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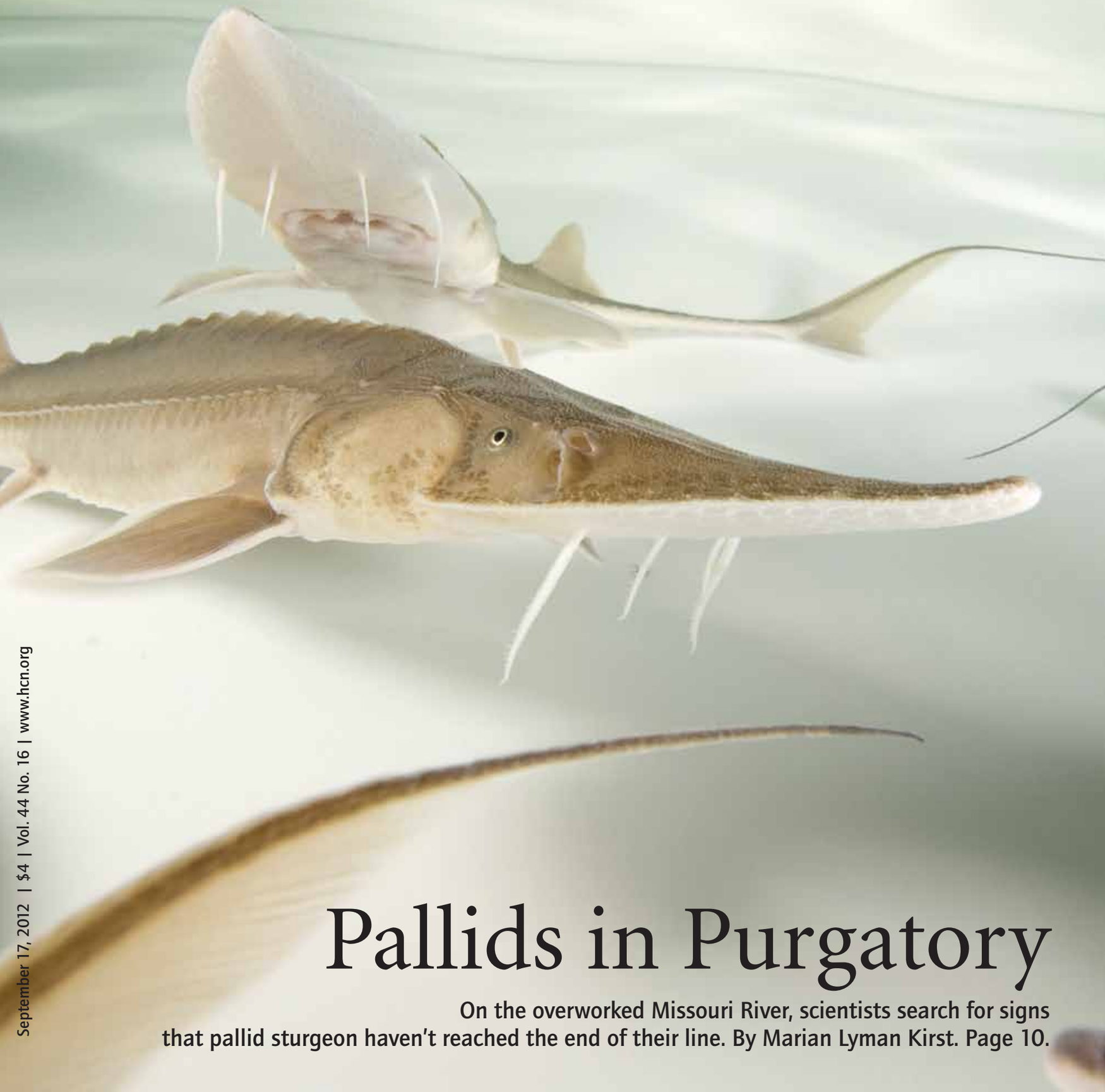

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Pallids in Purgatory

On the overworked Missouri River, scientists search for signs that pallid sturgeon haven't reached the end of their line. By Marian Lyman Kirst. Page 10.

