Intro:

You are listening to Making Waves: Fresh Ideas in Freshwater Science. Making Waves is a bimonthly podcast where we discuss new ideas in freshwater science and why they matter to you. Making Waves is brought to you with support from the Society for Freshwater Science, Arizona State University's School of Life Sciences, the University of Washington School of Aquatic and Fishery Sciences, and Cornell University's Ecology and Evolutionary Biology department.

Erin Larson:

Welcome to Making Waves. I'm your podcast host, Erin Larson and with me today is Arial Shogren. Arial is a PhD candidate at the University of Notre Dame where she studies eDNA. So welcome to the podcast, Arial.

Arial Shogren:

Hi. Thanks for having me.

Erin Larson:

Oh, it's great to have you. I was wondering if you could start out by telling us a little bit about your research and what makes you so excited about it.

Arial Shogren:

Sure. So I'm really interested by streams and river's ability to move materials through a landscape, and also by the role of biology and adding a lot of complexity to ecological predictions. So the overarching theme of my current dissertation is to understand the fate and transport of these kinds of novel materials throughout the environment, and how environmental heterogeneity influences how those materials move throughout aquatic systems. So it's really an exciting time to be in this field because a lot of what I do is very interdisciplinary. So I work with physicists, geneticists, hydrologists, I'm not stuck in this ecology box. And so there are these intersections that are really productive and useful that I've been really lucky to work within.

Erin Larson:

Awesome. That's super cool. So one thing I wanted to start out asking you a little bit about, because even as an ecologist I feel like I don't know as much about it as I would like to, is what exactly eDNA or environmental DNA is, and where it comes from? Because a large focus of your work is studying how environmental DNA moves through streams. And so I was wondering if you could give us the easy to understand for anyone version of what environmental DNA is, and where we get it from.

Arial Shogren:

Sure. So this technique was developed a couple of years ago at Notre Dame to combat the spread of invasive fish species. And really the idea behind it is to treat the river like a crime scene, right? So we all leave our own genetic cloud of ourselves in our environment with our skin cell, our hair, our sweat, et cetera. And aquatic animals do the same thing. When they're swimming around in the water column, they're just existing in their environment exuding this genetic cloud of themselves. So eDNA really is that mixture of secreted cells, feces, mucus, all these tissues that contain genetic material that's found in the environment. And really it's just like fingerprinting that you see on CSI or on crime shows, but it's used in an environmental context.

Erin Larson:

Awesome. That's super interesting. And it seems just like when you watch a crime show or... I'm not a forensic scientist, but if you were a forensic scientist, I know there's a lot of issues that can come up with doing that type of genetic work. And so what are the things that are challenging with working with something like environmental DNA, especially in streams?

Arial Shogren:

Right. So eDNA as a technique is still rather young. We don't have a good idea of the fate of that DNA, the source of that DNA, the age of that DNA. So in order to figure out the ways to optimize it's use, we still have a lot to constrain. Genetic techniques have only really been on the market and affordable for ecologists for the last 10 years or so. A lot of this is just really new, so that's the biggest issue with the eDNA I think.

Erin Larson:

Are there some animals too that secrete more eDNA than others? Is it hard to figure out? Because I know sometimes people use it to estimate potentially a population size of a rare species, but do you have to know something about how often they're losing their skin cells or pooping or secreting other types of material that then creates eDNA?

Arial Shogren:

Yeah. So that's definitely one of those complications. A fish might exude mucus or if it's spawning, it might exude those eggs that's genetic material. And so the timing of eDNA release can be really important. And also those behavioral dynamics or those dynamics of when they're actually exuding that DNA. And a lot of that still is very [inaudible 00:05:00] especially in the stream ecosystems. And it's definitely an important variable for understanding how to back calculate those species abundances.

Erin Larson:

Right. Have you found any crazy unexpected animals in streams when you've been doing eDNA, things where you're like, "Oh, a cow must have walked through here," or DNA that you weren't expecting to find?

