Hey to all you fish enthusiasts out there. Whether you're an avid angler or just curious about fish, we'd like to welcome you to fish of the week, your audio almanac of all the fish. Monday, September 25, 2023. And we're on a week-by-week tour of fish across the country with guests from all walks of life. I'm Katrina Liebich with the US Fish and Wildlife Service in Alaska.

And I'm Guy Eroh. And this week we're tackling the cod of the Amazon, the mother of all fishes, a big fish with a small tail. It's the Arapaima.

That was awesome.

And we're very lucky to have an ichthyologist who works at The Field Museum in conservation science, Dr. Lesley de Souza, and we're really excited to learn about this fish with you. So welcome.

Hi, everyone. Thanks for that introduction.

Okay, so we're talking about a megafish today, it's got some major superlatives, including being among the world's largest freshwater fishes. And I'd love if you could just help us imagine what it's like to be in the presence of this fish. And what really stands out about it physically.

Yeah, the first time that I was in the water with an Arapaima and realize I am with a fish that's bigger than me, and I'm gonna have to handle this fish. Just the scales are so gorgeous. It's kind of a torpedo shape, has this really kind of slender nose. And then as you kind of move towards the back of the fish, the anal fin and the dorsal fin are really close towards the back, but they have these gorgeous red scales. Some of the Arapaima can have darker coloration depending on the type of water you're in. Oftentimes, they have this kind of greenish color, but then sometimes they can have a dark gray color. But then you have the scales that pop out. I think what was so majestic about being in the water with an Arapaima, the largest freshwater scaled fish, one of the oldest lineages out there. Their relatives are around with the dinosaurs. So we're talking about a really ancient fish, and you're just feeling like you're connected to something from a long, long, long time ago. And right now, in that moment, super magical.

Their face definitely looks like a dinosaur. They're beautiful.

What are all those grooves? It's almost like you're looking at like a topographic map of Mars or something. It's just got all these canyons and scratches, what are those?

Yeah, I mean, the skull is super intricate. And one of the discoveries that happened recently is that if you look at the top of the skull, they have these depressions. And there are holes in those depressions. And the first time that I was working closely with Indigenous communities, I remember one of the Indigenous leaders saying, "milk comes from those depressions and the young feed on that." And I thought "you're blown my mind right now." You know, the indigenous community that I was working with really helped me learn how to work with these fish, but also every aspect of living in the jungle with them. I was like, "Yes, I will listen to everything you say, because I want to be alive." But one of those

groups we came out a couple of years ago in a paper is milky substance that they were able to show that young feed on that. And so it is directly connected to their development.

What?

Yes, it's like sort of like milk fish. I mean, it just it, yes, blow your mind.

Had no idea. So I want to talk a little bit more about the scales, just what are they like? And what are they for?

They kind of look like a poker chip that's about the size. And the coloration of those scales, a lot of people think might be associated with sex. They're really difficult to tell whether it's a male or a female in the field. But those colorations can vary. And some of those seem attributed to water chemistry. So some of the like clear waters have different coloration. Some of the older fish like really big arapaima tend to have a more brilliant red color. As the air primer grows, and they can grow really fast over one rainy season. They're very tied to the fluctuations of the Amazons like rainy and dry season. And so when you have a really productive and strong rainy season, fish get really big. They get really fat. An Arapaima can go from like, two or three inches to about three feet.

Whoa!

And those scales are growing with them over time.

Yeah. Is there anything up with their tongue? I've heard the tongue is kind of interesting.

We were arguing whether they counted as bony tongues or not.

Yes, they are bony tongue fish, and they're in the order Osteoglossiformes. And their family Osteoglossidae, which are the bony tongues, and that's Arapaima and Arowana. And the really cool thing about Arapaima’s tongue is that local people use it for a file. Some of the communities use it for medicinal properties. They can combine it with bark and make kind of a tea that helps for like intestinal worms and things like that. They're obligate air breathers, so they have to come up to take in surface oxygen to breathe. And so when they come up, it's such an impressive loud motion, where they open their mouth, they come out of the water to take in air, or if they're feeding, they like crush their prey, and they use that bony tongue to help crush their prey.