Pallids in Purgatory

On the overworked Missouri River, scientists search for signs that pallid sturgeon haven't reached the end of their line.

A pallid sturgeon netted in the Lower Missouri River. Below, fisheries technician Dave Fuller pilots a boat on the Upper Missouri River, keeping tabs on the fewer than 150 wild pallid sturgeon that persist there. USGS (LEFT); MARIAN LYMAN KIRST (BELOW)

MISSOURI RIVER, MONTANA-NORTH DAKOTA BORDER

hrrrrp, chrrrp: Our headphones echo with the tinny peeps of a radio-tagged pallid sturgeon (*Scaphyrincus albus*). Dave Fuller, a Montana Department of Fish, Wildlife and Parks fisheries technician, maneuvers the jet boat up and down the Missouri River on a beautiful October day. The sapphire sky has yet to succumb to winter's haze, and the cottonwoods and willows that line the bank are dressed in fall's finery, their branches sleeved in green and gold.

Soon we zero in: *CHRRRP*. "It's a female," says Pat Braaten, a U.S. Geological Survey research fish biologist, checking the transmitter. "Code 117." He throws a buoyed net into the water, and we drift downstream until the buoys start dancing: We've got her.

"You can look into (a pallid's) eyes and back into the future — or something," Fuller says as the two men haul in one of North America's largest and most endangered fish. Braaten smirks at this facetious attempt at eloquence, but Fuller's sentiment is one often evoked by pallid researchers. Aaron Delonay, a USGS ecologist who works with the fish, calls them an "irreplaceable treasure from a time older than the Missouri River itself."

Today's Missouri River pallids are descended from fish that lived alongside dinosaurs more than 70 million years ago. They've weathered ice ages, volcanic explosions and a mass extinction event. Through it all, the fossil record indicates that, in form and function, they've hardly changed.

Lately, though, their remarkable evolutionary tenacity has been tested. Since dam-building and channelization began on the Missouri in the early 1900s, roughly 80 percent of the fish's habitat has been modified or destroyed. Scientists estimate that if they stopped stocking the river with hatchery fish tomorrow, the species could vanish from the Upper Missouri — the dam-locked stretches of river in Montana and the Dakotas — by the century's end.

After freeing Code 117 — a four-foot-long behemoth — from a dripping tangle of net, Braaten and Fuller slip her into a tank. With the caution of a beast accustomed to life in the murky dimness, she lifts her spade-shaped snout from the water. She has the sickly hue of a corpse but her tiny eyes are the color of warm honey. Her under-slung mouth is fringed with fleshy whiskers, and bony scutes armor her from tip to tail. She is weird and wonderful, beautiful and bizarre.

Fuller pulls on rubber gloves and assembles his tools: scalpel, forceps, suturing thread. He makes a one-inch incision in 117's lower abdomen and peeks inside, looking for signs of recent reproductive activity. If 117 hadn't spawned, her ovaries would be filled with large, gray-black eggs, which she would eventually reabsorb. But her eggs are tiny and white: She's spawned. He stitches her up; then, as if handling a priceless antique, he and Braaten lower 117 back into the river.

In recent years, Fuller and Braaten have biopsied a handful of wild pallids that, like 117, appear to be spawning successfully. What's troubling is what they haven't found: wild offspring, in either the Upper Missouri or the lower reaches of a major tributary, the Yellowstone River. A hatchery and propagation program has bought the species time. But the ultimate goal — a population that can sustain itself in the wild — remains elusive.

"We are always hopeful," says Braaten. "But I've been working on this stuff for 10, 11 years, and little sturgeon are just not found. Something is happening between reproduction and the rest of their lifespan."

Figuring out what that something is would help answer a more fundamental question for this and many Western rivers: Can struggling fish be rescued without tearing down dams?

FROM THE BEGINNING, the U.S. Army Corps of Engineers' dramatic makeover of the river seemed the obvious culprit for the species' decline. Pallid sturgeon evolved in warm, dynamic rivers that were free to jump their banks and ramble about the floodplain, muddying themselves with the dirt and clay churned up in the roil. Flows swelled every spring with snowmelt, peaked again with early summer rains, then dropped off in early fall. This ebb and flow added organic matter and nutrients to the river and redistributed sediment. For native fish, these changes — and their associated shifts in temperature and turbidity — triggered spawning migrations, and enhanced spawning conditions and nursery habitat.

