American Currents

Publication of the North American Native Fishes Association

Volume 48 — Number 2 — Spring (April) 2023

(See Contents page.)

IN THIS ISSUE:

The North American Native Fishes Association

Est. 1972 — John Bondhus, founder

Mission: The North American Native Fishes Association (NANFA) is dedicated to the appreciation, study and conservation of the continent's native fishes. NANFA is a 501(c)(3) not-for-profit, tax-exempt corporation chartered in the State of Maryland. The purposes of the organization are: • to increase and disseminate knowledge about native North American fishes; • to promote practical programs for their conservation and the protection/restoration of their natural habitats; • to advance the educational, scientific and conservation benefits of captive maintenance and husbandry; • to encourage the legal, environmentally responsible collection of native fishes for private aquaria as a valid use of a natural resource; and • to provide a forum for fellowship and camaraderie among its members.

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Volume 48 — Number 2 — Spring (April) 2023

Konrad Schmidt and Fritz Rohde, *Co-Editors*

Bruce Lilyea, Olaf Nelson, John Olson, and Tom Watson, *Associate Editors*

Olaf Nelson, *Design and Layout Editor*

Christopher Scharpf, *Editor Emeritus*

CONTENTS

FRONT COVER: Spawning Summer Suckers *Catostomus utawana* photographed in a surprisingly small tributary of Squaw Lake in the Adirondack Mountains of New York. Some eggs can be seen floating around in the photo. (Photo by Eric C. Maxwell)

BACK COVER: Texas Tetras *Astyanax argentatus* at Balmorhea State Park, Reeves County, Texas. Eric Maxwell recommends the area for any native fish enthusiast due to its crystal clear water and great numbers of several native fishes that are used to swimming around people. (Photo by Eric C. Maxwell)

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NANFA News

MEMBERS, EVENTS, ACCOMPLISHMENTS, AND ADMINISTRIVIA

WE HAVE LOST A STALWART ASSOCIATE EDITOR

In late March, we received the sad news that Bruce Bauer had passed away unexpectedly. He was a meticulous editor and an integral part of the team effort making *American Currents* the excellent publication it is today. He will be sorely missed, both for his service to NANFA and for being a genuinely wonderful person to know.

We will honor his life and work more fully in the next issue. If you knew or worked with Bruce and have photos or stories to share, please contact the editors.

If you spot a mistake in this issue, know that it wouldn't have made it to print if Bruce had edited the article.

NANFA BOARD OF DIRECTORS

With no nominations from the membership except for the three current board members, who all agreed to continue serving, the election was suspended. Board members for 2023 are Josh Blaylock (Kentucky), Fritz Rohde (North Carolina), Scott Schlueter (New York), Tom Watson (Washington), Derek Wheaton (Tennessee), Michael Wolfe (Georgia), and Brian Zimmerman (Ohio).

NANFA'S 2023 CONVENTION A ROUSING SUCCESS

Over 105 fish nerds from 24 states gathered on the banks of the Saluda River in Columbia, South Carolina, for the long-delayed convention. Things started off with a bang on Thursday as the early arrivals got to see big river fishes shocked up from the Congaree River by South Carolina Department of Natural Resources biologists and got to view the fishway at the Columbia Diversion Dam. Friday was the educational day with 10 informative presentations ranging from tiny Blackbanded Sunfish to giant Atlantic Sturgeon, capped by Chris Scharpf's entertaining talk about his ETYFish Project. The evening ended with a South Carolina BBQ and fried chicken dinner and a highly successful auction. Although cool on Saturday and Sunday, the weather cooperated and field trip participants got to see the beautiful fishes of South Carolina. Thank you to our hosts for a great convention! More details in the next *AC*.

If you were there and have photos, please share them with us by emailing them to nanfa2023photos@gmail.com. Please include information such as who or what is pictured, where the photo was taken, the photographer's name, and anything else that seems relevant. Thanks to those who have already sent photos.