Arial Shogren:

That's a really good point. So there are kind of two ways of looking at eDNA. So there's the first approach, that's the metagenomics approach that's looking at the entire community analysis. And that's one way that people can look at the entire community of a stream or river. But what I've done in my research is doing target specific eDNA. So that's looking at, is it common carp there or not, is a bluegill or not? And anything else doesn't get detected. Yeah, so separating those two things out can be really important. And I think that's also why eDNA can be kind of confusing for ecologists, because there is that distinguishing technique base I guess.

Erin Larson:

Yeah. So you're trying to decide, depending on your question, if you're going to sequence everything versus really try and target something that you're interested in. Maybe we could talk a little bit about how stream ecologists and managers often use eDNA, because I know for things like invasive species it's been a really up and coming thing. So yeah, maybe you could tell us a little bit about... we've talked about the things that sometimes make it confusing, but we can talk about the benefits of it as well.

Arial Shogren:

Sure. Yeah. So one significant application of that eDNA approach is the early detection of invasive species so that managers can prevent further spread and mitigate those damages. And the reason that it's so useful is that to go out and actually net a species, net a fish, or have to electroshock a fish, takes a lot of money and a lot of manpower, especially if those species are elusive or low in density. It can take a lot of effort to just find one. It can take quite a bit of effort in order to go and actually confirm that yes the species is there or no it's not. In contrast, taking a water sample and being able to identify the genetic material, it's a lot easier quite frankly, and it can be cheaper than investing in that much manpower. So it's really useful in order to monitor and also detect those invasive species at low density. And it can also be a proactive assessment tool for endangered species as well, it's not just for invasive.

Erin Larson:

Yeah. So anything that where you either don't want to harm the thing that you might be sampling or the thing might be rare or you're trying to figure out if something's arrived yet, that you wouldn't necessarily be able to detect by normal sampling methods.

Arial Shogren:

Exactly.

Erin Larson:

That's super cool. So I wanted to get a little bit into your research more specifically. Because I know you have a couple of papers out about modeling how eDNA actually moves through streams and all the complications associated with that. So I was wondering if you could tell us a little bit about that work and how you've dealt with helping to fix some of the things that make eDNA challenging to work with in streams.

Arial Shogren:

Sure. So in flowing waters, we really lack a quantitative framework that describe how eDNA moves in systems. And what we really want to know is where, when, and how many individuals existed in this flowing system. That's the main premise of that question. And we know just from previous studies that eDNA is transported, so it is actually suspended in the water column. So it does move throughout its system. But what we were really trying to understand with this most recent scientific reports paper, was how environmental context really changes how that eDNA moves and also get an estimate of those rates at which eDNA might be deposited on the stream bed and whether or not that eDNA being transported is new or whether it's being resuspended off the stream bed. Because that could be considered old DNA, right? You can deposit on the stream bed and then be resuspended later and caught in a water sample.

Arial Shogren:

So distinguishing what a sample means when it's captured in a flowing water system, is the premise of that paper. The other approach that we really wanted to take was... I'm trained as a stream ecologist and that's my bread and butter, but we also wanted to have this interdisciplinary approach. So involving a hydrologist and involving these geneticists was kind of the unique aspect, I think, of the project and what made it so useful I think.

Erin Larson:

And so can you tell us a little bit about what you found in that paper? So what surprised you about your results or what your results were in terms of how you can think about modeling how eDNA moves in streams?

Arial Shogren:

Sure. So the key to this study is that we used a traditional stream ecology approach using traditional stream spiraling metrics, which is measuring the average distance that a particle would transport in flowing water. And it's never really been used for any kind of genetic material before. And so in using this technique, we were able to find that eDNA signal could become really low at relatively short distances given our experimental conditions. So transport distances, so the average distance that one particle of eDNA would move downstream, was really influenced by the structure and the size of that stream bed. So whether or not the stream bed surface was made up of pea gravel, so really, really tiny little rocks, or bigger cobbles, really controlled how that eDNA was moving throughout our experimental system. And if you think about the fact that a molecule of the eDNA might move twice as far in a given system, that would really change how you interpret a positive eDNA result. If you're actually looking at an entire watershed or even at an entire river reach.