Today's "Big Muddy" — a nickname the Missouri shares with its cousin, the Mississippi — is not nearly as big or muddy as it once was. At the start of the 20th century, the Corps began wrestling the river into submission, hoping to create jobs, minimize flood risk, and ensure a reliable thoroughfare for the barge

industry. Six dam and reservoir projects went up in the Upper Basin, and the river's southern stretches were straightened and stabilized.

The dam system, which provides water for cities, irrigation, hydropower and recreation, was one of the 20th century's great engineering achievements. But it wreaked ecological havoc, severely altering the river's natural temperature and hydrologic patterns, which play key roles in the movement, growth and reproduction of native fish. It's halted most annual floods, preventing the river from connecting to low-lying lands and reducing key nutrients, forage and habitat for young fish.

Though hard data are lacking (pallids weren't recognized as a separate species from the smaller, darker shovelnose sturgeon until 1905), records suggest pallids may never have been common. Still, according to Braaten's calculations, roughly 1,000 cruised the river between Fort Peck Dam, in eastern Montana, and North Dakota's Garrison Dam when the latter was finished in the early '50s. Fewer than 150 wild fish persist here today.

"If we stopped stocking (hatchery fish) now, pallids won't be any better off."

–George Jordan, pallid sturgeon recovery coordinator, U.S. Fish and Wildlife Service

The U.S. Fish and Wildlife Service listed pallid sturgeon as endangered in 1990 in response to declines throughout its range, which runs from Montana to the Louisiana Gulf — some 3,000 total river miles. It's considered an indicator species for the Missouri; if it's in trouble, other species probably are, too. Indeed, two native birds — the piping plover and least tern — are listed under the Endangered Species Act, due in part to the loss of winter and midstream nesting habitat. And roughly half of the river's 106 native fish species are uncommon, rare or decreasing across all or part of their ranges.

In today's Missouri, the pallid sturgeon's biological quirks aren't doing it any favors, either. Pallids are poky and particular about life and love. They grow slowly, live for decades, don't reach sexual maturity until they are at least 10 years old, and spawn only every few years. And if the spawning set-up isn't perfect — if the river is too cold, for instance — the females re-absorb their eggs and wait for conditions to improve.

In the upper river, the dam-locked run where we found Code 117 has been a top priority for recovery teams because it hosts the largest remaining cadre of "heritage" fish, the biggest (50-70 pound), oldest (40-80 year-old) wild fish that hold the genetic key to their species' long-term survival. Scientists believe the Upper Missouri adults are genetically distinct from their Lower Missouri and Mississippi River counterparts, where hybridization with shovelnose sturgeon is thought to be more common.

The first 10 years of pallid recovery here focused on preserving these genes and stocking the river with hatchery fish. "(Stocking) has certainly helped boost population numbers," says George Jordan, who coordinates recovery for the Fish and Wildlife Service. "(But) if we stopped stocking now, pallids won't be any better off." For pallids to make it, they must spawn and their babies must survive.

Gonadal biopsies help researchers Dave Fuller (blue jacket) and Pat Braaten (camo) determine if a reproductive female has spawned. MARIAN LYMAN KIRST

IN 2000, THE CORPS TAPPED Dave Fuller and Pat Braaten to lead an experimental effort to help that agency comply with the Endangered Species Act and boost the species' prospects in the upper river. Scientists have long suspected that channelization and bank stabilization on the Lower Missouri, and dams and reservoirs on the Upper Missouri, were responsible for the species' decline. But the details — the exact whys and hows — were still uncertain.

Braaten had been working downstream in Missouri and Kansas on another native fish study. He grew up fishing in Minnesota and by high school knew that he wanted to be a fisheries biologist. His mother remembers him cutting open his catches to see what the fish were eating. "Now, I get paid to do that," he chuckles.

