3 Takeaways Podcast Transcript
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Ep. 145: Now Hear This: Non-Humans Communicate Highly Complex Information Through Sound

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INTRO male voice: Welcome to the 3 Takeaways Podcast, which features short memorable conversations with the world's best thinkers, business leaders, writers, politicians, scientists, and other newsmakers. Each episode ends with the three key takeaways that person has learned over their lives and their careers. And now your host and board member of schools at Harvard, Princeton and Columbia, Lynn Thoman.

Lynn Thoman: Hi everyone. It's Lynn Thoman. Welcome to another 3 Takeaways episode. The world, it turns out, is filled with sound which humans cannot hear. As Blackfoot philosopher, Leroy Little Bear says and I quote, "The human brain is like a station on the radio dial parked in one spot, it is deaf to all the other stations." Just as telescopes and microscopes expanded our ability to see the world, advances in sound are expanding our ability to hear the world along a wide range of the sonic spectrum well beyond human hearing. Today I'm excited to be with Karen Bakker, a professor and author of the wonderful book, The Sounds of Life.

LT: She's going to take us beyond the confines of our own senses to hear the animals, plants and the world around us. According to Karen, carefully listening to the animal and plant world reveals complex communication and challenges the claim that humanity alone uniquely possess language. I'm excited to find out more. Welcome, Karen, and thanks so much for joining 3 Takeaways today.

Karen Bakker: Thank you so much for having me.

LT: It is my pleasure. I loved your book. It was really eye-opening.

KB: Well, thank you.

LT: Recent scientific breakthroughs have revealed that a vast array of species make an astonishing assortment of sounds, mostly beyond the range of human hearing. Let's start with the ocean. Western culture has always assumed that the ocean was silent, what does the ocean actually sound like?

KB: The ocean can be quite cacophonous. If you're on a coral reef, you'll hear the clicking of shrimp, fish might pop and grunt, if you're lucky enough, you might hear the calls of whales in the distance, at some points on the full moon or just after the full moon when there's a mass spawning event on a coral reef, which is like an underwater fireworks display with all the coral spawning at the same time, this attracts a feeding frenzy, and there's just an abundance of noise, which can be easily drowned out by boat motors or even diving gear. So a lot of these noises can simply pass us by, but even something as seemingly silent as a seagrass meadow actually makes sound if you're able to quiet yourself enough to listen.

LT: How important is sound to fish? For example, how important is sound to whales?

KB: There's no one simple answer because each species is different, but a general point is that sound is very important for all aquatic species because sound travels better under water than it does through air, and if you've ever done any diving, you'll know that you can hear often better than you can see under water and many aquatic creatures have evolved to essentially see the world through sound. Take whales, for example, the neurological apparatus they have to process sound far exceeds our own. And of course, some citations echo locate as well as vocalize, meaning literally they see the world through sound, because through echolocation, which is a form of biological sonar, bio-sonar, they're literally sending out sound waves at frequencies that we cannot hear, but they can, and those sound waves bounce back off of objects.

KB: It's a bit like an ultrasound in a doctor's office, but far more powerful. So literally, sound is being used to navigate, to locate prey, to locate kin, to find mates, to sing territorial songs in the case of, for example, humpbacks or orcas. So if you see the world through sound, actually singing your way through the world becomes a way that these creatures live.

KB: We used to think that was only true for whales, but it turns out that a lot of fish can hear these sounds. The amazing thing is that we're now able to detect this with modern digital bio-acoustics, and this is revealing not only all the beautiful sounds, but the very exquisite sensitivity of many creatures to those sounds, including creatures without ears like fish larva and coral larva, and hence their great susceptibility to noise pollution.

LT: So interesting. And it's both fish that use sound, I guess from an evolutionary standpoint, perhaps because light doesn't penetrate the ocean very deep, but also animals and plants on land also use sound beyond the human spectrum. Is that right?

KB: That's right. So a really fun example is the work of Dr. Heidi Appel at the University of Toledo, she took a simple model organism in biology, Arabidopsis thaliana, it looks like a weed, it doesn't look like a very complicated plant, and she played different sounds. Okay, so using speakers, so you can imagine, you can set up the control, which might be white noise or the sound of rain or music, not a threat, but then you have a sound that is a threat, in this case, the sound of an insect chewing on leaves. Now, no insects are present, no leaves are being chewed, it's just the sound, and it turns out that the plants are able to distinguish between non-threatening sounds like rainfall and threatening sounds like chewing insects, and they release their defensive biochemicals only in response to the insect chewing sound.

KB: So although they don't have what we would recognize as the neurobiology that would allow them to hear, they are sensing sound, and we think they do that with the little hairs called cilia that they have on their leaves, which are somewhat akin to the hairs you have in your ears that are enabling you to listen to me right now. Except of course, they're exquisitely sensitive to sound, more sensitive to sound than we are because they hear with their entire bodies.

LT: So fascinating. Whales have been studied a lot, can you tell us about the different sounds whales make and the ways that whales use sound to communicate?