LET'S REVIVE THE RIFFLES!

Riffles, a collection of brief items such as summaries of research results published in journals, magazine articles on native fishes, new book releases, interesting and/or crazy fish news, and much more, has, for many years, been a very popular section in *American Currents*. Topics varied greatly and the following examples barely scratch the surface: descriptions of new species, first records of species in a state or province, species reestablished to historical habitats, stream restoration, fish-named sports teams, fish recipes, and aquarium care and maintenance tips.

The current team of editors have learned to spread the work involved in putting *AC* together among several people, and believe this model should be tried with the Riffles section, which has been absent for a few issues due to a lack of space caused by the sheer volume of excellent articles we have had. Past Riffles editors have done admirable jobs finding and condensing interesting items, but also have always burned out. It takes time for one person to read all the material, and is always challenging to accurately summarize sometimes complicated research into one or two paragraphs.

The editors are recommending the formation of a Riffles committee to search out interesting material on native (and sometimes non-native) fishes and write and edit the synopses so we can have at least a few pages per issue. Anyone interested in a Riffles renaissance, please contact Fritz Rohde or Konrad Schmidt.

THE X-FILES: MYSTERIES OF MINNESOTA FISHES

On April 4, 2023, Konrad Schmidt (St. Paul) gave his first Zoom presentation to the Bemidji State University chapter of the American Fisheries Society. He is always a fan for what technology can do but knows it is not infallible. After a few agonizing moments with technical difficulties, the presentation went smoothly and Konrad told students about some of the unsolved mysteries of fish distribution in Minnesota and the unique forms some species' populations exhibit. Matt Kvam (Chapter President) texted afterward that the meeting was well attended and students expressed interest in many of the topics covered. Thanks to Jenny Kruckenberg (Inver Grove Heights) for use of her computer and expertise with Zoom. The next day Jay Hatch (Minneapolis) emailed Konrad to tell him how much his son John-Carlos enjoyed the presentation. He may be a Wildlife Major, but some of his dad's fishy background must have rubbed off on him!

NANFA BOARD OF DIRECTORS MEETING

The NANFA BOD met, via zoom, on April 16, 2023. All directors were present as well as NANFA grant committee members Bruce Lilyea and Chris Scharpf.

1. **NANFA Grants:** The discussion centered on how to increase the number of applications that we receive each year, especially the Corcoran Education Grant, which has seen a significant decrease in applications. All discussed ways to reach out to applicants. A variety of organizations were discussed as a way of connecting to a larger pool of potential conservation-minded applicants, including environmental education associations, Master Naturalist organizations, Water Keeper / River Keepers, etc. Bruce Lilyea, Chairman of the Research Grant Committee, indicated that since graduate students are always seeking funding, the Research Grant shouldn't have an issue with getting sufficient applications. The John Bondhus Grant has been inactive but will be soliciting proposals soon. Everyone was reminded that the grants are reviewed by a committee, which then makes recommendations to the BOD, who then makes the final approval. Tom Watson, Treasurer, made the point that NANFA is financially stable and that we have a responsibility to give out these grants. Specific discussion ensued about increasing the grant amount to $2,000 every year for each of the three grants. Several other options were discussed around membership prices and requirements for grant applications, but any decisions about this were tabled until a further meeting. **Motion was made to increase the grant amount to a total of $2,000 annually for each of the three grants. The specific amount and numbers of grants to be determined by the committee up to the maximum amount. The motion was seconded and passed unanimously.**

2. **2024 Convention:** After two very successful conventions in Minnesota and South Carolina, there is a loft of interest and questions from NANFA members where the 2024 convention will be held. No member or group has approached the BOD about holding next year's convention. The Board discussed several possible ideas, such as West Virginia (might be challenging with few members and regulations), Alabama, western Kentucky (Josh Blaylock is interested in hosting but prefers to defer consideration to 2025), Florida panhandle (on Fritz's wish list, and we do have members in the area), and Ohio (Brian Zimmerman offered this as a fall back option). Keep in mind that the 2023 Convention was earlier than normal in March, and there is time to work on a location. But the Board hopes to have something definite lined up by fall.