Fuller's road to fisheries work was less direct. He started out in engineering, following in his father's footsteps. But the idea of working with fish lingered, and in the early '90s, he moved from New York to Bozeman, Mont., chasing dreams of blue-ribbon trout streams. "I told my folks the move was for school, but it was for fishing," he confesses. After taking a year off to do Westslope cutthroat trout habitat work, he decided to switch careers and eventually ended up in Fort Peck, studying sturgeon, catfish, suckers and chubs.

The two biologists soon discovered they had much in common. "We hit it off really well," Braaten says. Both in their early 40s, they dress alike — T-shirt, ball cap, jeans, boots — share a love for bird-hunting and the outdoors, and even speak in the same cadence, their voices equal parts dirt and drawl. But it's their differences that make them a good team: "I'm more the thinker, the idea man," says Braaten. Fuller is "extremely good at making things happen in the field."

The Corps' plan when the two teamed up at Fort Peck was to help restore key aspects of the river's ecology that had been lost to dams, and see how the fish responded. The Fish and Wildlife Service, which drafts the biological opinion telling the Corps what recovery measures to implement, recognized that the fundamental aspect of all rivers is the seasonality of flow. If sturgeon did well before people altered things, then adjusting the dams' releases to better mimic natural conditions would, in theory, enhance spawning and juvenile development for pallid sturgeon and other native fish species.

They suspected that water temperature might be limiting reproduction and the survival of hatchlings. At Fort Peck, the dam releases water from the reservoir's chilly bottom, making the river much colder than it would be naturally. The Fort Peck Flow Modification Project, or "Flow Mod," would address this with two test releases of warm surface water over the spillway in 2001 and 2002, followed by spills once every three years if reservoir levels allowed.

At the time, this sort of thinking was taking hold on dammed rivers worldwide. In the 1990s, says Brian Richter, a freshwater conservation expert with The Nature Conservancy, scientists learned a lot about how important natural fluctuations, temperatures, and the like, were in maintaining river systems and native species. In the last decade or so, this knowledge has begun to influence management, with numerous experiments under way to "renaturalize" rivers without removing dams. The Grand Canyon has become a laboratory for some of the most high-profile of these experiments in the U.S. *(see sidebar page 15)*. But there are plenty of obstacles: funding, politics, the limitations of existing infrastructure — and on the Missouri, nature itself.

As it turned out, Flow Mod was not so much born as stillborn. Low water levels in the reservoir behind the dam prevented the Corps from conducting test spills in 2001, 2002 and 2003. The region was suffering from severe drought, making it technically impossible to spill since the reservoir was 30 to 50 feet below the spillway.

The delays had a silver lining, though. They allowed Braaten and Fuller to collect baseline data on the pallid population under normal dam operations, so that when the spills finally came, they would have something with which to compare the fish's response.

They also began investigating the mystery of the pallids' missing offspring. By sampling the stomachs of potential predators, they eliminated the possibility that ravenous fish, not dams, were to blame. This brought them to the most popular theory: that the distance newly hatched pallids, or "free embryos," need to drift while they develop into larvae and gain the strength to swim and forage exceeds the amount of free-flowing river between Fort Peck Dam and Lake Sakakawea — the vast reservoir that Garrison Dam created downstream. Scientists thought the drifting embryos might be reaching the reservoir's slack water too early and getting gobbled by lake fish or sinking into the reservoir's oxygen-poor bottom layers and suffocating.

In 2004, Braaten and Fuller released thousands of hatchery-reared embryos into a side channel near Culbertson, Mont. They followed them downstream and re-collected what they could at different time intervals. The results were deflating. "It looked like even if we got pallids to move up the Missouri, there wouldn't be enough drift distance to make a difference," Braaten says.

But the release was the biologists' first crack at things, and because it took place in a side channel rather than the Missouri mainstem — the far more complicated and dynamic part of the river where embryos naturally drift — the results, says Braaten, didn't mean much.

This new information, however, renewed interest in modifying Intake Diversion Dam 70 miles up the Yellowstone to allow fish passage, opening up more than 150 miles of new habitat to native fish. If sturgeon used the passage, the added mileage might give embryos enough time to develop before hitting Lake Sakakawea.

