DOSITS Webinar: Fundamentals of Underwater Sound (April 20, 2022)

Question and Answer Summary
(Questions asked/answered in real-time during the webinar or in the Q&A box)

Questions asked/answered live by Dr. Joseph Warren during the webinar:

Question: Speaking of relative highs and lows, is there a standardized set of units to compare the number of decibels, high/low, like putting things on the equivalent of a sound kelvin scale?

Answer: (Dr. Joseph Warren) Yes you can. You can convert between decibels in air and decibels and water. I think it's 60 db difference (don't quote me on that), but it's basically an offset that you can do. What gets complicated is when you try and describe how loud a sound is, your maximum pressure value may not describe how long the sound is, and so there are a lot of different ways that scientists talk about that, so spectral energy densities versus sound pressure levels. And this is where it gets really complicated and there's a fair bit of math involved, and it's trying to come up with a parameter that best describes, you know, how loud the sounds are. There's a basic issue like if I gave you a little wave form that looks like that (indicates a wave shape on video), one way to describe its amplitude is peak to peak, but you only get that peak to peak for a very short period of time, so people will use something called the RMS value, which is kind of the 70% level because that's kind of what your ears are exposed to more; and so there are ways of doing it, but because our hearing systems are pretty complex it's not a straightforward thing like temperature. Temperature is a much simpler measurement.

Questions (multiple similar questions): How does sound change when ocean parameters such as temperature change and could it be harmful for animals to communicate through the ocean? Does a warmer ocean translate into a louder ocean? I (Chris Knowlton, DOSITS Webinar Host) think they're both getting at, you know, what are, maybe sort of climate change things, but then, what are the short-term and long-term changes in temperature in the ocean, because that is seasonal but then there's climate [change to factor in] as well?

Answer: (Dr. Joseph Warren) Yes, so temperature change is probably the biggest one, like pH will change some things a little bit, salinity will change some things, but temperature is the variable that changes the most in the oceans just naturally, as well as a result of climate change. So the first thing that happens is if you have a warmer ocean, sound is going to travel faster and so sounds will arrive just a little bit quicker. The absorption coefficients will change as functions of temperature and so, and I should know the answer to this off the top of my head, but I don't, but I believe a warmer ocean is noisier, but I'm not 100% positive on that. But it's also not just that absolute temperature change, it's when we talked about sound refraction and bending, if you make that ocean surface a little bit warmer that's going to change where those rays bend and how they bend, so it can get pretty complicated. Well, I lost track of the other aspects of that question.

Chris Knowlton: Oh, that's okay. You answered part of it. They also asked: **Is it harmful for animals who communicate through the ocean when the temperature changes?**

Answer: (Dr. Joseph Warren) That's a good [question]. If temperature changes result in a noisier ocean, then that might reduce how far animals can communicate with each other, so animals might have to travel closer together to remain in communication. That also then is related to how other sources of sound [travel], so we have more shipping activity now than we did 50 years ago, so the ocean is noisier in general, so animals' effective communication ranges are already reduced as part of that. I think the temperature changes in the ocean are probably less important than sort of anthropogenic noise sources in terms of the impact on marine animals but both could probably be important.

Question: Can you explain again, or maybe expand on it, why a larger driver is needed to produce a lower frequency sound?

Answer: (Dr. Joseph Warren) Yes, so this is basically an issue of physics. So lower frequencies have a larger wavelength, and so you basically need a larger aperture to move the medium to create the pressure signal within that medium. You can build synthetic aperture arrays or panametric sonars, they use smaller drivers, but you put face shifts on each of them to mimic a larger transducer. But it's basic physics, like back in the day before you had split beam transducers, the diameter of your transducer squared divided by the wavelength, that was your near field range. So it was just a question of physics. There are several textbooks that that can go into that in more detail.

Question: Can you explain the harmonics that are detected say from a humpback whale song?

Answer: (Dr. Joseph Warren) Harmonics occur for certain types of sound generation. The easiest example of this is a singer or a guitar string. If you play a guitar string and you record it on the spectrogram (if you go to that website that does the live spectrograms: https://musiclab.chromeexperiments.com/spectrogram/) you'll see the energy that's created at that fundamental frequency and then add multiples of that frequency, so if your primary frequency is 100 hertz, you will get harmonics at 200 and 300 because those are shorter wavelength waves that also have the same node structure on your sound generating mechanism. So guitar strings are a really easy way to think about that. The guitar string is like a bow that oscillates back and forth, with two fixed endpoints, and then you can also have a wave that has a peak and a trough to it and will oscillate, and you can have three waves. So, it really depends on the sound generating mechanism, like a clap will not produce a harmonic but oscillating mechanisms, fish, many fish make their sounds by basically oscillating their swim bladders and those often just produce harmonics. Trumpets, brass instruments also produce harmonics as well.