3. **NANFA Website:** Josh Blaylock has been looking at a number of other websites that he would like to emulate, specifically their use of images and a more modern look. He has contacted a number of different companies that could do the work for us. Derek Wheaton indicated that his co-worker used Squarespace to build the CFI website from scratch. We need to determine what we want our website to do and decide what to keep and what to drop to keep it clean and direct. We talked about investing money to improve our organization through the website and that we could do so. Everyone was encouraged to share ideas and websites they like with Josh. He is going to further investigate and bring back a proposal to the BOD.

4. **Canadian Dues:** Tom Watson informed the BOD that Canadian mail prices have gone up and requested that we increase Canada dues to $40. Even at this amount, it does not fully cover the expense of mailing four *American Currents* to each member annually. The BOD discussed the need to update the website and potentially other brochures with the new price. **Motion was made to increase the Canadian dues to $40 and a second received. The motion passed unanimously.** Tom will contact our Canadian members regarding the increase and reason for it.

MINNESOTA DARTER HUNTS

If you live in or near Minnesota or need a reason to visit, may we suggest a Darter Hunt? If you would like to join in, contact Jenny Kruckenberg. She hosts these hunts annually during weekends in May and into June, and sometimes in September. She provides the collecting gear, critter tanks, and bags for transporting fish home. Kids are welcome! Email Jenny to be put on the contact list: jennyk@usfamily.net.

NANFA News, continued

A PRELIMINARY SURVEY OF FISHES NEAR SAN ANGELO, TEXAS

James E. Burgess, Glasgow, Kentucky

Texas has an interesting variety of waterways, lakes, and reservoirs. I have called Texas my home since I was a boy, when my family moved there in 1968, and I wanted to come home to survey the fishes in the area where I grew up. San Angelo is about 90 miles southwest of Abilene. The Concho River—so named for the numerous freshwater mussels that were once found there—flows through the area, along with a variety of other waterways. As I prepared for the trip from Kentucky to Texas, I gathered all of my regular fishing gear along with a cast net, a dip net with an elongated pole, and minnow traps. Since I had not kept up with Texas fishing regulations, I reviewed them and obtained the appropriate license, since I learned that any type of collecting requires a license.

Three phases were planned. The first was to survey the various named creeks between San Angelo and Abilene via two different routes (Figure 1). The second was to survey the Red Arroyo waterway that flows through the southwest edge of San Angelo. The third was to survey the Concho River in San Angelo between the Irving Street Bridge and the 19th Street Bridge. Photos were taken of each site and the species caught. I took water samples and did chemical analyses at my home lab. Data are available upon request. The conditions during the April 2022 sampling period in San Angelo were very dry and hot, with temperatures in the upper 90s F. The West Texas wind was very prevalent and constant.

Phase I—The Creeks: The creek survey started by travelling north on Hwy 277 toward Abilene. The return trip went south from Abilene on Highway 83 through Ballenger and then on Highway 67 back to San Angelo. My good friend Kippy and I came across 17 named creeks with road signs. Twelve of the 17 were dry or fenced off and could not be surveyed, leaving only five that had water and access. I collected only three species of fishes in only two of the creeks: Mule and Valley creeks; the others had only crayfishes or small organisms. Mule Creek contained a single puddle, and I found only Western Mosquitofish *Gambusia affinis* (Figure 2). Valley Creek had running water, and I caught Green Sunfish *Lepomis cyanellus* and juvenile bass *Micropterus* sp. These low numbers are most likely due to high levels of ammonia (0.5–4.0 ppm) that were measured in the creek, some at potentially lethal levels (> 8 ppm).

