S U N Y College of Environmental Science and Forestry Campus Conversations: The Podcast
Season 2, Episode 4
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Joanie Mahoney: Welcome. This is Joanie Mahoney, and I'm back with the Campus Conversations, the Podcast. Today we are talking about Project Breathless, and I have three of our esteemed faculty here. And if you've heard any of our podcasts in the past, you know that one of the things I like to do is ask our guests to introduce themselves a little bit. I'll start with you, Dr. Karin Limburg.

Karin Limburg: Okay. I'm Karin Limburg. I'm in the Department of Environmental Biology. I'm a professor there. And I like to think of myself as kind of interdisciplinary, working on the edges of different fields from physics to economics with a lot of ecology in between. And long time ago, I decided I wanted to work with something that had meaning, meaning to people in natural resources sense. And I decided to work with fish because I always like fish.

Joanie Mahoney: Thank you very much.

Roxanne Razavi: Hi. I'm Roxanne Razavi. I'm also in the Department of Environmental Biology with Dr. Limburg, and I'm an environmental toxicologist. My research spans limnology to ecotoxicology, and primarily I work on mercury pollution and mercury pollution in freshwater systems. I also work on harmful algal blooms with colleagues, and sources of nutrient pollution. So, yes, spanning all areas of environmental toxicology.

Joanie Mahoney: Thank you very much. Welcome.

Andrea Feldpausch-Parker: Hi, I'm Andrea Feldpausch-Parker. And I'm actually in the Environmental Studies Department. My early education was actually in the biological sciences, and I transitioned into the social sciences because I was wondering why don't other people find these issues as important as I do? And I started to explore that. And so, my area of expertise is in science and environmental communication. And I'm really interested in public and engagement in environmental decision making. And because of my background, I get to work with these wonderful individuals

over here and kind of help contribute to understanding of the science. But how can we engage on these really critical issues?

Joanie Mahoney: We've said that a lot here in my time at E S F about how there's this incredible research that's being done here. For that research to be maximized, it has to be something that's translated to policymakers so that they put good policies in place. Using your research to make sure that we stop doing some of the things that we're doing that are bad or do more of the good things. And so, I do think that it's great that E S F has this focus on translating this science through the work that you're doing into actions that policymakers can take. Let's start back at the beginning. Dr. Limburg. Can you tell us what is Project Breathless?

Karin Limburg: Yes, it's a project that's funded by the U.S. National Science Foundation to study the problem of the loss of oxygen in water. And this is a phenomenon that society has been grappling with for a long time in freshwater ecosystems, primarily in the context of sewage pollution. So, you know, you add sewage to water. It is actually adding organic matter. Microbes will feed on that organic matter. And as they do that and break it down, they're consuming oxygen in the process. And if you have enough of that going on, you deplete the oxygen out of the water. And many organisms, including fish and big invertebrates like clams and crabs and whatnot, can't survive and they die. So, we've been dealing with that through pollution control for about 125 years or something like that. But recently, and this has been a big problem, not just in inland waters, but also in rivers, estuaries, coastal ecosystems, lagoons, etc., etc. from the runoff from sewage, urbanized areas, and also agricultural runoff for a long time. And it's led to things like what's called the dead zone of the Gulf of Mexico. But recently it has become clear that there's a second driver that takes not only areas like that that become depleted in oxygen, but it exacerbates it, not just from the nutrients, but also from this other factor, which is climate change. And what happens is that you have warming of the water, and the warming itself means that water holds less oxygen. It's just a physical fact. And then it also changes other properties, other physical properties of water. Water tends to not mix as well. The water that's warmer is lighter. So, when it doesn't mix as well, it means that deeper layers don't engage and reaerate with the surface as well. And so it also means that there's less oxygen available for when those organic matter inputs go in. If it's sewage or it's nutrient runoff, you have less oxygen to begin with to decompose. And so, it exacerbates that. But in addition to that, there are large areas of the oceans, very large areas of the oceans, and these areas are also getting depleted in oxygen. And those areas are called oxygen minimum zones, and they're increasing worldwide, too. And so, we know that climate change, climate warming in particular, is exacerbating and worsening this

phenomenon. And we call this phenomenon deoxygenation. It's a very funny sounding term, but the idea is to let you know that the water is losing oxygen. And I'm part of an international working group through an UNESCO, which is called the Global Ocean Oxygen Network. And we've adopted the motto from the American Lung Association, which was, "if you can't breathe, nothing else matters." So, in that theme I've been working on studying the impacts of deoxygenation on fishes now for this is into my second project. So, my first project started I think around 2015 or something like that, and we completed that and it was basically to document a method that we could use to track the lifetime exposure to high hypoxia, low-oxygen conditions caused by deoxygenation in fishes in in three big aquatic systems, one being the Gulf of Mexico, which is North America's most famous, quote unquote, dead zone, the second being Lake Erie, which is which N S F counts as part of the marine ecosystems. And then another one, the Baltic Sea, which is the world's largest human-caused dead zone. It's not, they're not really dead, but they're called dead popularly. And when that project was completed, we wanted to do something that was looked at, explored at a larger scale, more aspects, more dimensions. And so, we came up with a project that looks at food web impacts in a number of different ways. But very smartly, I thought it would be good to have some communicators with us as well, but I like to call this project Everything and the Kitchen Sink because there's so many different things in it. And if you've had a chance to look at our website, then you will see that it does have many, many, many things in it. And we have a large team. Not everybody is funded on the project through the project, but we have a lot of collaborators and I think I'll leave it there.

