Eric Moody:

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Eric Moody:

This is Eric Moody with the Making Waves podcast for the Society for Freshwater Science. Joining me this week on Skype is Dr. Wyatt Cross who is an associate professor of ecology at Montana State University and the director of the Montana Water Center. Thanks for joining me.

Wyatt Cross:

Thanks for having me, Eric. It's great.

Eric Moody:

So in stream ecology, a lot of scientists work on small headwater streams that could easily be waded in, and you've worked in both these small streams as well as larger rivers. My first question is, what motivated you to start working in larger rivers? Because I think, if I'm not mistaken, your background is working in small streams.

Wyatt Cross:

Yeah. You know, can be totally honest. My motivation was I got a job working on large rivers. And that was one of my postdoctoral positions was working on the Colorado River. And so that was the original sort of shift. And it was pretty intimidating to go from working in small streams, you can barely get wet in [inaudible 00:01:44] to basically getting in a dry suit and being in the Colorado River and working at really a much larger scale. So it was definitely intimidating but got thrown right in the mix there and realized that it was a lot of the same kinds of sampling and questions and things, but just at a slight, at a larger, more logistically challenging scale, basically.

Eric Moody:

You said that you notice a lot of the same questions and same approaches. Do you see any differences in the fundamental ecological processes that are driving interactions in large and small rivers?

Wyatt Cross:

Yeah, I mean I think that's a really tough question. It's like one I'd like to ask my graduate students on their comprehensive exams.

Eric Moody:

That is a good kind of question.

Wyatt Cross:

Many of us were trained and sort of came up at this time where the river continuum concept dominated, right? And we tend to think about small streams and large rivers as being really different and largely different because of their longitudinal positions along a river network. And so this classic notion that along this gradient you have very, very large differences in biological structure and ecological processes and things like that. And I think it's undeniable that there are big differences between these systems, right? So if we think about the types of habitats in small streams versus large rivers, you might have very different types of sediment size for example. You might have very different types of resources that fuel food webs. So shifting from terrestrial leaf litter to algae to fine particular organic matter and things like that.

Wyatt Cross:

And of course, that's kind of the canonical framework that we were all brought in up in. But I think more recently I'm becoming convinced that small streams and large rivers are much more similar than they are different. And I think that's, especially when we think about things like basic patterns that actually generate those physical or ecological processes, right? So you know, a good example, is geomorphology. We know that geomorphology is a really important determinant of things like biological production. So certain certain habitats are much more productive than others based on things like how stable they are, how stable the substrates are, how those habitats concentrate resources, how those different habitats alter flow environments and so on. So it's funny cause my lab group was just recently reading a paper by Ellen Wohl about particle dynamics and basically this discussion about are there differences across these scales?

Wyatt Cross:

And one of our conclusions was that, you know there are huge similarities in terms of the key drivers of for example, productivity. Where really stable substrates in large rivers, things like large wood or, or big bedrock outcrops or talus. Those are the productive hotspots in large rivers because they're stable, they're not moving as much. And the same types of dynamics and true in small streams as well. So there are huge differences in small few versus large rivers, but I think it's more productive to think about how these common characteristics scale with size and to me that's super exciting and there hasn't been much work done there.

Eric Moody:

You also mentioned that it's logistically difficult to work in these larger rivers compared to a small stream that you could just walk across. And I imagine you've worked in places like the Colorado River in Grand Canyon and then now in the Yellowstone and Missouri rivers in Montana and these are really beautiful places, but they're also fairly remote. What challenges do you face in doing this type of large river ecology in places like this?

Wyatt Cross:

Practically and logistically there's no question that it's much more difficult to work in these sort of remote locations. Especially the Grand Canyon. Right? So that's a place that you can't drive to many locations in the Grand Canyon and work. We did a couple of the sites, but most of the sites we had to take river trips down on the river and do our sampling. That was super fun, but it was also this situation where you'd get ready, you know you're spending a lot of time, effort and resources on a single trip and everything's got to go really well. You've got to make sure that you've got everything and that everyone's on board and that your plan is really straightforward and, and it's all going to work out. You can't run back to the lab and grab something you forgot.

Wyatt Cross:

So in terms of that, it's challenging to make sure you get the most out of each of those trips. The Yellowstone and Missouri rivers are a little bit different. Yeah, they're pretty remote. But they're still drivable, mostly, at least in terms of getting to some of the sites. Many of the stretches that we work on out there, you do have to use it like a jet boat and boat around and get to different locations. And so again, that's like logistically just a huge deal. And sometimes the water's low in the Yellowstone, you get stuck in the sand. I mean, my student, Eric Scholl could tell you lots of stories about spending way too many hours trying to figure out how he's going to dig this jet boat out. So yeah, I think it's way more challenging from a practical perspective, but it's also more challenging I think to conceptualize.

