excellent agreement with direct measurements from a core collected at the site. In particular, the inversion results closely track the core density profile to ~3-m depth; below this discrepancies are likely due to decompression of the bottom 0.5 m of the core during extraction. The inversion and core results for sound speed agree closely to 2-m depth. Below this the higher-speed sediments are expected to exhibit dispersion (speed varies with frequency) such that the discrepancies are likely due to the much higher frequency (200 kHz) applied in core measurements. Hence, in this case remote acoustic sensing provides in-situ geoacoustic profiles at frequencies of interest which are likely more reliable than core measurements.

Geoacoustic inversion of natural ambient noise is of recent interest due to continuously-available signals and reduced environmental impact. Ambient-noise reflection inversion uses a vertical sensor array to beamform the noise field into up- and down-looking angles (Fig. 2). Assuming surface noise sources (breaking waves) and propagation via successive bottom and surface reflections, sound in a down-looking beam has always suffered one more bottom reflection than that in an up-looking beam at the same angle. Hence, the ratio of the down- to up-looking responses provides reflection coefficients, although angular resolution is degraded by beamforming. Figure 2 shows good general agreement between ambient-noise and (higher-resolution) controlled-source inversions on the Malta Plateau (different site from Fig. 1), with both results in agreement with core measurements.

Stan E. Dosso

Jan Dettmer

This article is a summary of paper 1aID1 at the June 2013 Montreal ICA/ASA/CAA joint meeting. Further details and references are given in: POMA 19, 032001 (June 2013, 14 pages).

Desalination and Water Remediation by Hydrodynamic Cavitation

Project results validated by independent EPA certified laboratories

Element	In	Out	Reduction
Arsenic	6.7 ug/L	ND*	100.00%
Magnesium	13 mg/L	ND*	100.00%
Chloride	480 mg/L	100 mg/L	79.17%
Sodium	330 mg/L	110 mg/L	66.67%
Total Dissolved Solids	1400 mg/L	400 mg/L	71.43%

ND = Non Detectable

Table 1. Some typical results obtained with the GP System.

sands of kelvins. These high pressures and temperatures can result in sonoluminescence [Crum, 1994], in which light is emitted from the gas heated to luminescent temperatures, and/or sonochemistry [Suslick, 1990], in which mechanical bonds between molecules are broken. There are many ways to generate cavitation but all of them generally rely on the requirement that the liquid experience a pressure below the vapor pressure of the host liquid (in order to grow the bubble), which is followed by a pressure higher than the vapor pressure (in order to collapse the bubble). There are two principal ways of generating these pressure sequences: The most common is with acoustic transducers that can develop intense pressure differences, especially if the acoustic field is focused; a second method relies on the Bernoulli principal in which liquids develop pressure variations due to changes in flow velocity, commonly called hydrodynamic cavitation. Acoustic cavitation is used when localized intense pressure fluctuations are required; hydrodynamic cavitation is used when large volumes are to be treated.

METHODS

Globe Protect (GP), via the efforts of Dr. Bertwin Langenecker, developed a hydrodynamic cavitation system with a novel approach that permits it to perform a variety of applications that meet a number of important societal needs.

In the GP system, shown in Fig. 1, cavitation is generated by a rotor-stator combination in which a disc (rotor) is rotated in close vicinity to a stationary disc (stator). Both the rotor and stator have "teeth" that pass each other within a close (~ mm) tolerance. When liquid is flowing through the rotor-stator combination, alternating pressure waves are generated, thus inducing cavitation. Depending on the physio-chemical conditions of the liquid (viscosity, density, dissolved gas concentration, etc.), and the mechanical operation of the mechanical drive (rotation rate, mesh clearance, etc.), copious and intense cavitation is generated. There is also some indication that cavitation and other mechanically-generated sound (called "Macrosound by Dr. Langenecker) is influential in complementing and/or determining the nature of the cavitation generated with the GP system.

RESULTS

Hydrodynamic cavitation systems such as described above are in common use in a variety of applications; however, Dr. Langenecker added an ingenious and innovative twist to this system [2010,2011]. He recognized that within the rotor-stator unit, where copious and intense cavitation was generated, sonochemistry was occurring. The intense temperatures and pressures within a collapsing cavitation bubble can cause a variety of molecular chemistry effects, such as bond breakage, free radical formation, molecular and atomic excitation, etc. [Suslick, 1990]. In particular, when metallic salts, such as sodium chloride, are contained within the liquid, and in addition, surface-active particles are also added to the liquid, the sodium and chlorine radicals can interact with the particles and form new combinations. If the particles are then removed by simple filtration, the salt can be removed from the liquid also, resulting in desalination. GP has demonstrated desalination and other element removal from liquids as shown in Table 1 above.

SUMMARY AND CONCLUSIONS

The novel idea of combining hydrodynamic cavitation with entrained particles can result in efficient removal of undesirable, dissolved elements from a liquid. Such removal has important potential for desalination and water remediation in a variety of scenarios.

REFERENCES

Suslick, K.B. (**1990**), "Sonochemistry", Science, 7, 1439-1445.