Ooh, all right. This is the first fish from South America that we've ever talked abou. First fish on the Amazon first fish from that continent. So geographically, where are we speaking? Where are you finding this fish? And then what habitats are they utilizing like where they have to be these obligate air breathers?

Yeah, so Arapaima are native to the Amazon Basin and the Essequibo basin in Guyana. And something that's really cool about their range is that at the border between Brazil and Guyana, where

the Essequibo River is in Guyana, is called the Rupununi portal. It's a hydrological corridor that connects the Amazon basin with the Guyana shield.

So it's like a natural canal kind of thing?

Yeah, it's well, what happens is there are wetlands and savannas that become inundated during the rainy season and allow for kind of movement of Amazonian fishes into the Essequibo drainage.

That is really cool.

It's super fascinating. We could go on a whole nother show about just the interesting things about geology in terms of how river drainage does have influenced diversity and evolution of fishes. But where you'll find them usually are in these oxbow lakes. They love wetlands, they love kind of these backwater habitats. You'll see them in the main river channel for sure. But they love lakes, ponds, oxbow habitat. They're typically in these anoxic areas. So like places with low oxygen

Give them their air breathing strategy, then.

Yeah, so their swim bladder has lung like tissue that allows them to take in surface oxygen, which is really ideal in these habitats that are low in oxygen.

Amazing. So you've mentioned with their mouth, how they will crush their prey, and I've seen them in aquariums, and they're just kind of like hanging in there usually, but like, what are they like? What's their behavior, like when they're hanging out in the water?

Yeah, in the morning hours, or like early evening, you'll see them kind of moving out around in the water, and you'll see them close to the surface. And a lot of times you can see them because they'll come up for oxygen. So you can kind of follow them, especially if there's good visibility, during kind of like the heat of the day, they seem to be in kind of shady areas of their habitat. And also like lower in the water column, they do seem to just hang out in a spot for a very long time unless they're actively feeding. I remember I was at the aquarium looking at this fish thinking about the research project that I was about to do to understand their behavior. But it wasn't until I was in the field with them that I realized, you know how these different habitats influence kind of some of their activity, as well. So some of the shallow areas, you would see them come up a little bit more often for oxygen, so the adults come up less frequently. So the smaller Arapaima may come up every eight minutes or so. And then you could have an adult that could take up to 20 minutes or so before they come up for air.

Does the frequency of surfacing have anything to do with the dissolved oxygen content of the water that they're currently in?

I was seeing more of a difference between the size of the individual like the age of the individual not necessarily like the potential DO or dissolved oxygen in the water. So I would say that it has more to do with their age and size. But also if they're actively feeding, they come up way more. The adults, you can see them kind of moving around, and then they'll come up again. If you're in a pond and you see a

bunch of Arapaima. And you like let's say we were targeting one to catch and capture and process, we would wait like 20 minutes and know that they're going to be closer to the top of the water column. When you see them in a river. You don't necessarily just see them rise to take in surface oxygen. Sometimes they come up and they do a leap that looks almost like a dolphin. And other times they come up and then they do a twist and they slap their tail onto the water. It's so gorgeous. And it's something that I never knew about Arapaima until I started spending a lot of time and habitats where they were present. You never know what it's going to look like and how gorgeous it could be.

We just talked about Atlantic sturgeon leaping out of the water and yeah, just kind of the mystery around that but that is an impressive way to see a fish when they actually come out of the water. You can see them.

Yeah, the whole body all the red scales. It's just it's pretty magical. But then to think that they're in this like mysterious waters of this, you know, the largest river in the world, most diverse in terms of freshwater fishes. And they're just one of many. But pretty amazing, magical.

What kind of stuff are they eating? Like, what's their range of prey? I guess when they're small and then as they get huge what are they eating?

Yeah, big.

Arapaima are omnivorous so they eat everything. Fruits and seeds, other fish, frogs, birds that might be on the bank. Lizards. We've seen it all. Crustaceans, and they're really good at crushing this crustaceans with those bony tongues.

I'm surprised you haven't asked a question of what you could fit in its mouth yet.

Oh, well let's ask that question! Fish with big mouths. We're always curious what size object could they take into their mouth if they needed to?

Oh my gosh.

A softball? A small watermelon? A potato? A big one?

Oh, um, I think a big watermelon is like what I'm picturing because I've seen them put a caiman in their mouth. And so it's just, yeah, it was gnarly.