KB: Some listeners may recall the beautiful songs of the humpback whales that were released by Roger and Katy Payne with their best-selling album of whale music several decades ago, which

played a pivotal role in halting the industrial whale hunt, but raising public consciousness. And scientists have since learned, since the Paynes did their landmark research, that the humpback whale songs are forms of culture, new songs are invented, they can be transmitted quite quickly across entire ocean basins, but many other whales make sound. So for example, sperm whales make sounds that are more like Morse code, very complex. Many other whale species have really interesting communication like Orcas.

KB: Orcas both echo-locate and vocalize, we know that they too have dialects that the elders teach to the young, dialects that are specific to family groups and that pass down through the generations. So there's just so much we don't know. But let me sum it up this way, scientists used to think that whales didn't make sound, then they discovered they made sound, but they assumed that these were songs without words, these were just sort of ululations with no meaning. And now we're at the point where with digital technology, we can record these whales, we can track them with bio-loggers while they're deep under the ocean, so we understand their behavior while they're making different sounds, and we may be on the brink of a breakthrough, essentially an interspecies communication, where we begin to decode the meanings in different whale sounds, we've just...

KB: I'll say one more thing, I could go on for hours about whales, but using these technologies, we discovered something very beautiful. We knew whales spoke very loudly, but we've just learned that mother right whales whisper to their baby calves in very soft voices when they're born, and we think that's because they're trying to help them avoid predators. So they're not so much at risk of predators when they're fully grown, but the new calves are at risk. We would never have even known about these whispering mothers had we not had these amazing digital bio-acoustics devices that scientists are now using to record the sounds of nature from the Arctic to the Amazon.

LT: Do we have any idea what their sounds are communicating?

KB: So in general, no. It's been much harder to study whales 'cause they spend so much of their time under the waves, unless you observe their behavior in the wild and correlate their behavior with the sound, it's very hard to guess the meaning because the next step you need to take is essentially a playback experiment, this is how researchers discovered that dolphins have signature whistles which are unique to each animal, which function much like names, 'cause of course, if you're watching them long enough, you decode that particular sound and then you play it back, that particular dolphin will respond. So that is the methodology by which scientists are now gonna be providing an answer to your question. We don't know what they mean, but if we assemble a dictionary, link it to behavior and then do these playback experiments, we hope we'll find out.

LT: So fascinating. We often hear about coral reefs and how important they are for ecosystems and for fish, can you tell us about coral reefs, what are they and if they make sound?

KB: Coral reefs are incredibly important to the global ocean bio-diversity, and of course, also to human health. For many coastal communities, they're a source of medicines, actually as well as food, they provide a barrier against storm surges, they have so, so important role to play in global ocean biodiversity, that the current crisis with coral reefs due largely to climate change and ocean acidification is a real concern. We're losing coral reefs. Even the magnificent great barrier reef off the coast of Australia, which you can see from space is disappearing at an alarming rate.

KB: So in the midst of all of this, scientists who do bio and eco acoustics, listening to individual

organisms and listening to entire ecosystems have discovered an astounding fact, this fact is that coral larva, which are microscopic, which have no central nervous system, I mean, they're really tiny little blobs, can actually hear sound and respond to sound, the experiments were done by a wonderful researcher named Steve Simpson and his team in the UK, based in the UK, but they did the experiments off the coast of Australia and in Curacao. The coral larva are able to discern the sounds of healthy reefs, even though they're washed off the reef and they might be miles away in the open ocean, and they're able even more astoundingly to distinguish the sound of their home reef, their mother reef and swim back home across miles of open ocean.

KB: So not only do they hear the sounds, but they locomote. And again, we think they do this with these little cilia, their bodies are covered with little hairs. So we think they both hear with those hairs, the coral reef lullaby they've imprinted on the moment of their birth, the brief moment before they wash out to sea, and they must use those cilia also to locomote. Now, that sort of begs the question of how they're processing these sounds, but it does raise an interesting hypothesis, and the hypothesis is this, it may be that every living organism is sensitive to sound, we just haven't realized it yet. And again, that makes the salience of noise pollution a pressing issue for us to address.

LT: What is the impact of noise pollution on animals and on fish?

KB: We know that noise pollution is detrimental to human health, it raises stress hormones, it increases cardiovascular risk, even the normal levels of ambient noise we tolerate in most large cities, some of the greatest human health threats of our time, and so there's a new initiative to clamp down. But what we haven't yet really come to grips with is that noise pollution is even more pernicious for other species because they're often more dependent on sound than we are. There's a ton of research that shows increased stress responses in many organisms from crustaceans to marine mammals, inhibiting feeding, mating, reproducing.

KB: So it is an onslaught that is creating the equivalent of a dense acoustic fog or the worst smoke you can imagine where you can't even see a foot in front of you, that is what it is like for these creatures which are so dependent on sound. So you can see why it's so important to start enacting new noise pollution regulations.

LT: Karen, can you tell us about some of the animals that you find most fascinating from a sound perspective?

KB: Yeah, and I'm going to try and play a clip, if that's alright.