Crum, L.A. (**1994**), "Sonoluminescence", Physics Today, **47**,22-29.

Langenecker, *et al.*, (2010), "Method and apparatus for desalination of seawater", US Patent 7,770,830.

Langenecker, *et al.*, (2011), "Method for desalination of seawater", US Patent 8,021,557.

Larry Crum

Bertwin Longnecker

Larry Crum is a professor in the Applied Physics Laboraory at the University of Washington. Michael Skinner, and Scott Zellinger are with Globe Protect, Inc. in San Francisco. This article is based on paper 2aBA1 at ICA 2013 in Montréal.

Scanning the journals

Thomas D. Rossing

• The 19 April issue of *Science* has a special section on "**Grand Challenges in Science Education**" that begins with an article by Nobel laureate Carl Wieman entitled "Transformation is Possible if a University Really Cares. The way most research universities teach science to students is worse than ineffective, says Wieman, it's unscientific. Wieman has spent the past 15 years applying the science of learning to how undergraduate science courses are taught, first at the Unversity of Colorado and then at the University of British Columbia. Later he worked in the White House Office of Science and Technology Policy (OSTP) as associate director for science until he resigned for reasons of health.

• The April issue of *Acoustics Australia* is a **special issue on Underwater Acoustics** edited by Alec Duncan. The editor reminds us that since sunlight penetrates only to a depth of about 200 m (the average depth of the ocean is about 4000 m) and other forms of electromagnetic radiation are attenuated faster than light, the only form of radiation that travels any significant distance in the ocean is sound. Thus the importance of underwater sound cannot be overstated. The collection of thirteen papers on underwater sound begins with a review of "International Regulation of Underwater Noise" by Christine Erbe, who also winds up the issue with a report on a workshop on "Underwater Passiv Acoustic Monitory & Noise Impacts on Marine Fauna."

• The edgetone is one of the most simple aeroacoustic flow configurations, and thus a perfect subject for research on numerical schemes in aeroacoustics. A paper in the March/April issue of *Acta Acoustics/Acustica* discusses a hybrid method to calculate sound production in a planar flow by **coupling two-dimensional computational fluid dynamics to acoustical simulation** that reduces the time and memory requirement. The method, which uses Lighthill's analogy to simulate the acoustic source terms, is applied to an oscillating jet impinging on a sharp, wedge-shaped object.

• **"An Acoustics Arms Race"** is the title of an article on animal sonar in the May-June issue of *American Scientist*. It discusses in detail the similarities between echolocation, used by bats and other animals as a hunting tool, and radar. Late in the article it discusses countermeasures used by insects to play the stealth game. For example, scales on moth wings may decrease the amplitude of the echoes they return to bats by absorbing sounds at freuencies between 40 and 60 kHz. Equadorian tiger moths produce a cacophony of clicks when they are targeted by an echolocating bat. The anti-bat clicks are produced at a rate of up to 4500 clicks per second. They appear to produce these jamming clicks only when the bat has "locked on" to them and they are in great danger.

• In inland estuaries and shallow coastal waters, small particles of organic waste and debris clump together to form an aggregate known as floc. According to a paper (online) in *Journal of Geophysical Research-Oceans*, scientists have used **acoustic backscatter measurements** to study the properties of floc particles. They found that theoretical models using conventional scattering assumptions were capable of only partially describing the observed scattering properties and suggest that future models should better align with the observed scattering characteristics.

• **"Noises On"** in the May issue of *Smithsonian* describes an exhibit of acoustic paintings and other experiments in visual and sonic minimalism by Jennie Jones at the Hirschorn Museum. The exhibit combines Jones' sound collages with painted and sculpted objects employing what she calls the "physical residue of music."

• Plants are known to communicate with each other by means of shade, aromatic chemicals, and physical touch, promoting processes such as growth and defense against disease. According to a paper published online 7 May in *BMC Ecology* plant researchers in Australia deduced that **plants were communicating by "nanoscale sound waves"** traveling through the dirt. Understanding this novel communication could help growers to boost crop yeields and increase global food supplies.

• A pair of letters to the editor in the April issue of *Acoustics Australia* address the ongoing debate on **wind farm noise** (see Summer 2009 and Spring 2010 issues of ECHOES).

• The greater wax moth is capable of **sensing sounds with frequencies as high as 300 kHz**, according to a paper in the 23 August issue of *Biology Letters*. The moth's hearing has evolved because of predation, say the authors. Bats use high-frequency echolocation calls to find the moths and to prey on them. But it appears that the moths can hear frequencies even higher than used by the bats. Studying the structure and functionality of the greater wax moth's ear could help researchers build miniature microphones.

New fellows Michel Versluis, Philip X. Joris, Eric W. Healy, and Peter F. Assmann, with Vice-president Michael Stinson and President David Bradley.