Joanie Mahoney: And that's what made this conversation different than the ones I've had previously, because there are more of you here as testament to what you just said about the size of this team. And it's important to hear from the different components and being able to communicate what you're seeing and what you're studying, what you're learning about these dead zones, but also about the changes that you can see in the fish and how to translate that into why people need to care about this. Right. So, you're also, Roxanne, in this same space with, I think the word was hypoxia. Can you tell us a little bit about your role in this project?

Roxanne Razavi: Absolutely. So, the process that Karin was describing about the water layers not mixing as well, what that does is create loss of oxygen at the bottom of lakes, for example. And we know that those low oxygen conditions are really well linked to the production of methylmercury. And mercury is a pollutant, global pollutant. It's everywhere, moves through the atmosphere and ends up on our watersheds and

ends up in our lakes. So even if there isn't like a point source of mercury, mercury still is in our lakes and oceans.

Joanie Mahoney: Unfortunately, there are also a lot of point sources.

Roxanne Razavi: Exactly. So, when there is this inorganic form of mercury present, it doesn't necessarily mean there's a problem. What needs to happen is that that inorganic mercury has to be converted to organic mercury, methylmercury. And that's the form of mercury that can easily enter the food web. So, what's so concerning about the loss of oxygen that's happening in our lakes and oceans is that this process can promote more methylmercury production because the bacteria that are responsible for changing that inorganic mercury form to methylmercury are more active at that low oxygen levels.

Joanie Mahoney: Got it. So that's where that mercury oxygen connection is. And so, I have had the opportunity here locally to learn a lot about Onondaga Lake. And that's a water body where we put the mercury into the water on purpose. I mean, it's amazing to think how recently people thought that that was okay. Right? Or maybe they didn't think it was okay, but it wasn't regulated in such a way to prevent it. But what can you tell people about this mercury that's been converted, being ingested by the animals? Like, how does that affect us?

Roxanne Razavi: So, it's basically when people want to eat fish from their local water bodies, they can't just freely go out and fish anymore. They have to think about, am I providing a safe food source for my family and for myself? And that really creates a distance between us and the natural world when all of a sudden, we have to think about that. Right. So, mercury in methylmercury is a potent neurotoxin and it has really important effects on our body's nervous system. And you would have to eat a lot of fish in order for you to be exposed and have severe mercury poisoning. But in general, we're all exposed to a little bit from eating seafood. And I never want to tell people not to eat fish and seafood because it's also such a healthy source of protein. But I do think it's a great way to bring to people's attention the problem of pollution of our environment.

Joanie Mahoney: Is the poisoning or the toxins in mercury and the effect on us similar to the concern that we have about lead poisoning? I know it's not an area of research, but I'm trying to translate this. You know, there are people that go to the pediatrician office and get a whole primer on lead poisoning and why it's so important. This seems like it's in that same category from over here. Like the actual damage that

it's doing might be different, but it's the same concern for people about having this in our system.

Roxanne Razavi: Yeah, absolutely. The main concern we have about exposing humans to methylmercury is actually to the developing fetus and to future generations. Because when a mom is ingesting fish and that may have a lot of mercury, that mercury can cross the blood-brain barrier and enter into developing brains. And we have strong evidence that shows that decreases in IQ are related to exposure of mercury in the womb. And, you know, we know less about the harms of mercury on adult populations, say. But there's increasing evidence that shows links to cardiovascular issues in adult males. So, it's it isn't just an issue of protecting the young, but it could also be something that affects adult populations as well.

Joanie Mahoney: And how then do you take all of this information and what, what is your role in this project?

Andrea Feldpausch-Parker: Yeah, so my role in this project is basically communicating the science, but it's more than just communicating the information which getting the information correct. Making sure that it's something that the public can digest is really important. To kind of interpreting the scientific information and putting it in layspeak is very important. But the other thing that we have to take into consideration is that the public really isn't just this one homogenous population. They're heterogeneous, they're diverse, and they have various values, experiences, opinions on things. And so, taking that into consideration means that we have to really think about our messaging and making sure that we're talking to various relevant publics about the issue and what is important to them and what is the takeaway that they should be getting from the research that we're doing. But how does that transition into the policy realm? How does that transition to our dietary preferences? How does that transition to what issues we're going to stand behind as something that we need to deal with and that we're going to encourage our policymakers to take a stance on and do something about. And so, I think that there's a lot of kind of relevant things. And so, we don't want to just educate somebody on an issue. We want to get them to a place where they feel like they can act. And issues like this are really difficult because they're really large, they're very complex. And we get to this kind of apocalyptic point of, oh, my gosh, things are going to hell in a handbasket. How do we get ourselves out of this situation? And so, one of the things that we've really been kind of working at is getting an awareness out there, but also making them realize they have agency that they can do something. So, it could be through citizen science. It could be through posting this on social media, right? If we think about some environmental issues that the

issue going viral is because somebody brought attention to it and all of a sudden the world is on fire and we need to do something about it. And so those types of things can be so powerful, but it's giving people agency.

Joanie Mahoney: I totally agree with that. And I, I have a couple of questions for you in there. But this topic that we're talking about, what can individuals do other than draw attention to it? This feels different. So, is our goal communicating this? Getting the word out, as you said, and letting policymakers know that we need regulatory action to mitigate the damages that we see, try to undo some of this.