Pay back for caimans getting them?

Yeah, exactly getting their young. Bbut you can kind of see their, their jaws kind of extend out. So they're able to put in a lot.

I've watch those videos online where they give watermelons to zoo animals, I would love to see one of these fish just crush a watermelon.

Oh my god, I can't even imagine. But not many things can come after them. And as they get bigger, they're the apex predator of a system. And so the juveniles, of course, can be predated upon more easily. But adults, the only things that I've witnessed before are generally river otters. Giant river otters

Watch those otters, they're ferocious. I'm hearing a lot about them lately.

Yeah. And caiman, so black caiman. And jaguars, the big cat.

Man, that'd be something to see, to see a jaguar carrying around a big Arapaima.

I know, we would have oftentimes ones that had been killed. And we would know immediately if it was a giant river otter or caiman just because of the way that it was killed. And that was really interesting, because giant river otters would attack the Arapaima, but then stash it, and then keep coming back to eat it. Yeah, it was super interesting to see how the different predators were enjoying the Arapaima.

I'm kind of interested in follow up on the study you're doing looking at their movements and how it's related to the seasonality and the flow regime. We've talked about several fish on this show that kind of require this periodic flooding for their reproduction in their life history. Is that something that is important for the Arapaima?

Yeah, especially for many of the fishes in an Amazonian ecosystem, because everything about the ecosystem is so closely tied to the fluctuations of the river and the water. Because it's a tropical ecosystem. Arapaima especially are really cute and tuned in to the fluctuations. The minute the waters are beginning to rise in a system, you start seeing activity like reproductive activity, start seeing pairs coming together, you start seeing nests building, so very sensitive to the cues and then fluctuations of this ecosystem.

What are their nests like?

Yeah

Oh, they're so cool. If you think of their tail as like a spatula, they use that tail to like, scoop out and create this huge depression at the bottom of like a lake or a pond or an oxbow lake. And I've tripped and fallen in one, that's how I usually find them. But they're pretty big. I mean, they scoop them out, and it's kind of a shallow depression, but that's where the eggs are in the nest, and the males are the mouth brooders. So typically, once those hatch, the males are protecting the young and the female is the guarding the nest.

And feeding the milk.

And feeding them milk, yeah! This fish releases milk that juveniles feed on I mean, it's like mind blowing, but what I would witness before this villager told me this was that the Arapaima would be swimming along, and you could see it close to the surface and you would see all of the juveniles on its head. So that was something that I had, like, witnessed many times but didn't realize that it was

connected to them feeding on the milky substance that was being released to these pores. It's just mind blowing.

So when the male goes up to get a gulp of air, though the babies are kind of just around his head.

Exactly. Yeah.

Okay. This seems like a really kind of, I don't know, familiar fish and a lot of ways we see it in aquariums here, but like, is there still like a lot of research that needs to be done about their life history? I know you've mentioned a lot of things we know already but like what do we not know?

So we know that this fish, the populations, at least at one point, in recent memory, we're not doing great and maybe still aren't doing great in some places. But it doesn't share a ton of life history characteristics with say, like sturgeon that make it prone to overfishing and make it a conservation interference. It sounds like it matures pretty early. It has lots of young, it grows pretty fast. So what has led to those declines that we've seen?

That such a great question, because this is a fish that's been in trouble throughout the Amazon basin. What we think we know is that there's about five species, three of them we probably haven't seen in a couple of decades. We're still trying to understand the taxonomy of this group, their data deficient, because we don't know enough about some of the basic biology of this species. For example, when do they reach sexual maturity? We think it could be anywhere between two to four years. I mean, there are some studies with Arapaima in Brazil that are different than the Arapaima found in Guyana. And is it because there are two different species? That's has been proposed that the ones in Guyana are endemic to Guyana and the ones in the Amazon mainstem is *Arapaima gigus*, which is kind of the more widespread species. But there seems to be potentially behavioral differences that we still don't know, we still don't know, this ancient species that has been able to survive.

I think that one big answer is habitat degradation, and illegal logging that affects some of these oxbow lakes that affect the riparian zone in some of these river ecosystems. I think that's a huge impact on this fish, as well as overfishing. If you harvest several females that are sexually mature, you're going to have a huge impact in the population. And there was a great example in Guyana because the fish populations for Arapaima had plummeted in the early 2000s. And I think local communities had counted something like 400 individuals by watching them surface and come up for air, it does take a little bit of training to be able to know that you're counting a different individual.

