Dr. Darlene Ketten interview on Discovery of Sound in the Sea

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Interview Transcript

Q1
How did you first become interested in science?

"I actually got into science sideways. I wasn't exactly interested in it. In high school in particular I wasn't very interested in science. I was more interested in languages and history. In college it was required that I take a science. So I took biology and discovered that there was a whole world I knew nothing about but which was fascinating. And that world was largely the world of other animals. What they hear, how they probably think, things that happen in their world that we can't even begin to perceive and that fascinated me."

Q2
What is the focus of your research and why did you choose this field of study?

"The focus of my research is really hearing in other species besides humans. Well, actually that is not fair. I have two foci, the plural of focus. One is to actually work with humans and the other is specifically to work on other species than humans. With human hearing what I do is to try to develop better ways of imaging ears that are dysfunctional or people with failing hearing or who have lost their hearing. So with humans, my human hearing work the focus is a better way to look inside the head to determine what's happening with their hearing structures, their auditory structures. With other species the focus is to try to understand what they hear very simply. Because no two species hear the same frequencies, they don't hear as well at one frequency or another. We wanted to understand what they do hear and how that happens, how they manage to hear differently."

Q3
What have been some of the recent discoveries about how marine mammals hear?

"Recent discoveries are coming from all fields. From behavior, from work like mine, which is mostly modeling and anatomy, and from direct measurement just like we test humans and babies, we can ask the same questions. The most recent discoveries are how very wide the hearing range is across most whales and dolphins. For about twenty years we've known that dolphins can hear ten to twelve octaves. We hear eight octaves. An octave is a doubling of frequency, for instance, 300 Hz to 600 Hz is an octave. These

animals hear from around 100 cycles per second up to almost 200,000 cycles per second and that is about ten octaves. We didn't know until very recently, looking at the ears for instance, that that is probably also true of the great whales, or the baleen whales."

Q4
How do you study the hearing of marine mammals?

"I personally study it largely by what you can think of as the watchmakers' approach, except it is the watchmakers reverse approach, take the ear apart. When an animal strands and dies, we start dissecting the head. It is called necropsy, to examine the body. So what we do is to work in my lab, people in my lab work specifically on the head and we start looking at the head. It is not just at the ears. You don't just run in and grab the ears. Ideally, what you want to do is to take a look at the whole head and try to understand how the ears fit into it and then fit into the physics of underwater sound. Most recently we've been very lucky in getting a CAT scanner, a computerized tomography scanner, just like they have in hospitals. And we use that scanner to take apart the head. It takes a lot less time than it does to go out there and cut it up on the beach. So what we want to do is see how that whole head is adapted for being able to hear or to see or any of the other senses. And then particularly the ears, how they are adapted, on a macro scale inside the head, to pick up sound and transduce it into something that the nervous system can use. And then inside that inner ear to actually see how that mechanical pressure is changed into a neural signal that the brain understands."

Q5
What challenges have you faced in studying the hearing of marine mammals?

"Challenges in marine mammals are pretty big. They're big because the animals are big. For instance, this is our head, or an example of our head, and this is a blue whale ear. So it's an ear that's almost as big as our head and it's a lot denser. This is the densest bone that's known to man. So something that is essentially the density of a bowling ball, inside that, is a very delicate structure which is the inner ear. And we have to get to that. So the first thing is you've got to find a way to approach that ear when you're dealing with something 30 meters long and you have to get in to get an ear like that. And what you have to do is just figure out how to get in there. The answer is frankly just chain saws. So we have most saws known to man. Or as I mentioned before we've got CAT scanners which let us, if the animal is small enough, to just put the whole animal through and look at it that way, and that's great. That's exactly it; in this case the one focus of my research on humans is feeding into marine mammals. But also because we learn about how human pathology looks on a scanner and of course we can investigate that surgically as well. And then with a dolphin, we bring it in, or a seal, we have seals with an ear that is oozing and the seal doesn't feel too good, and we say, "Ah, I see, this is just like an ear infection in a kid". We can't put tubes in but maybe we can give them this antibiotic or that. So the two things, it's a push-pull, but you have to keep inventing new ways to approach a wild animal that is really big with really complex ears."

Q6
What has most surprised you about the hearing of marine mammals?

"Two things have surprised me about marine mammal hearing. The first one is how diverse the hearing is. We now know that, one of the newer things also in the field is that, there are a lot of marine mammals out there that hear very well at very low frequencies. For about 50 years we've been studying the ultrasonics, the really high frequency animals, that, like bats, echolocate or they use bio-sonar to image their environment with sound. What we don't know too much about are the animals that hear at infrasonics, hearing frequencies that are below human hearing. So the first thing is how extraordinarily diverse these ears are. And then the second thing that surprised me when I came into the field was how very little we know. How much humans don't understand about something that's clearly important to us. For stewardship of the oceans, we have to know what sounds can impact these animals and how. But also we need to understand what's important about the sound to them. Not just how their ears can be hurt but how sounds can be corrupted, masked, or they can be confused by sound, affected by sound. It's like a workplace problem."