Andrea Feldpausch-Parker: Yeah, I think it's twofold. For the most part, to have broad impact, we need, you know, policy change. That said, people need to feel like they can do something. And so, I would say even if our solo acts don't have major changes, it does put that thought into our brain that we can actually do something. And that means that I can get engaged in other ways. I can, you know, it's kind of this growing sense of agency. I can do something by myself, but I can also support, and that larger support can have an impact. So, I think, yes, we need, you know, policies that are going to address this. But at the same time, I also, as an individual, need to feel like I have something that I can contribute. So, I would say it's a twofold. We need we need both. But it's that growing sense that I'm not a victim to something that's happening. But I also have the ability to change institutional structure.

Joanie Mahoney: Right. Right. And I appreciate that. Karin?

Karin Limburg: Yeah. I usually tell people to vote to support the people who are going to effect change. And I know this is something you feel strongly about as well. And I heard that National Geographic did a short film not too long ago about this and other coastal marine issues. And the scientists on that that were interviewed also said, vote, it's very important. Exercise our rights in this democratic society. It's super duper important. And I don't see how we're going to really make change unless we do. On a more local scale, I think we should be really pushing to do restoration that these ecosystems at risk are in worse shape if they aren't already healthy, if they're already impacted by pollution and degraded habitat and things like that, we know that we need to make them as whole as we can to withstand these shocks. We know that that's the case. A lot we don't know. We don't know exactly how things will play out. I mean, for example, with ocean acidification, which is a result of the same processes that with carbon dioxide loading from the atmosphere into the oceans and other waters. And I will also say that although we focused mainly on marine systems, the same thing is going on in spades in freshwater lakes, rivers

and ponds and anything you can think of. So, I think we need to bring information out. But as Andrea says, you can't just like serve it up and say, here you go, you've got to really engage people and make them feel like they are part of the change. And that's, you know, the Greta Thunberg thing, too, I guess.

Joanie Mahoney: Right. And I would love to meet her, right?

Roxanne Razavi: Yeah. I just want to add to the conversation before we get to all the exciting things that are going on in the science communication realm that Karin and Andrea have been working on. But what people can do aside from vote and get informed, is advocate for funding of research and institutions like E S F that are producing the next generation of scientists and managers who are going to be able to address these problems.

Joanie Mahoney: You know, I would say, having spent most of my life here in Syracuse, New York, that you've just touched on something that's very important, and that is that all goes together, the getting informed. This is a big part of that. I don't think people fully appreciate the research that's done here and the value of learning about that, and in talking about supporting the work that we do here, as you just said, I use the term climate warriors. That's who's graduating from this college. And I wish that we could quadruple our size because our students leave here not only passionate, which a lot of people across the world are becoming passionate, but with the knowledge about what they are supposed to be doing. So, I agree with you wholeheartedly, but I want to go back to the vote, Karin. You know, this permeates a lot of places, but people are busy. And, I wonder whether you all think there's a role here for us at E S F, not in advocacy necessarily, but in educating people so that they can make an informed decision. I think some people would be shocked to hear the elected representatives speak on some of these topics. We haven't got consensus, yet about the problem, much less a group effort toward these solutions. And that's on us, right? These are the folks that we're sending to contribute to that conversation. And I wonder whether as I sit here, there's a role for us during an election cycle to have a list of questions, let candidates answer them in their own words, and then just disperse it so that people can see for themselves. I wonder if that's a role for folks like you, though, because you know the questions.

Andrea Feldpausch-Parker: That's a really interesting idea. And to be honest, I'm going to have to think about that a bit more. But what I what I like about that is that like it's it gives us a space for dialog and it's taking advantage of decision leaders that have the influence to address these issues and in encouraging that interaction so that we

can have greater information dissemination. But then we're also kind of getting involved, these key players that can not only encourage change to be made, but are, you know, representatives that people are looking up to as, as those who have the capability or the influence of what's happening. So, yeah, I think that's that would be awesome.

Roxanne Razavi: Yeah.

Joanie Mahoney: I think that's something we should work on because we should be looked to as the place where you would get the information on environmental science issues. Right. There are different nonpartisan groups that provide information on their topics. It seems like a great role for E S F. It is frustrating to hear the hopelessness people have and then, you know, scratch the surface a little and find out you don't really know about the people that you're pulling the lever for. And they are who have the seats at the table and they're making the decisions. And we're seeing on the federal level the pro-fossil fuel voice that is still pretty effective. And we know here at E S F how many researchers at E S F are seeing their work detrimentally impacted by these decisions. And it does feel like we should be playing a role in that space.

Andrea Feldpausch-Parker: Yeah, I know. And I think this kind of gets to the scientists as becoming effective communicators and us having the tools to be able to do that. Now, that's my area of expertise, of course, but it's finding these ways of showcasing that the science is important and what we're doing is so important that it has on the ground ramifications. But we're also like, we care about this, you know, and this is not only important to us, but as Roxanne and Karin allude to, these are issues that are that are affecting families, that are affecting us. And so, it's not something that's kind of like this distant subject. It's a very much these are critical issues. These are crisis situations that we're trying to deal with. And not only are we researching it, but we're feeling the impacts of it ourselves.

Joanie Mahoney: I know that's interesting because we don't even have to do the seven generations. I mean, we're seeing it ourselves. You know, when I was reading about your research, there were some really interesting things, and I can't maybe use the right scientific words, Karin, but there's a part of the inner ear of the fish that you can study that shows you what?