So you can kind of tell apart a little bit.

A little bit. Yeah, but then just limiting the fishing and making it illegal to fish for them, in four or five years, it had already rebounded to a couple of 1000 individuals. And so it could also make a huge impact in the population in the alternative direction where you can see a rebound pretty quickly if you manage the populations well.

The indigenous peoples of Guyana have fished for these fish for a long time. But I guess what's just the fishing scene? Has it changed over time at all? And where's it at today?

Yeah, prior to the 1960s era, Arapaima was seen as kind of the mother of all fish, the sacred fish. There were stories about them being mermaids. That wasn't until probably the early 1960s or so that they became an important source of revenue for these communities. And a lot of Brazilians were coming into Guyana fishing for Arapaima. And so then it became kind of part of their livelihood where fishing for Arapaima was an important stream of revenue for the communities. And then in the early 2000s, when they saw, you know, the impact they were having on the populations of Arapaima, then that's when they turned to kind of look to conservation efforts to kind of protect the species. And currently now the populations are doing really well. There's ecotourism opportunities to do catch and release fly fishing for Arapaima.

Oh my gosh.

Yeah. Can you imagine?

I want to see what that fly looks like.

Yeah, some of the flies. They're so gorgeous, because they're like peacock bass or other fishes like that they really love. So gorgeous, but big flies.

Yeah, yeah.

So how did people originally harvest these? I mean, it seems like you're talking about they can count them when they're coming up. Were they targeting them with rod and reel, with nets with other means? How are they catching these fish?

Yeah, so I think because Arapaima are obligate air breathers might surface for oxygen that makes them vulnerable to fishermen. And early on, they used to be harpooned. So fishermen would either bow and arrow or harpoon, and they would go for these Arapaima when they would rise. And it was interesting, one of the villagers who worked with me on the research project, he was one of the best fishermen in the village. And he used to sit in a tree with a bow and arrow and wait for it to surface but the Arapaima became hip to the fact that they were being harvested and would take a very long time to come up. And he said that there were Arapaima that were only coming up like four times during the day.

Oh, wow. Wow.

Which is, which is pretty remarkable.

What are some of the traditional ways to prepare the meat? And what's it like?

Yeah, so I've only tried Arapaima in Brazil. I'm originally from Brazil, and so with some of the recipes are associated with stews, or there could be roast, when you're camping in the jungle. You just have a

fire and you cook it on the fire. That is delicious, as well as stews or baked Arapaima as well. A delicacy for sure. They're huge boneless steaks, it's just incredible. They're so delicious. There's just so much of that meat in the Arapaima that you can just get this incredible, delicious slice of Arapaima.

I've heard that the Arapaima gets this nickname "Cod of the Amazon" because people are able to preserve the meat sort of in a similar way to like how the Basques would preserve salt cod. Is there anything about the meat of the airplane that makes it particularly easy to preserve?

I mean, that's one popular way that people preserve and sell fish in the Amazon because we don't have refrigerators all over the jungle and so salting Arapaima is really important way to have fish for a long time, but also for traveling markets on the river to sell Arapaima.

Awesome.

But it's important for people to know where and when to buy Arapaima too, because there are some fish farms that are productive, and that provide Arapaima for markets, but then there are still people that are illegally taking them out of ponds and taking them out from the wild in places that are illegal. And you can usually know because the restaurant or somebody will let you know that, hey, this is Arapaima that comes from these aquaculture farms.

Right, given the fact that it can go from a couple inches to three feet in a year, and the fact that it's meat is so delectable it seems like it'd be a prime candidate for aquaculture operations down there.

I know you've mentioned kind of fishing regulations. But what are some other tools being used to conserve these fish both at the local level and maybe from afar?

Yeah, there have been some incredible efforts throughout the Amazon basin to protect Arapaima. And some of that is based on this community management, monitoring their ponds. In some places in the Amazon. I mean, a community can have like 50 or so ponds, a lot of different ponds with Arapaima in them. And so there's been some great work to figure out how much per year they can harvest. And that funding supports the communities, the fishes either sold commercially, or feed communities. So there are a lot of efforts to monitor the populations of Arapaima in these ponds, as well as monitor how many are harvested per year. And they do that based on accounts. So like a percentage of Arapaima can be harvested based on how many are there that next season.