In the meantime, Braaten and Fuller examined drift in the mainstem Missouri. In 2007, they released new findings: Immediately after hatching, pallid embryos drift for up to 14 days. Braaten's models showed that the slowest embryos would travel between 159 and 230 miles before they developed. But there are only about 211 miles of free-flowing river between Fort Peck and Lake Sakakawea. If spawning took place near or in the Milk, a turbid tributary that joins the Missouri 11 miles below Fort Peck, the slowest drifters might settle out of the current before hitting the reservoir. Most, however, would end up smack in the middle of it.

That same spring, Fuller discovered that two females he'd been tracking up and down the lower Yellowstone had spawned — the first documented instances of pallid spawning in the Upper Basin. It was a big step forward, one that allowed researchers to cross spawning off the "reasons-for-recruitment-failure" list.

Later that year, thanks in part to Fuller's spawning discoveries on the Yellowstone, the pair's disheartening drift results on the Missouri, and the region's relentless drought, which continued to preclude spills from Fort Peck, the Corps obtained the legal authority it needed to partner with the Bureau of Reclamation to work on Intake, which the Bureau operates. It helped that the fish Fuller followed that spring had gone all the way to Intake, says recovery chief Jordan. "Folks could now say, 'OK, we stopped a migrating, reproductive female from going up the Yellowstone (past Intake).' " On top of that, there were Braaten's drift models, and an earlier study proving that juvenile pallids stocked above Intake were alive and well, suggesting the river there was suitable habitat. "You had three indepen-

A juvenile pallid sturgeon, ready for release in the Yellowstone River. ROB HOLM / USFWS

Pallids' P.R. problem

For a large, ancient and extremely endangered species, the pallid sturgeon receives remarkably little respect. The fish is nobody's poster child. Unlike trout and salmon, it has no real champions among environmental groups; it occasionally gets passing mention, but little direct advocacy, and few are actively engaged in the recovery effort. Pallids spend their entire lives deep in cloudy rivers, so people rarely glimpse them, let alone connect with them. And though they face many of the same threats that salmon do, they lack that fish's economic or cultural value.

In the Lower Missouri Basin, in particular, efforts to restore the river to improve pallids' prospects are often loudly opposed by the barge industry, which requires deep channels and tends to resist changes in flow management. Though commercial freight is a relatively minor industry on the Missouri today, the Army Corps still concentrates much of its energy on preserving a nine-foot-deep channel for barges. This doesn't square with the reproductive whims of pallids, which are triggered by the river's seasonal changes. But given their lack of economic value, it's a tug-of-war that pallids are likely to lose. Nor do they have fans among anglers, unlike paddlefish, their arguably odder-looking cousins, which are fished for fun and for roe that's become a popular caviar.

People rarely glimpse pallids, let alone connect with them.

"If we said, 'We need to conserve paddlefish,' " says George Jordan, the Fish and Wildlife Service's pallid recovery coordinator, "people would come out of the woodwork (to support it)."

The agencies and biologists who work on pallid recovery have thus become the species' de facto champions. In recent years, the Fish and Wildlife Service and state wildlife departments have stepped up public outreach, sending biologists into schools to teach the fish's natural history, and offering hatchery pallids to Cabela's in South Dakota, the St. Louis Zoo, and California's Steinhart Aquarium. But the adults need flowing, turbid water to thrive and aren't easy to keep in aquariums. "And people like big fish," says Jordan. "When we send them hatchery fish that are eight to 10 inches long, they are less impressed." Pallids take years to reach their formidable lengths.

Still, river managers and researchers hope their efforts will foster public support for the fish. With more species in trouble than cash-strapped public agencies can handle and the Corps' facing big budget cuts to its Missouri River Recovery Program, the effort to save pallid sturgeon may only continue if the public starts caring about their fate.

"I think (pallids') eyes are too small," jokes USGS ecologist Aaron Delonay. "Bigger eyes would Disneyify it a little." Delonay himself finds the fish "awe-inspiring" and "elegant." He likens their strong, shark-like build and the way they cruise along the river bottom — something researchers can see thanks to advanced sonar technologies — to a Formula One racecar.

Even if it's "not a beautiful fish to some," says Jordan, "it's been in the river a long, long time" — before the dams, before humans were even around to build them. Pallids are a legacy of a river wild. "If (they're) not worth fighting for," he asks, "then what is?"