Erin Larson:

Yeah. If you're sampling and trying to establish where things are or aren't, if that DNA is being carried much farther in some systems than others, you might get super different maps of where you think something is or isn't.

Arial Shogren:

Right. Exactly.

Erin Larson:

So you were saying that sometimes old eDNA can get trapped in the stream bottom and then get rereleased back up into the water column. And how long can eDNA actually survive in a way that you can then actually analyze it and detect something?

Arial Shogren:

That's a really good question. And that is one of those black boxes that we don't know. So the really unique thing about eDNA is that it's just mixture of material. So it's free DNA that's just floating around in the system, it's cells, it can be even the organisms themselves if they're small enough. And so the rate at which eDNA degrades or persists, we don't actually know. So that's a really good question.

Erin Larson:

Yeah, I can imagine that, for example, a decomposing salmon carcass might release eDNA for a lot longer potentially than just some mucus that sloughs off a fish, for example. So you could detect that salmon for a long time, that dead salmon that's just lying there on the stream bed, versus a salmon that's just sloughing some mucus off and that's getting transported out.

Arial Shogren:

Yeah. And some of that material may or may not be more labile than others versus recalcitrant. So that's another aspect of the biogeochemistry of eDNA that we don't really know.

Erin Larson:

Yeah. Sounds like plenty of grounds for future research for you. It seems like there's so much to study and still find out about eDNA. But if you weren't studying eDNA, what do you think you would have worked on? You mentioned that you're sort of a stream ecologist who's moved on to do a lot of interdisciplinary work. Has that made you interested in pursuing other types of research, or do you sometimes miss, I don't know, more traditional stream ecology research? Yeah, what else excites you in terms of research?

Arial Shogren:

I really enjoy working in this applied sphere, working on a problem that is useful to managers. So I think anything that has that kind of applied spin, it would be really interesting to me. I'm also just interested in how things move. Basically if it moves I'm happy to study it. I've been really lucky that our field site is so close to campus and they've allowed me to dump eDNA in. I've been able to dump microplastics and et cetera. So eDNA isn't the only thing that I'm kind of interested how it moves.

Erin Larson:

Awesome. And so are you doing some microplastics research as well?

Arial Shogren:

Yeah, I'm working with John Kelly and Tim Hollein at Loyola University in Chicago to estimate microplastic deposition.

Erin Larson:

Awesome. And I'm sure there's a lot of, similarly to eDNA, some challenges with the way things can move and get resuspended in the water column as well.

Arial Shogren:

Yeah. I think that kind of challenge though, of trying to understand how different materials move and the different conditions at which they may exist, is part of why it's so interesting to me. Because it's just really hard to think about and there are all these different variables and that can be really fun. It's also really frustrating, but it's definitely fun.

Erin Larson:

Awesome. So speaking of fun, in Making Waves, we're trying to move on to also talk more about scientists themselves and scientists as people. And so I'd love to know a little bit about what you enjoy doing when you're not doing your science. What do you like to do in your free time if you hopefully have free time to do fun stuff?

Arial Shogren:

Yeah, I think it's all about balance, right? So I really love anything that gets me outside like running, canoeing, we're really close to Lake Michigan so I go there a lot. I recently got a new road bike, so I've been exploring with that and hiking, that type of thing. I'm also a huge animal lover, so I spend a lot of time with my dogs and with horses whenever I can.

Erin Larson:

Awesome. That all sounds great. And I agree, work life balance is probably one of the most important lessons in grad school that we can learn.

Arial Shogren:

Oh, for sure. It's a marathon, not a sprint.

Erin Larson:

Yeah, I told myself that all the time. Even though I think it's a marathon where there are moments where you feel like you're sprinting at least for a little bit, and then you walk. Awesome. Well thank you so much for taking the time to talk with us today, Ariel. It was a pleasure to have you on the podcast and we look forward to seeing where your research brings you next and see what you learn about how everything moves through streams.

Arial Shogren:

Thank you. Thanks for having me.

Erin Larson:

Thanks.

Outro:

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