Question: Is there any difference as how transient sounds and tonal sounds may travel in an acoustic channel?

Answer: (Dr. Joseph Warren) The frequency will change how sounds travel. The duration of the sound should not impact the physics, other than maybe detectability. So, if the frequency of sound is different than those sounds will travel in different ways. But whether it's a long sound or short sound that should not affect the physics.

Question: This is an interesting one. Do areas of the ocean with semi diurnal tides scatter sound more than areas like the Gulf of Mexico, which have only one low and high tide each day?

Answer: (Dr. Joseph Warren) So that's an interesting question. So, not so much sound scattering but sound propagation may differ depending on those tides, particularly in shallow water environments, right. If you're in an estuary or a coastal area and your tidal height is varying a few meters and you're in 10 meters of water, then that's going to change just how big your wave guide is and things like that, If you're out in the open ocean, offshore where it's 1000 meters deep, then that tidal range probably isn't going to have an impact. We actually had a grad student, Colin Worth, who was looking at a paper, where we recorded toadfish, which is another fish that makes noises in a local bay here that's about two and a half meters deep on average. This was a situation where, depending on the tidal range, where it was in the tide, we oftentimes wouldn't detect that fundamental frequency, we would only be able to detect that first harmonic and that's because of how it propagates through the water column, so it certainly can have an impact, but mostly in really shallow regions.

Question: Are there early acoustic triggers of geophony that marine mammals detect? Maybe they're referring to how some people have seen particularly large mammals move away from like an earthquake area or volcano or something.

Answer: (Dr. Joseph Warren) That's a good question, I don't know the answer to it. I want to say there's like some anecdotal stories about, you know animals leaving an area before a tsunami arrives, that maybe they detected the geophysical signal, the actual earthquake event. I don't believe anybody has demonstrated that, you know conclusively in any way, partially because it's just really hard to try and do that. But it's certainly possible those animals could detect those signals, as I did mention, sound travels really fast in the ocean, it's almost a mile a second, so those signals propagate in the ocean much faster than they do in air so, in theory, an underwater animal would have advance notice.

Questions asked/answered in the chat box during the webinar:

Question: Are tones always narrow band sounds?
Answer: Yes, tones are single frequency signals, so they are narrowband. Broadband signals include multiple frequencies at one time.

Question: In terms of disturbance to marine life, do continuous or intermittent sounds have different impacts? Is one more impactful than the other if all other factors are equal?
Answer: Determining the potential impacts from sound exposure on animals is complex. Please review this page on DOSITS to understand the process: https://dosits.org/animals/effects-of-sound/determine-if-a-sound-affects-a-marine-animal/

Question: What's the difference of sound traveling in the ocean and on air.
Answer: Please review this page on DOSITS about the difference between sound in air and sound under water: https://dosits.org/science/sounds-in-the-sea/how-does-sound-in-air-differ-from-sound-in-water/

Question: Can you have long or short duration tones?
Answer: Yes, duration of a signal does not influence its frequency (whether it is a tone or not). You can have long or short duration tones.

Question: Is it still passive acoustics when you use a call to analyze the response from the animal? For example, in acoustics study of jackals.
Answer: If you are playing a sound to the jackals, then it is considered active acoustics. Listening for their acoustic response is passive acoustics - so it would be a combination of both active and passive.

Question: What are the real impacts of active acoustics in animals? Is there an acoustic impact?
Answer: The response is very complex, depending on a variety of variables. I would recommend you review the DOSITS webpages on Effects of Underwater Sound (https://dosits.org/animals/effects-of-sound/potential-effects-of-sound-on-marine-mammals/) or previous DOSITS webinars that focused on this topic.

Question: What are good references to better understand transmission loss, acoustic impedance, absorption and scattering using towed arrays? The goal would be to estimate the range of high-frequency animals more precisely.
Answer: Urick's Principles of Underwater Sound is a good general reference book. The next DOSITS webinar by Aaron Thode will discuss acoustic propagation modeling.

Question: Can echo Doppler be exploited to extract velocity vectors for subject targets?
Answer: Yes, Doppler can tell a lot about the target. Please review this DOSITS webpage for more information: https://dosits.org/galleries/technology-gallery/observing-ocean-currents-and-temperature/adcp/