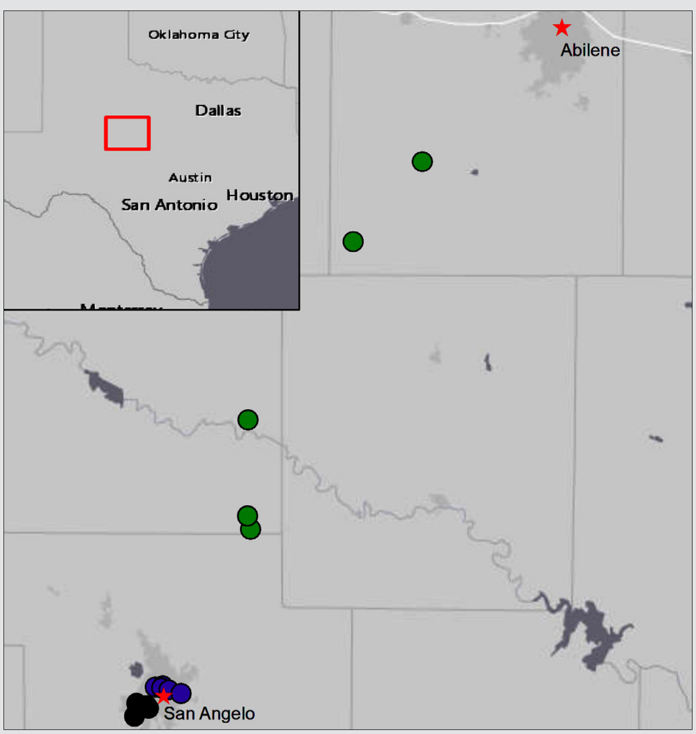

Figure 1. Collection locations for creeks (green), Red Arroyo (black), and Concho River (purple) between Abilene and San Angelo, Texas.

Phase II—Red Arroyo: Red Arroyo is a three-mile-long gully that runs through the southwest portion of San Angelo and joins the Concho River. It is dammed to form a reservoir off of Sunset Drive. When it rains, Red Arroyo becomes a very swift and dangerous torrent. At the time of the survey, the water level was down, and some sections had little or no water. The sampling was conducted at five road crossings. I collected four species at four of the crossings: Western Mosquitofish, Green Sunfish, Bluegill *L. macrochirus*, and Redear Sunfish *L. microlophus*.

Phase III—Concho River: Six sites along the Concho River were selected. The river in San Angelo goes from a very shallow, silty, odorous stream to a deep, wide waterway. While a number of fishes have been documented from the Concho River, I was able to find Gizzard Shad *Dorosoma cepedianum* (Figure 3), Channel Catfish *Ictalurus punctatus*, bullheads *Ameiurus* spp., black basses *Micropterus* spp., and sunfishes *Lepomis* spp.

Conclusions: The majority of the creeks within the survey area were dry, and the ones that had water were mostly isolated puddles. By using a combination of a dip net and cast net, some small specimens were captured and identified. None were retained. This preliminary survey was done to lay the foundation for a more in-depth analysis to be accomplished at a later date. Stay tuned.

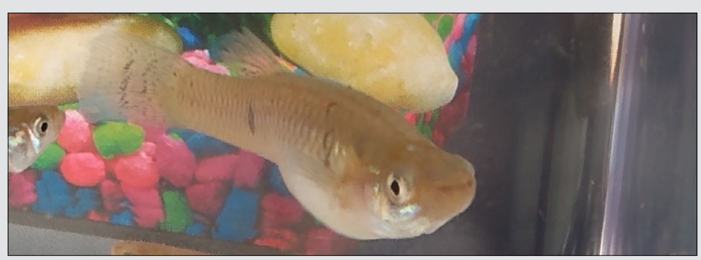

Figure 2. (top) Western Mosquitofish.
Figure 3. (bottom) Gizzard Shad.