Q7
What skills are important in your area of research?

"I'm not sure it's a skill, I'd say the most important thing is to have an open mind. And that's true of any part of science, I think. You have to go in and don't assume. It's good to have a good theory. And you want to do that by observing the animals but then, especially as an anatomist, the whole idea is to let the animal tell you. The one thing is to let the animal's anatomy tell you how it's put together and how it works. When we do an investigation into the cause of death of an animal, don't assume anything. Just go in and let the animal's body tell you its story and what happened to it. So all of these things, the same with people; it's just the same. The most important thing is keep your eyes open for something new, that you don't expect, that's when the most fun is. In terms of real skills, what every student doesn't want to hear, math, physics, chemistry; all of the stuff that's not really easy to do. And it doesn't frankly hurt to have a general background in natural history. Don't know just about, you shouldn't know just about marine mammals, but there are all kinds of things. Bats are a good way to become informed about how bio-sonar works. That field is light-years ahead of anything we know about marine mammals in many ways. So you have to have as broad an interest set as you can tolerate, if you've got time for it."

Q8
What are the opportunities in studying the hearing of marine mammals? Can people without PhDs participate in some way in this type of research?

"Absolutely, anybody that has a true, honest interest in science can participate and can be beneficial. And, I think, can do something not only of interest to them, but rewarding to the field. There are a lot of levels. It would be very hard to do anything without a college degree, just because, frankly, the competition is so stiff. A great many people are interested and laboratories want to get the very best people they can, the ones who have been well motivated and have been well educated. You can work as research assistants, you can do field studies. It's not the degree so much as it is getting the right background, being well motivated, being well educated in the area. There are lots of other areas that anybody can contribute to."

Q9
What is the greatest impact/relevance of your research?

"It's actually not for me to judge what the real relevance of my research is, so much as what does the field say. But I think it is fair to say that to marine mammal science I've brought an unusual perspective which is that of: while these ears are extraordinary, they are not perfect and we have to start thinking about them as we do about human ears. Is: how do they hear and if we get one ear, since these animals are so rare, sometimes we have one blue whale to look at, don't assume that animal is normal, especially if it is an older one. So, much of my contribution has been, I think, to bring to the field information in the perspective of how do we look at pathologies, at disease, at hearing loss, and what does human sound have to do with those. How much of it is natural to the animals and just part of the process of life and the risks of the cost of living. And how much of it is something that we are having an impact on. So it is kind of a different way of looking at the hearing, not as a model of how animals hear underwater, so much as it's an extraordinary ear but how does it get corrupted and changed and what can we do to prevent that, if possible."

Q10
What continues to inspire you about your work?

"The thing that inspires me the most is the unanswered question. Just like any field you can sometimes get a bit burnt out and you don't really like getting called at 2 o'clock in the morning saying something is dead and it's been dead for quite a while and its going to be really ugly and then somebody says, and it's a species you've never looked at before. Even those bones are going to be worth looking at. And sure enough it's always a surprise. In the last 3 years there has been a huge surprise about beaked whales and their sensitivities and their effects. But it is not even necessarily their hearing. It might be their physiology that is quite different. But it is not limited to just dolphins and whales and marine mammals. I'd love to get my hands on a giant squid. I wonder if they hear and if so is the last thing that they ever hear the click that a sperm whale makes? So it's all those questions and the ocean is an incredible place. We don't even know exist out there. Every

time we go deeper with more sensors. That's something dolphins have given to us is a way to sense in the deep, to use sound. Sound is so important for them and for us. We keep finding new stuff down there and new ways there're adapted."

Q11
What advice would you give a high school student who expressed an interest in pursuing a career in your field?

"Well, a high school student who thinks they have an interest in the field I guess the best advice I can give them is don't loose sight of the romance of, the mystery and intrigue of a field like ocean biology, marine mammal biology. But, the most important thing you can do is to get a really good grounding in math and physics because the oceans, it's an alien world and you can't just do things by instinct or reflex. That's where mistakes are made in science. So you really have to get the physical sciences that [...] as an integral part of you. So you can understand them and when you are confronted with something new you'll have a lot of methods for measuring, testing [...]. The typical thing is, get as much science as you can in high school. Get as broad a perspective about biology as you can and even if it is plant biology it's probably going to turn out to be valuable to you because you're really looking at a whole environment, and not just a single animal."