Karin Limburg: It shows me, kind of what I call a logbook of the life of the fish. And this organ that you're talking about is something that's in the modern fishes, so not in sharks or lampreys or things like that, but modern fishes have an inner ear structure that's

different from ours, similar in some ways and different in others. But they have these large calcified structures that are called ear stones, or the technical term is otolith, which is the same thing. And these grow incrementally from birth. Sometimes they even start forming before a fish is born. But they're intimately involved in the hearing and balance system of fishes. So, we know increasingly now we're getting a better appreciation that fish actually communicate with sound. Many species do. And so sound perception is actually quite important also for avoiding predators or finding prey, things like that. And these your sounds deposit calcium carbonate that's mineralized on kind of a scaffolding of complex proteins that we're also kind of learning about, now. There's sort of the field of proteomics, for example, has opened the window on our understanding, but there's still a lot that we don't know. Nevertheless, we've found that there are two things about your stones that have been used for a long time. One is we understand that they're part of that system. We don't really understand so well how they work. But we understand that if you take a section through them, it's sort of analogous to looking at a section through a tree and looking at growth rings. And so, we often can use these growth rings to count them and go, that's a summer. That's a winter. That's another summer. That's another winter. And in fact, right now I've got a student down in the lab in Baker who's looking at freshwater drum for Oneida Lake. And he's, we're seeing the chemistry played out in the growth rings as well. So, I think my specialty niche is to try to understand that chemistry. And one of the things that I have been developing is the use of one of the trace elements as kind of a proxy for the exposure they've had to low oxygen. And basically, it's related to the chemical properties of water. When there's low oxygen then this one trace element becomes goes into solution. Fish actually sort of drink water, pass it over their gills. And many of the trace elements that end up being incorporated into ear stones do it through that route. They go over the gills, into the bloodstream and up eventually in the in this little sacules and get incorporated. So, I actually knew that this biogeochemistry from my own, you know, classes as a student at Cornell. But it didn't really strike me that this was possibly telling me about hypoxia until I was studying some codfish in the Baltic Sea from the stone ages and the modern ages. And I just kept seeing this over and over again and then and that it was much greater now than it was in the stone ages. And then it struck me that, my goodness, I'm working in the world's largest dead zone, and this biogeochemistry makes sense. And when I first presented it, I thought about it at a conference and I put the idea out. When I did, I watched like the audience go, Oh. And then people came up to me afterwards and said, No, you're crazy. That's just not the way, because we see it all the time and it's related to the growth of the fish. But when I thought to myself, of course, at the time was,

well, I think I know where you're studying these. And I think they're probably places where you might have some hypoxia.

Joanie Mahoney: So, isn't that interesting? And I have a question about how you're studying fish from the stone ages.

Karin Limburg: Oh, when I was at my previous job, which was at the University of Stockholm in Sweden, I got the opportunity to co-advise a P h.D. student who was an archeologist and who studied the archeology of of stone age fisheries in Sweden. A really cool study.

Joanie Mahoney: Are these ear stones something that survive over time?

Karin Limburg: They can. Acid is their enemy. But if you have soils that are well buffered, soils with calcareous, you know, base, they can preserve and people find them. I think some ear stones have been found from as far back as the Jurassic.

Joanie Mahoney: Fascinating. Amazing. And so you are looking also, it sounds like, at the correlation between what you're seeing in these ear stones and the size of the fish.

Karin Limburg: Yeah.

Joanie Mahoney: And are they smaller?

Karin Limburg: Yeah. Yep, they are. And so, in our project, I've been focusing most on fishes in the Baltic Sea. And together with a P h.D. student of mine in Sweden, we found that fish have been declining in size. And I think since 1990, a fish of age seven a cod of age seven has declined by often a third. So very…

Joanie Mahoney: Huge.

Karin Limburg: Big drop.

Joanie Mahoney: Yeah. And then it's very easy to extrapolate the problems caused by that because…

Karin Limburg: It's not easy, because the other thing that's going on is also overfishing has been involved as well at times. And what we're finding, though, is that. So, maximum size of fish is one of those things that's kind of easy to keep track of. And that maximum size of cod has been dropping over the last 30 years or so. And right

now, I mean, the cod, which one would maybe normally think of as starting to reproduce, mature and reproduce at age four or five. They're reproducing at age one in the Baltic. They're very, very small fish. We're not so sure they're going to stick around. But what we're finding is that even though the fishery has now finally been closed, the fish are still getting small and the hypoxia is increasing because of the loading of C O 2 hasn't stopped. So, all those other processes haven't stopped. And then there's all the very complex things going on in the Baltic Sea management-wise there, the whole basin, which is 1.7 times the surface area of the entire Great Lakes combined. So, it's a very big system, but they've had good success at reducing nutrient loading. The problem is that when you have low oxygen, and Roxanne knows this very well. When you have low oxygen, you're actually able to bring back up some of the nutrients that kick the cycles into action again. And so, they still have persistent algal blooms and it's going to take decades before that stabilizes, if at all.

Joanie Mahoney: So, we're having success reducing the nutrient load, but we're not...

Karin Limburg: But you still have suspension, and particularly of phosphorus. And there's a term these days called legacy phosphorus. And I don't know if that's an issue in Onondaga Lake. I, I don't know.

Roxanne Razavi: I think the nitrate additions that they're doing in Onondaga Lake, which were originally intended to slow this process of methylmercury production, actually have the benefit also of reducing the phosphorus from the sediments going back into the water column.

Joanie Mahoney: So, how do we get to a point where the lake will turn over, or the water body will turn over the way it's supposed to? So, we reduce the nutrients, but what more can we do to bring that oxygen back so that the water body is working the way it's supposed to?