IN SEARCH OF NEW MEXICO'S NATIVE TROUT

John Lyons

University of Wisconsin Zoological Museum, Madison

When you mention that you're taking a trip to New Mexico, fish are usually not the first things that come to people's minds. Rather, they tend to talk of the desert and mountain scenery, indigenous Pueblo cultures, or spicy Hatch Chile cuisine. But for native fish enthusiasts like us, new fishes are always in our thoughts whenever we visit a new place. And so, it was for me as I planned a trip to Albuquerque in 2019.

I'm interested in all fishes, but I have a soft spot for native trout in their native habitats. A quick review of the scientific literature revealed that two trout species were originally found in New Mexico, the Gila Trout *Oncorhynchus gilae*, found primarily in the Gila Mountains of southwestern New Mexico and adjacent parts of Arizona, and the Rio Grande Cutthroat Trout *O. clarkii virginalis*, a subspecies of Cutthroat restricted mainly to the Sangre de Cristo Mountains of northern New Mexico and southern Colorado. Both species had once been much more widespread but were now greatly reduced in distribution and limited to remote, small, high-mountain streams. The status of both species is precarious, and both are threatened by lack of water from drought, forest fires, competition with introduced Brown Trout *Salmo trutta*, and hybridization with introduced Rainbow Trout *O. mykiss*.

I had only a couple of days to fish, making it impossible to go after both species, so I decided to pursue the Gila Trout. The most promising spots required long and challenging hikes, a dealbreaker given my limited time and gimpy knees. But then I found an article about a promising site that could be driven to with a four-wheel-drive vehicle: Willow Creek, deep within the Gila National Forest. Historically, this had been a native Gila Trout stream, but over time Brown Trout had colonized and eventually eliminated the Gila Trout. In 2012 the huge Whitewater-Baldy Forest Fire swept through the area, devasting many streams and eliminating all Brown Trout from Willow Creek. Seizing the opportunity, the New Mexico Game and Fish Department, the US Forest Service, and a variety of other state, federal, and non-governmental partners built a fish barrier to prevent Brown Trout from recolonizing from downstream and then stocked Willow Creek with Gila Trout. The Gila Trout thrived and began reproducing naturally.

The article talked about how easy it was to catch Gila Trout from Willow Creek on artificial flies and that the hardest part was getting there. The author said he lost count of how many he hooked. He hooked me too, and I made my plans to fish Willow Creek, reserving a four-wheel drive truck at the Albuquerque Airport and a motel room in Reserve, the nearest town.

Reserve was about a four-hour drive from Albuquerque, mainly on secondary roads, and had just one main street with a gas station, a couple of stores, a cafe, and a few houses. The motel didn't even have a clerk, and it was unclear how to check-in. My cell phone had no service, but I eventually found a land line and called the owners and got instructions as to where to find my key. Only one other group was staying there, and they were scouting for elk for the upcoming hunting season. They seemed a bit dubious when I said I was there to fish.

It was too late in the day to head up into the mountains, so I decided to explore the local area. The San Francisco River flows nearby but was not very encouraging (Figure 1). It was October and the water was very low and almost stagnant. The channel was shallow and full of sand and silt, and no fish were to be seen. At the few bridge crossings, well-maintained barbed wire fences and prominent "no trespassing" signs discouraged exploration. I drove along the river for over 30 miles before I finally found an old road right of way that allowed access.

The river there didn't look like much, and I had minimal expectations. It wasn't easy scrambling down the bank through the

Figure 1. San Francisco River near Reserve, New Mexico.

Photos by the author.

John Lyons is the Curator of Fishes at the University of Wisconsin Zoological Museum. He is a former Wisconsin Department of Natural Resources Fisheries Research Scientist who has been working on Wisconsin fishes since 1979. He received his PhD and MS in Zoology from the University of Wisconsin–Madison and his BS in Biology from Union College, Schenectady, NY.

Figure 2. Longfin Dace from the San Francisco River.

Figure 3. The Gila National Forest on the way to Willow Creek.