Acoustics in the News

• A team of Australian scientists has successfully managed, for the first time, to track the world's largest creatures, the Antarctic blue whale, using only its sound, according to a news story in the 5 April issue of *Science*. Although researchers have long used the whales' distinctive voices to study the animals, developing a passive acoustic tracking that could find them in real time was a trickier problem. Researchers were ale to detect the very deep song of the blue whale from 600 nautical miles away. They used those calls to triangulate the positions of the whales, so that they could collect photo IDs, as well as biopsy samples, and they placed satellite tags on two whales.

• Music and language are closely related. According to a story in the April 9 issue of *The New York Times*, people who speak languages that use tones to convey meaning have a better ear for learning music. The findings suggest that tonal languages may prime the brain for the development of musical skills. In complex musical and cognitive tests, for example, Cantonese speakers scored 20 percent higher than English-speaking nonmusicians.

• Noise, not age, is the leading cause of hearing loss, an article in the March 26 issue of *The New York Times* reminds us. Tens of millions of Americans, including 12 to 15 percent of school-age children, already have permanent hearing loss caused by everyday noise that we take for granted. After poor service, noise is the commonest complaint about restaurants. Yet many proprietors believe that their customers spend more on food and drink in bustling eateries and do little to minimize sound levels. A survey by the American Speech-Language-Hearing Association found that 35 percents of adults and up to 59 percent of teenages reported listening to partable music devices at loud volumes. Some toys meant for young children, such as talking dolls, vehicles with horns, rubber squeaky toys, and musical instruments generate ear-damaging levels of noise.

• **Sales of popular science books** peaked in 2006 according to an article in the 18 April issue of *Nature*. Now science book editors are more enthusiastic about apps and e-books. "The straightforward book that is nothing but words is not going any pleace," one editor predicted. Another commented that science books that find a devoted readership these days "boast provocative arguments grounded in original research." All agree, however, that well-written science books are unlikely to disappear, even in an age in which the average person's eyes seem to be perpetually locked on mobile devices.

• A few weeks ago, Valery Gergiev and the Marinsky Orchestra used the finale of Mahler's Fifth Symphony to test the acoustics of their new $700 million concert theater in St. Petersburg, Russia, according to a story in the May 2 issue of *The New York Times*. Called the Marlinsky II it is connected to the original 19th-century Marinsky Theater by a pedestrian bridge over a canal. The 1200-seat hall was a collaboration between Canadian and Russian architects.

• We use our tongues when we speak or swallow, but much about how they work remains a mystery. Now a 3D model of the human tongue has been published online in *The Atomical Record* in a story dated 6 May. Having no bones, the tongue operates like the tentacles of an octopus, with the motion of any one muscle depending on the activity of surrounding muscles in a complex manner. A number of the muscles overlap extensively.

• Just as humans make a sound as they gasp for air, vital trees make ultrasonic popping noises as they run short of water, according to a story on BBC News, May 2. At least some of that noise is likely due to cavitation. Cavitation occurs when air bubbles form in the tubes (xylem) that run up and down tree trunks, preventing water from being pulled upward—in some cases it causes the tree to die.

• Hotwire anemometers, known as acoustic vector sensors, make it possible to pinpoint gunfire according to a story in the April 30 issue of *Scientific American*. The device uses two small heated wires to measure individual air particles affected by sound waves. Sounds picked up can emanate from howitzers, helicopters, sniper fire, or even conversations. The devices can be mounted on helicopters, drones, or other aircraft or even on soldiers' epaulets. A typical probe is one millimeter wide, two millimeters long and 300 micrometers thick. It consists of two resistive platinum strips, each 200 nanometers thick by 10 micrometers wide, stretched parallel across a gap and heated to 200 degrees Celsius when operating.


Jennie Wylie

Student reception

Special session honoring Maa Dah-You: George Maling, David Blackstock, Leo Beranek, Christian Nocke, Jing Tian, Keith Attenborough, Ning Xiang, Jiqing Wang, Buye Xu:


Mary Florentine

Session in memory of Bertram Scharf. L to r: Huanping Dai, Fan-Gang Zeng, Erv Hafter, Harry Levitt, Barbara Shinn-Cunningham, Sabine Meunier, Mary Florentine, Jesko Verhey, Bev Wright, and Michael J. Epstein

ACOUSTICAL•SOCIETY•OF•AMERICA
SUITE 1NO1
2 HUNTINGTON QUADRANGLE
MELVILLE, NEW YORK 11747-4502

Echoes from Montréal

Technical tour of La Maison Symphonique

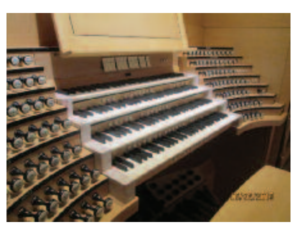
Left: Leo Beranek received 75-year award from President David Bradley

Music at opening ceremony

Charles Schmid

New Officers on the International Commission for Acoustics: Antonio Pérez López (Treasurer), Michael Vorländer (Past President), Michael Stinson (Secretary General), Marion Burgess (President), Mark Hamilton (ASA Board member) (Not pictured Jing Tian, Vice President)

Mary Guillemette and Jessica Eldridge at ASA exhibit



Organ Console

Left: Music at closing ceremony