Roxanne Razavi: Well, the issue of low oxygen in water is like Karin mentioned, related to increasing temperatures. And so, I think that the issue goes back to what are the actions we're taking to reduce our emissions of greenhouse gas emissions.

Joanie Mahoney: I know again, talking about Onondaga Lake, there were some researchers who talked about a plunge to force that to happen. I don't know if you know what I'm referring to.

Roxanne Razavi: I haven't heard about that specifically. But in other lakes like Honeoye Lake, in the Finger Lakes, where there is low oxygen conditions, that releases legacy phosphorus into the water column. One of the ideas that they're considering is oxygenating the water that's at the bottom of the lake. And so, in a lot of reservoirs and lakes, this oxygenation of the hypolimnion is one. So that's the low bottom waters is one way that people are trying to deal with the issue at a local scale. Like an immediate solution. But it's very expensive. Those are very expensive solutions.

Joanie Mahoney: So, we have a sewage treatment plant as a lot of water bodies do on that lake and the effluent, which is clean, presumably the way it was coming out, and then the trajectory of the water, for lack of a better that was affecting what people were seeing in terms of the lake. And they were saying it was the effect of that more than the natural movement of the lake. And decisions were made using these hypothesis that this was natural. And then some folks came along and said the quantity of water that's coming in at the way that it's coming in is affecting it as well, I guess topping the nutrient load. But also then, you know, the C O 2 and I don't know if anybody has a better idea than to stop burning fossil fuels.

Karin Limburg: I think that's it, pretty much, yeah. And bear in mind also when you're talking about Onondaga Lake. Lakes are individual bodies and they have their own characteristics. So even a solution for Onondaga Lake may be tailored to it and won't work for a different lake. So, that's something to bear in mind. And bear in mind also that the systems we're studying are far, far larger as well.

Joanie Mahoney: I was going to ask you about that. Lake Erie, that's one of the bodies of water that you study. Have we made progress on Lake Erie? What has been called a dead lake is not any longer called that. Is that because we've made progress?

Karin Limburg: We did make some progress. But unfortunately, there are still, you know, problems that have developed or persist. It's very, very hard, for example, to change some of the practices in agriculture, in some of the large drainages that drain into it. Also, and maybe Roxanne knows something more about this, but also than the warming, just this greenhouse gas warming is just warming up these lakes as well. And one of the things I think that's becoming more and more evident is that many, many waterbodies are getting these blooms of algae that tend to be, you know, blue-green algaes or things like that. Many of them are toxic. They're called harmful algal blooms. That's Roxanne's, one of her specialties.

Joanie Mahoney: And we are seeing those more and more. That was a term that we hadn't heard, you know, seven, ten years ago. But we hear about every year now. You know, it's

got to be difficult for you to take this idea that burning fossil fuels has a direct path to these harmful algal blooms that people are so concerned about in terms of swimming and drinking water. But that's what the job is of folks in your field, is to tie those together. Why does it matter that we're burning fossil fuel? Why? Why does it matter that temperatures are increasing? How is it going to affect me? But you could draw a straight line from pumping gas in your car to a harmful algal bloom on the lake that you like to swim in that's now closed.

Roxanne Razavi: And I would add just before you answer, Andrea, also a direct link to mercury in your fish, because burning coal is the source of mercury to the atmosphere. There are other sources too, such as the use of mercury in artisanal and small-scale gold mining, illegal gold mining in the tropics. But burning fossil fuels also is a source of mercury to our atmosphere and that's what gets into fish.

Andrea Feldpausch-Parker: Yeah. One of the things that I was thinking is oftentimes what we have to do, especially when an issue just seems so large, is kind of helping people zoom in and zoom out on these issues. But having this linked also to climate change gives us a whole wealth of possibilities of how we can also act on it individually and as a society. So that's a space for hope. And I think that when, you know, we have such complicated issues like this, that's what we start to lack. And that's something that we need to encourage and not let that be an excuse for inaction. But this is a space where we can start mobilizing and doing things to help out on this. So, the fact that climate change is part of the problem means that we have ways of moving forward for solutions. So, you know, if there's a silver lining, I think that's it.

Joanie Mahoney: Yeah. So, there's cause for hope, because ultimately, we can fix this. It's the collective will of people, but I don't think it's entirely the collective will. It's the collective education and the purposeful muddying of the water, pardon the pun, of people who have ulterior motives. So, people really don't know what the truth is, what the facts are. We're a trusted source. And so, I think I mean, I don't mean to be making you feel like you have all this responsibility on your shoulders. But the more I sit here and talk to you and the more information you have, you know, we are a place that can be a big part of that solution of cutting through the noise and saying, this is what the science is showing us and you don't even have to go to the causes. You can just stick with the effect. Like we're seeing the temperature, we're seeing the temperature of the water. We're seeing what the inner ear of the fish look like. We're seeing the size of the fish. We're seeing the mercury in the fish. We're seeing what damage that does to the neurological system of a developing child. You have all that information, and what you need to do is to translate that into a desire of a regular person out on the street to change their behavior.

Andrea Feldpausch-Parker: Well, it's kind of getting up that, you know, knowledge is power. It is. You know, this is but it's knowledge also needs to be empowering. First, it's, you know, getting a grasp of what's happening and what are the ramifications of that. You know, what are the problems and where are the complexities that we're working in? How can we unpack that to then address it, knowing that we're incorporating multiple different not only biophysical systems but social systems. So, it's navigating that landscape. And from a systems-thinking perspective, how can then we start to address these spaces that are then going to impact the environment, hopefully in a positive way to help us solve these problems. So, it's knowing where, where the pressure points in these systems to enact the change. And so that's an additional key. It's providing the information, but also knowing the social systems that then need to be put into action on these issues.