MARIAN LYMAN KIRST

dent studies that showed there is hope," says Jordan, that opening up habitat on the Yellowstone would help pallids become self-sustaining between Fort Peck and Lake Sakakawea.

Besides, both agencies were worried that long-term flow modifications at Fort Peck would require a dam retrofit that could cost as much as $500 million — 10 times the estimated cost of Intake improvements. Engineers were also concerned that Fort Peck's spillway wasn't strong enough to withstand large spills.

Despite Intake's reputation as the pallid's best — and cheapest — shot at recovery in the Upper Missouri, the project is controversial. Any money spent on Fort Peck or Intake is money that can't be spent on recovery and restoration elsewhere on the river — building aquatic habitat in the Lower Missouri, for example. This has angered some downstream biologists, who are not convinced that enough wild pallids currently swim all the way to Intake, or spawn in the upper river, for the project to matter much. (Only two or three fish typically make it to Intake each year.) Others believe that even with passage, embryos still won't have enough room to develop before hitting Lake Sakakawea.

Since the Upper Basin dams likely aren't going anywhere, some argue the Corps should focus money downstream. The Lower Missouri's fish have problems too, including water contaminants that have caused deformities to their reproductive organs, and hybridization. And young wild fish haven't been found there either: thousands of embryos have been genetically tested, but only one was a pallid, and it was collected in the Mississippi.

But unlike the Upper Basin populations, Lower Basin fish enjoy access to thousands of miles of free-flowing river, which means no devilishly complicated drift issues. Plus, the Upper Basin's wild heritage population will almost certainly die out within the decade. This won't end the species as a whole: Scientists have preserved roughly 90 percent of the Upper Basin pallids' genetic diversity in hatchery fish, some of which are finally reaching sexual maturity. But unless the drift issue is figured out, their offspring will meet the same fate as their wild brethren: death by reservoir.

Braaten understands the interest in Intake. "The Yellowstone is one of North America's premier rivers," he says. "It's relatively free-flowing with a natural hydrograph and thermal regime that is hard to find anywhere else in world. When you have a highly endangered species living there that has passage problems at one of the dams, common sense says improve passage."

On the other hand, Braaten says, "You have the Missouri, a highly impacted system where we know pallids were historically. So you have two situations for enhancing populations." Why not try to do them both? "Intake will be an experiment just as Flow Mod was," he says. And Flow Mod was foiled by drought, leaving unanswered the question of how pallids would react to flow changes and increased temperatures on the Missouri.

Nevertheless, in 2009, the Corps officially terminated Flow Mod. Braaten and Fuller would still share an office and a mission — pallid sturgeon recovery in the Upper Basin — but their research territory shifted. Braaten was assigned to the Yellowstone; Fuller, the Missouri below Fort Peck.

NOT LONG AFTER THAT, in 2011, the Missouri River Basin experienced a 100-year flood event. Throughout the Upper Basin, record snowpack and spring rains triggered massive runoff. To protect Fort Peck's structural integrity, the Corps had to release surface water over the spillway. The river raged for weeks.

For Fuller and Braaten, it was an ironic meteorological twist of fate. "We felt it imperative that someone be out there to document the pallids' response to the record flows," says Braaten. The crews mobilized: Fuller and his guys on the Missouri, Braaten and his team on the Yellowstone. The huge flows were a stroke of good luck. Getting crews out there, says Braaten, required foresight.

And it paid off. Pallid sturgeon migrated nearly 200 miles up the Missouri toward Fort Peck and the Milk River. "We had never seen that before," says Fuller. Spring after spring, pallids would leave their wintering grounds below the confluence and swim into the lower Yellowstone. But last year, 16 wild fish went "as high up (the Missouri) as we could have expected them to come."

What's more, in early July, Fuller and his crews located what looked like a spawning aggregation, when fish gather for a big, piscine orgy: the females release their eggs on the riverbed while the males swim nearby, broadcasting sperm. Six days later — about as long as it takes eggs to hatch and begin their drift — Fuller and company returned to sample for embryos. They positioned themselves downstream from where the spawning aggregation had occurred, and tossed in their net.