Yeah.

So how have people responded to these conservation and management actions. Are these rules that are being placed onto people by some external regulatory body, or or the folks who are using Arapaima actually involved in the management process.

I think there are definitely initial efforts that came from outside, they were like, "We have to protect the species, this is really important, they're on decline, they're important for the ecosystem." But I think seeing communities take ownership of the management of the species is what's really changing. And

that's why it's working. And there are great examples throughout the Amazon where this is working really well.

Okay. And I mean, you probably talked about this better than anyone but giving you like radio telemetry and stuff, but these guys are more or less sort of homebodies, right? They're not making mass migrations, where it's like, okay, we conserve it here. But then like, up in Iowa, you're not allowed to hunt doves. But then wintertime comes they go down south to Missouri, and people shoot them. And it's like, well, what's the point? So it seems like you can kind of do this with this species, right?

Yeah. And that was what sparked that study. And that beginning, like looking at their movement patterns, because this community wanted to protect the species. And they said, but what if we protect them, and then in the rainy season, they go somewhere else and other communities or illegal, poachers come in and take them out, but they don't migrate. They do make, like lateral migrations into the flooded forest and they do go up the river. But what they're looking for is shallower areas because they have They're young, they're not making massive long distance migrations, they kind of stayed in a general area and the individuals that we had tagged, I think like 85% of them came back to the exact same ponds that they were in the year before.

Okay, so they are coming back to very specific areas.

They are. Yeah, so one of the cool things about this study was that we were having a hard time going through the flooded forest, like in the rainy season for these individuals, as you might expect, like it was a super like manually intensive like thing that we were trying to do, we just thought that we could follow them moving out of the pond into the flooded forest and immediately would lose them pretty quickly, which is not surprising. So we did aerial telemetry, and we flew over the flooded forests. And it was incredible. We weren't able to get kind of the day by day, but they were coming back to the same areas.

So it's neat that they're homebodies. It's definitely helpful for their conservation. Are there any kind of larger issues like climate change or logging, where it's like bigger policy challenges and are there any ways for people to help with those issues?

I would say that one of the things that I witnessed that was really hard to see was climate change impacts on these oxbow lakes and ponds within the forest, because they were drying out. And so a couple of seasons, there were really intense droughts. And so Arapaima were getting stuck. And these ponds, they would die. We were able to go into a couple of ponds and move them out into the main channel. But I do think that climate change has a huge impact on how these ponds may look, depending on you know, from one dry season to the next. And the local people are aware of it. They're like we're seeing dramatic changes in the climate. rainy seasons are coming earlier, or they're really extensive and long, or they're barely a rainy season or barely dry season. So very major shifts in the way that the climate has been.

And that's not a problem you can solve locally.

Yeah, it's not a problem you can solve locally. I think everybody needs to get on board and realize that we're having an impact globally. And it's impacting these...

People's lives.

Yeah, people's lives everywhere. These communities used to harvest Arapaima for revenue. They've made an alternative stream of revenue and tourism and ecotourism. And so they're these incredible magical fish and other biodiversity from the Amazon Basin as part of like the natural attraction, right? For ecotourism. And so I think supporting these small scale community led eco tourism operations is one way to contribute to conservation efforts all over the Amazon Basin, across different species.

So you could go see them in the Amazon basin. You can also see them in aquariums, and I'm just curious that where can we actually see them here in the United States? And what role are aquariums playing and conservation if you could speak to that?

Yeah, I think that aquariums play a big role in the conservation of some of these species, because it's sometimes the first time that someone can actually see a species that they may never see in the wild. And I think that in my experience, they cared about the conservation of Arapaima and the Amazon ecosystem. And so that was a specific project that that was well supported by the aquarium because their goal is really to connect people to these incredible species. So I know the Shedd Aquarium have Arapaima, the Tennessee Aquarium I've been and seen Arapaima there. Several aquariums across the US that that have Arapaima

they are so cool. Yeah, I would recommend seeing them in an aquarium, you just like stare at that tank, and they're just kind of hanging in the water column. They're super impressive.