Joanie Mahoney: And that's another whole topic.

Andrea Feldpausch-Parker: Oh, yeah.

Karin Limburg: I wanted to mention just, you know, these kinds of communications take place at different scales. And my engagement in the Global Ocean Oxygen Network, I like to call that level of international science, it's science at a level up there in the atmosphere that is so high up, we can't see it from down here. So, we engage generally in sort of these things like, you know, Onondaga Lake or New York State or things like that. But actually, at that global international research level, you're engaging with people around the world in all of these working groups have requirements of how people are represented, the global representation, gender, age, ethnicity, you know, things like that. But I also just wanted to mention quickly that the Global Ocean Oxygen Network I'm part of recently got adopted into the Ocean Decade, the UN Ocean Decade as a program, and our project is called Good Global Ocean Oxygen Data. And they did a global webinar recently that was a kickoff for our participation in this global ocean decade. And the person from Australia who was supposed to speak couldn't, her computer died, and the day before they asked me Karin, we this person couldn't do it. Is there any chance you could give this talk at five in the morning? My time. And I happened to have written a talk about our project. So, I gave it. So, our little school has been elevated at that global level.

Joanie Mahoney: That's incredible. How did you become involved with a global organization like that in the first place?

Karin Limburg: I got recruited. By colleagues.

Joanie Mahoney: Because people know the work that you're doing and what is that organization? What? How many people? Where did you meet?

Karin Limburg: We are a working group of about I think nowadays about 30 people from around the world. We meet a lot on the Internet, but we're part of something that's called the Intergovernmental Oceanographic Commission. That's part of UNESCO. So UNESCO, of course, is an organization within the United Nations. And so, I think that there must be many, many levels and I don't know all of the different working groups by a long shot. But I do know that within the Global Ocean Decade that there are at least 30, I think, different projects. I think they can be looked up as well. But we have many places where we can overlap with some of these other projects. And this was kind of our debut, as it turned out, just by accident. I had to get up at five and do this thought.

Joanie Mahoney: Well, thank you for doing that. Yeah, that's incredible that ESF people say we punch above our weight. And that's a perfect example of that, that you have a seat at a table like that and are heard at a table like that and called on.

Karin Limburg: I feel incredibly privileged to do that honestly, because my colleagues are superstars and I'm just like, Wow.

Andrea Feldpausch-Parker: She's our superstar.

Joanie Mahoney: Yeah, I know. It must be such an interesting career that you have that you get to, you know, spend your times, spend your time with people that are studying these issues. What's the thing that you think we could do to move the needle? What would you like to see us do?

Karin Limburg: Boy, I would I would love to see us go fossil fuel reduced in a great way. I actually don't think that complete closing off of fossil fuels like coal, I think is one thing that we should really get away from. But if you think about it, fossil fuels are really valuable and we've just squandered them, I think. And we should be taking, you know, be more mindful about how we use them and use them to help prime the pump on developing new technologies, in my opinion. So, greatly reduce their use and try to wean off. But don't I don't think that we necessarily have to completely turn the tap off, but turn it off 95% or something like that. But we're on a collision course, honestly. And I think if we don't change, I'm not very happy about it.

Roxanne Razavi: Can I answer that question?

Joanie Mahoney: I would love for you to.

Roxanne Razavi: I mean, personally, I think we have to stop investing in war. We have money for the things that we care about, but we put money in horrible things. And I know that sounds very idealistic. And my students tell me this is why you're not in charge. I've been told that. But it's true. We have the money to solve world hunger. We have the money to invest in science. We have the money to educate our people. We're not making those choices, and that's the truth.

Joanie Mahoney: How about you? Do you want to take a stab at what's the thing that you would do if you were in charge for a day? Like, what's the thing that you think can move the needle for us?

Andrea Feldpausch-Parker: I'm going to join Karin on this one. Not to discredit you Roxanne, and but yeah, changing our energy infrastructure. And I think that's going to be a big one. But even if we do that, there's social issues related to our energy systems that we also needed to address in conjunction with those related to climate change. So, I think that if humanity can think of themselves as part of the greater ecological community, I think we would…

Joanie Mahoney: One of.

Andrea Feldpausch-Parker: One of, exactly, I think we would then rethink a lot of our approaches to our ecological systems and so, and try to better live within the limits of those systems. Because we don't. We think that we can just technologically solve our way out of all of our problems. But as you know, one environmental historian once said is, like any technological innovation leads to some other ramifications that we might not have even considered. And so, I think that if we approach things cautiously, but remember that we are a part of these systems instead of outside of that would make us reconsider our approaches.

Joanie Mahoney: You know, we were commenting some friends recently. When was the last time you heard someone ask you to carpool? We're at this crisis and we're not even asking people to take small steps. But I've argued that a lot of this stimulus money that's come in the last few years should maybe be spent helping people without means. There's a lot of heat island issues that are in places where the policies aren't reaching people.