LT: That would be lovely.

KB: As I do, I would really love you to guess what you think is making this sound.

[vocalization]

KB: So what do you think made that sound?

LT: Has that sound been speeded up or amplified, how has it changed?

KB: That sound was originally made above your hearing range and was slowed down so you could

hear it.

LT: Is it turtles?

KB: It's actually a bat. We've known for about a century that bat's eco locate, that is they use this sort of bio-sonar like ultrasound machines, but we've only really began studying bat vocalizations more recently, and those vocalizations are not for navigation, they're for communication. Bats would have individual signals that encode their gender, their family identity. They function like names, bats use these vocalizations to negotiate many things like negotiate food and resources. So they have very, very complex social lives.

KB: The baby bats of some species learn to speak just like you and I did, they exhibit vocal learning. So they listen to the adults around them and babble back till they speak adult bat. And some species, the male bats would learn territorial songs from the previous generation. So those dialects are passed down through the generations and they factor into mating choices, territorial defense. So there is whole world of complex communication out there.

LT: That's amazing. How about bees?

KB: Bees are fascinating because in a way, they've been long studied and yet we're still uncovering an enormous amount of information about them. Your listeners may know the work of Karl von Frisch, who of course won the Noble Prize for his study of the Waggle dance, which communicates nectar location and can allow bees to find sources of nectar that are really quite far away, and to communicate this, they use acoustic vibrational, spatial positional communication. Their abdomens have six degrees of freedom, they're touching their antenna to the abdomens when they're communicating, they orient their bodies to the position of the sun because they can see polarized light. So that's also important for this way finding. Amazing. But it turns out bees make many other sounds. So I'm just going to try and play a couple. So listen to this.

[vocalization]

KB: And now listen to this honey bee queen.

[vocalization]

KB: So the Queen has her own sounds, there are many signals we think we know what they mean. There's maybe a begging signal, there's a stop signal, but there are many, many more that we have really no idea about, but at the same time, my research on bees has made leaps and bounds, and we know bees can recognize individual faces. They can be trained to distinguish between different painters, like a Monet versus a Picasso. Recent research has showed them able to learn how to use tools like put a string in a honey pot to dip it out to get the honey and teach that tool used to other bees. So there's a lot more to learn.

KB: One of the cool things about the new wave of digital technology is we can use computer vision to track the movements of bees, and then we can combine that with the bio-acoustics listening to the bees. And so we can discern a lot that the human ear cannot capture and the human eye cannot capture by using these technologies. This is how Thomas Seeley did his amazing work on honeybee democracy, that demonstrate that honeybees have a kind of quorum sensing when they swarm and

pick a new hive with very complex mechanisms for essentially voting and down voting and reaching consensus and avoiding sail mates. So there are sort of a democratic decision-making going on when the bees are selecting their new hive location. So again, bat communication is very rich and we're only just scratching the surface.

LT: Karen, let me ask you more about plants, they detect and they respond to sound, do they also make sound?

KB: So yes. Work done by Monica Gagliano and others has revealed that plants astonishingly, and I should point out this is peer-reviewed research, [chuckle] they make sound. The plants that have been studied include corn and wheat, tomatoes and tobacco. We've known for a long time that these plants respond well to ultrasound, it can make them grow faster. So in some parts of Asia, they're using ultrasound to accelerate plant growth. One of the simple ways you can start to look for organisms emitting sound is to sort of begin with a hypothesis that they're probably emitting sound at the frequencies they can hear a sound, like you and I hear sound and emit sound pretty much at the same frequency.

KB: It turns out plants do as well, they emit ultrasound, it may be simply passive and it could be due to cavitation or if they're going from a dehydrated to a hydrated state. So I wanna clarify, we don't know. And it's probably not the case, these sounds are purposive, but they do emit sound. The research proliferates every day. And it's really delightful.

LT: Karen, what are the three takeaways you'd like to leave the audience with today?

KB: The first is in nature, sound is everywhere and silence is an illusion. There is infrasound, there is ultrasound made by plants, animals, even our planet itself makes infrasound so deep that you cannot hear it, but is everywhere around you. The second point I'd like to make is that these sounds convey complex ecological information, they are not sounds without meaning, they have meaning which can be interpreted by their species. And the third point is that thanks to digital technology, we are now able to essentially extend our listening ability beyond the limits of our sensory capacity, beyond the limits of our biology, it's much like the microscope and telescope enabled us to see into the microscopic world and eventually discover DNA and the ability to manipulate the code of life, much like the telescope enabled us to see into the stars and eventually back in time to the origins of the universe.

KB: And thus, bio-acoustics decenters humans from the Tree of Life and reveals that we have more commonality than we knew. And that is profoundly exciting and important, it's a collective scientific discovery many decades in the making, but is something that is as important as optics. So I'd like to say sonics is the new optics or bio-acoustics is the new optics, and we're just at the beginning of learning, of realizing what this will mean.

LT: Karen, this has been wonderful. Thank you so much.

KB: Thank you so much for your time.

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