"I did not have my hopes up at all," says Fuller. "We were sampling such a small fraction of the (river)." Yet they did net some embryos, which they sent off for genetic testing to determine if they belonged to pallid sturgeon, shovelnose or paddlefish.

Finding a wild embryo has long been one of the effort's "Holy Grails" — a sought-after sign that pallid survival in the post-dam era is even possible. Last December, Fuller received some incredible news: One of the embryos was, in fact, a pallid sturgeon — "the first genetically confirmed wild-produced pallid (embryo) collected anywhere in the Missouri River Basin," he says. "It was a giant haystack with probably just a few needles. We got lucky, there is no doubt about it." He called his boss. "I was worried he wouldn't be that excited because he's more of a walleye guy," he recalls. But his boss went out and bought two bottles of champagne. The men spent the afternoon celebrating.

Since Fuller went public with his discovery, the tiny embryo has been the talk of the recovery community. "The Service built its original (plan) on the hypothesis that if you can restore historic flow and temperature conditions, pallids will respond," Braaten says. "That appears to be exactly what happened." What's more, Fuller's finds — the spawning aggregation and the embryo — show that the dammed Missouri below Fort Peck doesn't have to be "a terrible, inhospitable, crappy place" for pallid sturgeon, Braaten says.

For others, though, last year churned up more questions than answers. "The fact that they captured one pallid (embryo) is huge," says Steve Fischer, the senior program manager for the Corps' Missouri River Recovery Program. "But how many were actually spawned that year? Can we find them again, or were conditions just right last year? And, if so, what might those conditions have been?"

"It tells us that wild fish will spawn and eggs can hatch in the wild," agrees Jordan. But, he says, whether the embryos survived their drift between dams is still unknown. If in the next few seasons crews start finding wild, young fish, then, Jordan says, we will know that they've recruited on their own, and "the champagne can really flow."

Given the massive property damage caused by last year's flooding, in Braaten's mind, the biggest question now is whether pallids will respond as well to much less extreme flows — the kind it might be possible to release from Fort Peck on a more regular basis. "What would it take?" he wonders. The experimental spills prescribed by Flow Mod were less than half the volume of last year's emergency spillway releases. "Could we get away with something less?"

If the answer is yes, it may still be possible to help the fish below Fort Peck by modifying dam releases to more closely mimic natural conditions. If the answer is no, the pallids' future in the upper river looks far less bright, and passage at Intake might be their only shot. After all, the Corps would be hard-pressed to elicit public support for pallids if, to save the species, it essentially had to flood the Missouri Basin every spring. On the other hand, the Intake project has faced significant design setbacks, delays and cost increases, and is still controversial.

"There is a lot of jabber going on about putting emphasis back on Fort Peck and this section of the Missouri," says Fuller. The Service, he says, now has solid evidence to pressure the Corps to follow through with flow and temperature changes below Fort Peck. This year, the Corps held meetings to discuss the feasibility of fitting Fort Peck with a temperature-control device that would funnel warm water from the surface of the reservoir to the dam's lower intakes instead of using the spillway. This would increase temperatures below the dam — and, ideally, compel pallids to migrate up the Missouri to spawn — without increasing flood risk or interrupting the dam's hydroelectric operations.

In the end, says Fischer, the Corps has to decide if it's cheaper to invest in Intake or pursue changes at Fort Peck. "We have to take into account the social, cultural and economic impacts," of each project, Fischer says. "We have to factor all of those in to our management actions."

LAST JULY, just a week before Fuller collected his embryo, Braaten made an important — though sobering — discovery of his own.

Braaten and a USGS technician had spent the day tracking telemetered pallids on the Yellowstone. As they were driving back to Fort Peck, Braaten received a call from a hydrologist who'd also been on the river that day. He asked if Braaten saw the dead pallid near the bank. "Are you sure it was a pallid?" asked Braaten. "Oh yeah," the hydrologist replied. "And it reeked."

Braaten drove back and walked the bank until he found the corpse, afloat amid a tangle of vegetation. It was easily four feet long, says Braaten, "one of our heritage fish." The smell "was horrible and mostly undescribable," he says. "I've smelled many a dead fish in my days, but the pallid odor was different — at least to me."