Andrea Feldpausch-Parker: So I love that you bring this up. So, I'm on a separate N S F project so unrelated to this, and it's on energy, democracy as a growing social movement. So, half my heart is still in kind of like the biological sciences, but I've also developed a solid research program in energy systems. But one of the things that I think that we have to do, and you just brought up, and thank you for that, because I think it's so important not only do we need to change our energy infrastructure, but we also have to change our approach because when it comes to those model renewable energy projects, those are generally happening in affluent places where people could afford to make the change. That's not where we need the effort. Energy, poverty, those are issues that are happening, you know, at the lower economic levels. And that's the space, that's the opportunity to make those changes and we can adopt up from there. That's easy proof of concept. We already have the proof of concept, but we're not addressing it in the space that is most needed.

Joanie Mahoney: I think it's interesting that you're saying that because it's consistent with this conversation that Karin's way up here from a global standpoint and knows the needle can really move if the whole world. But from this local view. You know I'd love to take some of that stimulus money and put electric car chargers all throughout the city and give people a lot of money to buy their old gas guzzler car that they will have to be able to put toward a more affordable electric car. And they're becoming more affordable, the lifetime cost as the gas price goes up. And then we have folks trying to artificially lower the price of gas. It's just sometimes it feels overwhelming. But I'm curious, what, like what keeps you going? What's the next thing that you want to do, Karin?

Karin Limburg: Oh, well.

Roxanne Razavi: Karin has so many exciting projects going on.

Karin Limburg: It's just that they're constantly get surprised by my research in the, in the first hypoxia project I came across. You know, I'm curious, I've just always tried this and that and the other thing when I'm doing my research and I came across something that gave you an insight that, you know, this other trace element might be actually reflecting something about metabolic rate. And I came up with, you know, I actually wrote a very strange paper about it that at the end of the paper we made an appeal and said, if there are some physiologists out there who are interested in this, please do the experiments that we're just talking about theoretically. That's fascinating down at the subcellular level, which I'm not, you know, and then now last summer in our current project, I was fiddling around again with trace elements and I started to realize that a trace element that has been shown to relate to a

page was declining. So, it's positively correlated with ancient carbonate rocks. Ear stones are kind of like carbonate rocks. And I saw it plummeting and I was thinking to myself, Oh my goodness, is the next thing happening in the Baltic Sea, ocean acidification. And so, you know, working on a, you know, developing the data sets for a manuscript about that now. And I think I've even convinced some of the biogeochemists in Sweden that this is plausible. What I'm seeing at first they, when I first came to them and said, I'm showing you this preliminary data and they said, oh, no, the Baltic Sea is well buffered by, you know, riverine inputs. And there's complications about that, too. But they also said it looks like it's on the verge of tipping. And so, it is very possible that the depths of the cod or at are picking up some of the deeper signatures of acidification. And this sort of water that's oxygen depleted and acidifying is actually kind of rising up in the water column there in the from the deep, deep basins to the higher because of warming, really all these other processes going on.

Joanie Mahoney: So you sound like you have plenty to keep you busy on the horizon.

Karin Limburg: Every time I turn around, it's like, Oh, no, I don't know anything about this.

Joanie Mahoney: Now you must be the most curious person. I can't imagine what you were like as a young child.

Karin Limburg: Probably a terror.

Roxanne Razavi: One of the best things about getting this N S F award has been to be able to work with Karin and just watch how she works. And as a new faculty learning from her, she is so curious, and it is just like so inspiring to work with someone like that and to see how she thinks about things and what catches her attention and how she works. It's been really great for me to have her as a role model.

Joanie Mahoney: What's next for you?

Roxanne Razavi: So, research-wise, I just put in a grant to look at marine vertebrate top predator movement in the Atlantic Ocean, the South Atlantic Ocean, just off the coast of Patagonia in Argentina, to look at elephant seals and penguins and try to couple their movement and their migration and their to see if they're being exposed to oxygen and relating that back to how much mercury they have internally. So, some exciting projects.

Joanie Mahoney: More to come.

Roxanne Razavi: Yeah.

Joanie Mahoney: For the next season, right? We talk about how it's great working at an institution like this where we have this shared mission. And we're also narrowly focused, focused on environmental science. All of the conversations that I've had remind me of other ones. And we were talking about sea-level change and how some plants, because they can't move as quickly as birds, as some others have said, you know, some species are really going to suffer the consequences hard and fast.

Andrea Feldpausch-Parker: Oh, yeah.

Joanie Mahoney: Compared maybe to others. Where are you going to add to that?

Roxanne Razavi: Yeah, I was just going to say, I think part of the trouble or the difficulty of communicating oxygen loss and deoxygenation hypoxia is that unlike a wildfire, for example, where it's so easy to imagine animals caught and not being able to get away fast enough, is you don't really have that visual. You know, it's harder to imagine that or see it. We don't have images to show it.

Andrea Feldpausch-Parker: Right.

Joanie Mahoney: But that's really a good analogy. It it is a wildfire.

Roxanne Razavi: It's a wildfire in the ocean. And I experienced a wildfire while I was in Argentina this past January and doing some of the field work to get some preliminary data for this grant. And, you know, it's a scenario where, like in a lot of parts of the world, there's drought going on. And it doesn't take much for a fire to develop and to experience tha,t and to think about this particular fire was very in a preserve and to think about the animals not escaping. Right. It's so visceral. It makes you really feel terrible. But that's exactly what is also going on in these parts of the ocean and our lakes. And so, we have to bring that to people's attention.

Joanie Mahoney: And they'll feel the same visceral reaction to it if we're successful bringing that wildfire analogy. I mean, you have a wildfire and it's all hands on deck and people come from all over to put that fire out. And here we have a fire that you are looking at every single day and you're not getting people's attention to the extent that we need to.