Wyatt Cross:

And so you think about working in a small stream, most of the things you're interested in, most of the organisms that you're working on are all operating at scales that you can walk around and observe. Right? And so in a couple of hundred meters you can sort of encompass that the important ecological processes like metabolism, leaf decomposition, etc. And you can also encompass the ranges of the organisms that exist there. The invertebrates, there are small fishes and so on, amphibians, et cetera. When you get to larger systems, and this is a really important point that I think Kirk Fausch and those guys made in their riverscapes paper that we have a much harder time perceiving the important ecological processes at larger scales. Right? And so you really have to start and get your head around sort of zooming out and saying at what scale do things matter?

Wyatt Cross:

So a good example of that is in the Yellowstone and the Missouri rivers. We're working on this project in the context of the endangered pallid sturgeon. And again, my student Eric Scholl is working on sort of constructing food webs. And of course during the year those things migrate and travel huge distances, right? Even when they're forging. So they might forage across tens of kilometers. And so many of us are used to getting into a stream and working on these relatively small sections.

Wyatt Cross:

But basically what Eric had to do was think about what's the scale in these rivers that matters for these pretty top predators. And then he basically had to match his conceptual framework and match his sampling to a scale that matched these important predatory fishes. So that was another challenge too, just like getting our heads around how do we sample the food web? How do we sample invertebrates and learn something about these highly mobile, large predators. So not only are there sort of these practical issues, there's also the conceptual issues of getting your head around what's going on at these really large scales.

Eric Moody:

Let's get back to some of your work in the Colorado River. So you mentioned primary production and secondary production earlier. And a lot of your work has focused on that in particular. One thing that I think is interesting is that you found that the production of nonnative fish, especially rainbow trout, seems to be higher just below Glen Canyon Dam, which is sort of where we think about the Grand Canyon starting in the Colorado River. So how does the dam actually affect downstream food web structure? And especially why does it affect trout so much?

Wyatt Cross:

The dam has, like many other large dams, has massive effects on food web structure just below the tail water and beyond. It's important to sort of think about the fact that dams like this fundamentally alter the physical template. So this large desert river that should be turbid, warm during certain times of the year, super cold during other times of the year, has been altered physically in a big way. So many of these large dams have hypo limnetic releases. And so there's cold clear water coming out from the hypolimnion, the lower part of the lake and feeding that tail water system. And so you get really typically pretty cold waters. You'd get clear waters and you also get dampening of a lot of the important variation that matters for organisms. If you look at temperature variation in Glen Canyon and below, it's really constrained. It doesn't get really hot, it doesn't get really cold.

Wyatt Cross:

If you look at the variation in flow, it's totally wacky. I mean it's like the flow is basically managed for things like hydropower largely or just moving water from Powell to Lake Meade. And all of these changes play a huge role in affecting the biota, right? So a lot of the biota that should be there, a lot of the native biota are filtered out because they are missing their important natural cues. Like temperature cues or other sorts of things like that. Right below the dam it is really strange food web, right? So at the base of the food web in Glen Canyon, you have big flowing mass of super productive green algae, Cladophera, most of which isn't passed up into the food web. So it's this big flowing mass of Cladophera and almost nothing is feeding on that source of productivity.

Wyatt Cross:

At the next level up you've got a bunch of weird things like New Zealand mud snails that were accidentally introduced. You've got Gammarus scuds, like crustaceans that were purposely introduced to feed trout. You've got other things like cold adaptive black flies that really shouldn't be in that stretch. So you've got that weird sort of primary consumer base and then you've got a trophy rainbow trout fishery that we have constructed and managed and maintained.

Wyatt Cross:

And so from an ecologist's perspective you get into the system and you're like, this is a Franken river. You know, this is like weird and mismatched and these species shouldn't be together and they haven't coevolved and all those sorts of things. It sort of creates this situation that supports and maintains this important trout fishery that has a huge part of the economy there.

Wyatt Cross:

So long story short, I guess, is that the dam has huge effects on the physical template and that cascades up to affect these higher trophic levels. As you move downstream that changes of course. So as you get down river you start to pick up tributary inflows. So they're important tributaries like the Perea River, the Little Colorado River and so on that dump huge amounts of sediment into the Grand Canyon. And in some ways not totally, but in some ways, they kind of start to renaturalize the system, right? So temperatures start to climb, sediment and turbidity starts to climb and so on, and you start to see a very slow recovery of some of the native taxa as you move down stream. And in particularly you see things like the endangered humpback Chub that are able to hang on largely because of these tributaries for spawning, but also for providing warmer temperatures and turbidity and things like that.

Eric Moody:

Any listeners have ever looked at a hydrograph before for a stream? You should look at the hydrograph below Glen Canyon Dam because it's one of the strangest ones I've ever seen.

Wyatt Cross:

Yeah.

Eric Moody:

So you mentioned that due to the strange flow regime caused by the dam, the food web below is very sort of unusual. And to alleviate that, there's been some work doing experimental releases of water causing floods. Can you talk about sort of who is leading that charge and what the idea is and how it's working?

Wyatt Cross:

Yeah, so if we go back far enough, I think the first experimental flood was in 1996, if I'm not mistaken. There are a lot of different angles to this and one of those is that, because of the new hydrology below the dam, beaches downstream, sediment dynamics downstream have been changed in a big way. So in a natural, large desert river, you have building and eroding of these big sandy beaches. And those are important for a lot of reasons. But one of the really important ones is that those habitats set up backwater environments that are thought to be really important for say early life history of some of these native fishes like humpback chub and in some other places, other fishes. That was part of the reason behind trying to do these experimental floods was to provide more of that backwater habitat for the endangered humpback chub.