He scanned its tag: It was a female that was captured in 2007, taken to the Miles City Fish Hatchery and spawned. Since then, 10,000 of her progeny had been stocked in the Upper Basin. It was comforting to know that she had some descendants out there, Braaten thought.

The fish was the first dead pallid he'd ever found. The fact that he was there to identify her was just dumb luck, he says. What are the odds with so few fish out there? "(Maybe) it's another commonality that Dave and I share — working with hard odds and coming up with something."

Braaten believes the pallid succumbed to old age; a poignant reminder that, despite Fuller's heartening discoveries, the upper river's wild pallids are on their way out. When Braaten got home that night, he sent an email to colleagues describing the fish and its fate. The first line read, "Sad day on the river." □

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A humpback chub along the banks of the Little Colorado River, Arizona. COURTESY BRUCE TAUBERT

Grand Canyon floods and fish

The last time the Colorado River plunged unhindered through the Grand Canyon, swollen by snowmelt to 126,000 cubic-feet per second, was in 1957. Glen Canyon Dam rose soon after, delivering cheap hydropower and reliable water to cities, farms and industry.

For native fish, the transformation was debilitating. Most of the river's sediment — which built sandbars that shelter backwater habitat favored by young fish — settled in Lake Powell, the reservoir behind the dam. And the water downstream became much colder, since dam discharge comes from deep in the reservoir. This limited the ability of native fish to spawn in the mainstem Colorado, and stifled young fishes' growth there. "Growth is a proxy for survival," says Ted Kennedy, a USGS biologist with the Grand Canyon Monitoring and Research Center. "They have to get to a size where they're large enough to not be eaten by other fish." Four species have disappeared from the Grand Canyon, and another, the humpback chub, is endangered.

The scarcity of sandbars, which make primo camping spots, also disappointed river runners and hikers. So in the late 1990s, a plan was hatched to allow controlled floods to sweep the canyon. Scientists theorized that high water releases from the dam would mobilize tributary-deposited sediment and build up shrunken sandbars. "Flooding is a natural part of river dynamics," says Kennedy. "There was a lot of hope that it would be beneficial to the system as a whole," much as it was hoped that spills over Fort Peck would boost the Missouri River ecosystem.

The Grand Canyon releases — made from low in the reservoir — weren't thwarted as the Fort Peck spills were. Since 1996, three experimental floods have been unleashed, and scientists have gained important insight into their effect. Sixty-hour floods of around 40,000 cubic-feet per second in 2004 and 2008, timed to follow natural flooding in tributaries, successfully enlarged sandbars, though they eventually diminished. The floods also created more backwater habitat. But fish didn't benefit as hoped. The water didn't warm to optimal temperatures, says Kennedy, and the habitat quickly vanished once normal operations resumed. Humpback chub still largely ignored the main stem for spawning, crowding instead into the Little Colorado River, a warm, silty tributary.

The takeaway, says Kennedy: Floods alone aren't likely to boost native fish, since they can't remedy other alterations to the natural system — especially water temperature.

It's even possible that the 2008 flood had a slight negative impact on chub, by boosting mainstem invertebrates that rainbow trout love. The non-native sport fish thrives in cold water, competes with chub for forage, and preys on them. Newly hatched trout feasted on the invertebrate bounty, according to a new study of the post-flood food web, and their numbers skyrocketed: Near the Little Colorado's mouth, trout catch rates grew by 800 percent. It's not yet clear how that's impacted chub.

Nevertheless, Interior Secretary Ken Salazar announced this spring that the controlled floods will begin taking place whenever conditions allow. If they occur annually or more often, their impacts could change. Regular experimental floods on a Swiss river took three years to shift the composition of organisms at the bottom of the food web, which influences which other species thrive. Native trout redds, for example, increased sixfold.

"That probably wouldn't have happened if they hadn't (flooded that river) consistently," says Wyatt Cross, a Montana State University ecologist who researched the 2008 rainbow trout bump. "We don't know how multiple floods will affect the Grand Canyon. But we want to." CALLY CARSWELL