Karin Limburg: It's very unphotogenic, for one thing. I tried to interest David Doubilet and Jennifer Hayes of National Geographic in it, and Jen finally told me that Dave just doesn't like to photograph ugly scenes. And that's difficult. I mean, they're not pretty generally.

Andrea Feldpausch-Parker: Well, and so, that's actually why we've taken a more creative route for this project, because I find, like, my job here is to mobilize and empower the troops. Like, how can we actually start to, like, address this stuff? But how do you put a face on? How do you kind of bring attention to this? And so, one of the things that Karin and another colleague of ours, Liz LoGiudice, came up with is creating songs from the biochemical data, from the ear stones. So, it's kind of like it's poetic. It's a wonderful metaphor that from the ear, we are allowing people to hear.

Joanie Mahoney: That is really incredible.

Andrea Feldpausch-Parker: I wish I had like some part of that now. You know, I get to nerd out with my colleagues on it. And but by putting that data to instrumentation, you can feel like it actually kind of reverberates in you, like what hypoxia does to a fish.

Karin Limburg: And so, it's people tear up when they've heard the presentation. I've cried all about the Baltic Sea Science Center. Yeah.

Andrea Feldpausch-Parker: So, what we've done is because of the data that Karin and colleagues have collected, and our collaborator Liz, who's also, you know, a science communicator but a musician, and so she put these fish to song. So, we have a stone age fish. We have a fish from the 1950s.

Karin Limburg: 1930s.

Andrea Feldpausch-Parker: 1930s.

Karin Limburg: Under good conditions, good aquatic conditions. And I just want to mention quickly, the technique we use is something called sonification data, and that's turning numbers into tones. But then we've interpreted it, too, so.

Andrea Feldpausch-Parker: And we, you know, Liz chose the instruments that would best fit, you know, the gravity of the situation.

Joanie Mahoney: So, can you hear through these sounds, the distress?

Andrea Feldpausch-Parker: Oh, yes. It's like thriller music.

Karin Limburg: Go to our website and listen.

Joanie Mahoney: Everybody, everybody can, right?

Karin Limburg: So, it's open.

Joanie Mahoney: Where do they find that go to?

Andrea Feldpausch-Parker: If you search Project Breathless Cod Songs.

Joanie Mahoney: Oh, Good. Okay.

Andrea Feldpausch-Parker: But you can hear a happy fish one that's in an oxygen rich situation. And then you can hear a hypoxic fish that you can hear the stress. To me, it's like that thriller music in a horror film.

Karin Limburg: Where it's just heavily interpreted.

Andrea Feldpausch-Parker: Yeah, it's very upsetting. And then what we have is a fish that was in a hypoxic situation that was moved to an aquarium that is located in Stockholm.

Karin Limburg: It's part of a, it's in a very nice science center dedicated to the Baltic Sea called the Baltic Sea Science Center. But it's actually in an open-air park that's extremely famous in Stockholm. Everyone in Sweden knows about this park. So, but when we played some of the draft songs for the director of the Science Center, she got really, really, really excited and wanted us to develop an exhibit to go along with the aquarium.

Andrea Feldpausch-Parker: Yes, we're developing that exhibit. It's developed. Yeah.

Karin Limburg: It's almost ready to launch. Yeah. Waiting on you, I think.

Andrea Feldpausch-Parker: No. Well, now we're waiting on the I R B office. And.

Roxanne Razavi: Andrea, didn't you have your daughter, like, listen to the songs and then…

Andrea Feldpausch-Parker: Yeah, my six-year old daughter was just like, That was a happy fish. It's like that fish feels really sad. And so it was. It was so impactful. But again, you know, if we can't provide images for , or these aren't necessarily the charismatic fauna, you know, I still remember W W F had this campaign where they put a polar bearmask over a tuna fish saying like, these species matter, too. But what we're doing is we're acknowledging the emotional stress and we feel it too. So it's humanizing.

Joanie Mahoney: Yeah. And if you saw a small child in a situation struggling for breath, you would get all hands on deck.

Andrea Feldpausch-Parker: Right? And so this is what we're trying to do. So now we're all for doing a side research study, looking at the impact that these songs have on people's willingness to then engage on the issue. So, this is one of those things where every time Karin dragged me into a project and we just start brainstorming, you never know what you're going to get.

Joanie Mahoney: That that that's the really interesting thing for me about talking to researchers, though, is you you don't take a problem and then go and look at it. You learn something in that observation that leads you somewhere else and somewhere else. And it doesn't seem like it ever stops. And it's such an interesting life that you get to have. And we're the beneficiaries.

Andrea Feldpausch-Parker: Yeah. I mean, I think it's a prerequisite for our jobs to, like, just be perpetually curious. And if that curiosity dies, so does our career. But it it really is. I think one thing leads to another. And that been some like just wonderful opportunities. And I'm really proud of what we've been able to do with this project and others in the inspiration that it's brought.

Joanie Mahoney: Well, this has been a fascinating conversation, and I've learned that there's more to come. So, I'm hoping we will continue this conversation again in the future. And in the meantime, I think for those of us looking for ways that we can support the work that you're doing, it's to become informed, to vote, and to stop using fossil fuels. Thank you very much, Dr. Karin Limburg, Dr. Andrea Feldpausch-Parker, and Dr. Roxanne Razavi. I have very much enjoyed our conversation today, and I appreciate you taking the time to educate us about the work you're doing.

Karin Limburg: Thank you so much.