Well and their eyes, like roll all the way back. So I remember when I was in the water, and was holding one because we were getting ready to process and measure it and do the science. And then just watching their eye just like turn up and look at me in I thought, "Oh, this is this is all of a sudden personal."

Like "what are you doing to me?"

Like, "I promise I'm putting you back. I'm not gonna hurt you."

How do you keep them calm and restrained? Cause you're talking about a six plus foot fish very strong. I've seen videos of them just launching out of the water like a missile. How do you keep this fish under control? So you can imagine you're taking some tissue samples and or doing some surgery to put a tag in or something?

Yeah, and I would go back to what I said earlier that the working closely with Indigenous People who have intimate knowledge of a lot of the biodiversity in this area and intimate knowledge of Arapaima is really what led to the success of the project. So having strong people that can contain this animal, but also learning a little bit about their behavior as we were capturing them. So we would wait a few

minutes for them to calm down before doing the surgery. They were like "just let's give it a minute. They'll calm down they fight for a little while but then they'll calm down." And we're turning them over to insert the radio [tag] into the inner coelom area and they did they calm down. But it does take a couple of people holding them really tight to keep them in place at the very beginning. But you're right, Guy, they do they like launch themselves out. And that head is a missile and it's a weapon. They will use that head. And so bony and big and strong, like the power, they have to be able to like, use it as a weapon to protect themselves. And the most aggressive Arapaima that I had ever encountered was during their reproductive period. So when you get close to their nest, they're like get away. I agree, I would protect my nest too.

So you get back from Rupununi, you're doing really cool research down there. I'm curious if one way you could expand on what you're doing. And then to if someone is an undergrad student or a high school student right now, who hears this and is really interested in the work you're doing? What could they do to get themselves on the right path? So they could maybe be doing sort of similar stuff in the future?

Yeah. So I would say that some of the work that I'm doing at this point is really trying to apply the science to conservation action. So this is a region that we're working closely with the communities to create some sort of conservation area. And I think communities you're trying to figure out what that is, it's a place that is a stronghold for the Arapaima in Guyana. So that's kind of the focus of the work right now, there is continued tagging and monitoring of the Arapaima, and one of the river systems. So there's PIT (Passive Integrated Transponders) tagging, and just continuously tagging to see how these ponds are doing in Guyana. So in terms of a high school student, or a college student that would be interested in studying this incredible fish or any of the other fishes of the world, I would say look at internship projects that might be able to give you an opportunity to experience research with an ichthyologist or someone getting in the field, I would also just cold reach out to somebody, if you look online, and you're like, wow, this person is doing incredible work on surgeon or, or primer or car, you want to learn something about their work or get experienced. And I would say just reach out to them and email them. I've taken people to work with me in the field who just cold email to me. So

And we cold email you. We cold email people all the time!

But you guys are the coolest though. I'm actually a fish nerd. And I love your show. So thanks for highlighting Arapaima.

Awesome. What are your aspirations for the future of this fish? Are the Indigenous Peoples within the range of the fish? And do you have just any kind of final thoughts on why people should care about this fish outside of that local geography?

I would love to see this fish expand back into the range that it used to inhabit, meaning the places that they've declined, that they've been extirpated. The species that we don't know if they're extinct or not. I'd love to see a rebound throughout the whole extent. So the Amazon Basin as well as within the Essequibo basin. A dream would be to see policy and structure in place to protect the species. We need more conservation areas for freshwater ecosystems, whether they're wetlands or whole

watersheds to be protected. And that's something that I'm thinking a lot about lately. My son is four and to be able to go there with him and to see Arapaima but also for his kids to see Arapaima is the dream.

All right, well get out there and enjoy all the fish, especially the Arapaima.

Thanks for listening to Fish of the Week! My name is Katrina Liebich. And my co-host is Guy Eroh. Our production partner for this series is Citizen Racecar. Produced and story edited by Tasha AF Lemley. Production Management by Gabriela Montequin. Postproduction by Alex Brower. Fish of the Week! is a production of the US Fish and Wildlife Service, Alaska Regional Office of External Affairs. We honor thank and celebrate the whole community, individual tribes states, our sister agencies, fish enthusiast, scientists and others who have elevated our understanding and love as people and professionals of all the fish.