Wyatt Cross:

The other major part of this was the idea that we needed to rebuild beaches so people could camp, right. And so of course that's a huge part of the economy is recreation, boating and camping and over time these beaches were becoming so eroded that it was becoming hard for people to find campsites along the river. And so in a way it was kind of a win-win. We're doing these experimental floods and hopefully provide new habitat, for not for native fishes, like humpback chub and hopefully reset some of those sandbars once there's enough sediment in the system to be sort of re distributed for those sandbars.

Wyatt Cross:

It got a little bit tricky because there was this perception that floods were bad for the rainbow trout fishery below the dam. And so a lot of the fishing guides and others were sort of not super happy about these floods because there was the perception that it scoured the river and that it was bad for trout populations because a lot of them were scoured downstream and a number of other reasons.

Wyatt Cross:

But truthfully we didn't have a lot of good data on the response of this ecosystem to floods. There have been a little bit collected in previous flood, but nothing in terms of sort of integrated ecosystem work, trying to understand connections in the food web and so on. And so while we learned a lot from the prior work, we were really sort of geared up to follow energy flows and how the flood affects those. And so I think that the biggest take home from our work on the flood below the dam was that floods actually benefited rainbow trout.

Wyatt Cross:

The floods scour the bed, right and scoured all that big sort of non palatable Cladophera and sort of created a fresh new environment of things like diatoms and rapid growth of other parts at the base of the food web, that then fueled the production of certain taxa like black flies and Chironomid midges that are important in the diet to trouts and especially juvenile trout.

Wyatt Cross:

So what we saw after the flood was this sort of flushing or resetting of the system and that cohort of juvenile trout that emerged from the gravel did awesome. Like they had a lot of their preferred food was readily available and it was one of the largest cohorts we've seen to that point. And so it was really interesting and exciting because sort of that science, when we started presenting this to the managers and so on, started to change the way they thought about these floods and think about well maybe these floods can be positive for the rainbow trout fishery and they can also be positive for building backwater habitat downstream for humpback chub. And that's the tricky part is like trying to manage this Franken river in a way that benefits things that shouldn't be there but that we want there but also benefits things that should be there and we want to maintain. So that's the challenge I think.

Eric Moody:

So your work in the Colorado River was primarily aimed at basic research, but it's also been able to tie in to certain monitoring goals and certain goals such as maintain the recreational fishery and maintaining populations of endangered species. So what were you able to learn about how to, particularly basic research, and in two applications such as that?

Wyatt Cross:

When we got funding to do the original work in the Grand Canyon, it was really exploratory and it was coming from this idea that we knew very little about how the ecosystem worked. And we had to put in this sort of sweat equity to understand how these food webs work. But all along of course the goal was to be able to monitor the system in an adaptive management framework. And so the idea was we would take some of the things we learned from our research and pass that on in terms of trying to understand the mantra of the ecosystem for long periods of time in the future. It takes a lot of people, a lot of effort, a lot of time and so on. And so we really were trying to help the Grand Canyon monitoring and research center develop a monitoring scheme.

Wyatt Cross:

Now what we've learned, and some of the things that we found out were that, again, we can't go out and sample the benthos. We can't sample the food web and at the same level that we've always, that we did for this research. And so one of the ideas was to shift towards measuring the other metrics that are much easier to monitor but still tell you something about change in the ecosystem. And so one of those, Ted Kennedy, who's a biologist at the USGS in Flagstaff at the Grand Canyon Monitoring Research Center, developed a method for measuring emergence. For measuring invertebrate emergence at large scales and doing it in a way that captured really large patterns across space and time to look at how changes in dam management influence productivity through this metric of aquatic invertebrate emergence. The super cool thing about this is that he talked to himself, well, the ton of boat people out there, that are taking people down the river every single day, right?

Wyatt Cross:

And many of these boat people are extremely interested in the science and interested in helping. And so he developed this citizen science program where he sort of sent out guides on trips with these little kits to when they're in camp, kind of cooking food or whatever, and working with their clients, to be collecting emergence overnight or whenever they were there during the day. And so he's developed these incredible datasets on insect emergence across space and time using citizen science.

Wyatt Cross:

And if anyone's interested, I mean there's some really amazing videos about this. Jeremy Monroe with Fresh Water Illustrated has produced a video about it, and it's just a cool way to sort of monitor some of these factors that we couldn't do with normal paths of science basically. So the long winded way of saying we couldn't keep doing what we were doing in perpetuity because it just takes too much money and resources. But what Ted Kennedy and others at the Grand Canyon Monitoring Research Center are starting to find is that these other metrics that some of which can be employed by citizens, can be really effective in helping us understand long term change. That's been super exciting.

Eric Moody:

Thanks.

Wyatt Cross:

Thank you, Eric.

Eric Moody:

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