Figure 4. A forest recently burned in the Gila National Forest.

brush, and the streambanks were deep, sticky, foul-smelling mud. But in a small pool I thought I saw a fish dart away. I rigged up my microfishing rig and cast a minute piece of worm on a tiny hook. To my surprise, I immediately had a bite, and after a few frustrating misses, managed to land a three-inch Longfin Dace *Agosia chryogaster*, a native Sonoran Desert species (Figure 2). I was delighted. I caught five more then dragged my small-mesh landing net through the pool, finding native Speckled Dace *Rhinichthys osculus* and young-of-year Sonora Sucker *Catostomus insignis* and non-native Fathead Minnow *Pimephales promelas*. This ugly looking stream had proven to be a gem!

Figure 5. Willow Creek on a cold October morning.

I was too excited to sleep well that night, and I woke very early the next morning. Too antsy to wait for the café to open for breakfast, I left before dawn. It was freezing cold, about 20° F, and I was wearing every stitch of clothing I had brought and was still chilly. The road was easy to follow, not in too bad of shape except for a couple of spots. The drive was quite scenic (Figures 3, 4), and two hours later I was at Willow Creek. The sun was above the horizon, but it was still bitterly cold, and I shivered continuously as I rigged up. The creek was crystal clear, and although I saw no evidence of fish anywhere, I started fishing with great optimism (Figure 5).

After an hour, my optimism had evaporated. I had covered a couple of hundred yards of good habitat and hadn't had any response to my flies nor seen any fish. And it was still cold. I finally decided to stand in a sunny opening along the creek to warm up (Figure 6). As the sun climbed overhead the temperature rose into the 40s and I felt a little better. I started to see tiny fish darting around in the creek in front of me. I re-rigged my fly rod for microfishing. The fish were so small that it took a while to get a good hookset, but eventually I landed a two-inch Speckled Dace (Figure 7) on a piece of worm. I wasn't sure how they had gotten there, and I wondered if these fish had somehow survived the forest fire.

They weren't trout, but my fishing motto has always been "action is action," so I concentrated on catching more Speckled Dace. It was challenging but fun. About 15 minutes later, as I was drifting my tiny hook towards some chubs, an eight-inch trout darted out from under the bank and grabbed my bait. I was completely unprepared, the hook was too small to hold the trout well, and it escaped after a couple of seconds.

I was stunned but then energized. I immediately switched to a larger hook, a larger piece of worm, and a stronger line. I worked the bank edges carefully and soon was rewarded with another

Figure 6. A sunny patch along Willow Creek.

Figure 7. Speckled Dace from Willow Creek.

Figure 8. My first Gila Trout from Willow Creek.

Figure 9. Another Gila Trout from Willow Creek.

Figure 10. The barrier dam on Willow Creek that prevents non-native trout from recolonizing upstream.

strike. But I missed it. A few minutes later I had another strike, but I missed that one too. This happened five more times over the next hour. I couldn't believe it. I felt snakebit and feared that I would have nothing to show from my trip but brief glimpses and lost fish. Finally, I drifted my bait into a nice slot between two boulders and a trout took it. It was hooked solidly, and I winched it to shore as fast as I could and threw myself on it to prevent it from escaping. Finally, success!

The Gila Trout proved to be a handsome fish (Figure 8). It reminded me of a subdued Rainbow Trout, not a surprise as the two species are closely related. I carefully released the fish and continued fishing. Now that the hex was off I stopped missing strikes. I picked up four more trout in the next 100 yards (Figure 9) and then I reached the barrier dam (Figure 10). There was a plunge pool below, and I switched back to a fly and caught one last Gila Trout on a weighted nymph. After starting out so cold, the day had now gotten hot, both temperature and fish-wise. But I had a long drive ahead, so I packed it in and headed back to Albuquerque, feeling pretty good about my experience and life in general.

I had hoped to get back to New Mexico in 2020 to look for Rio Grande Cutthroat Trout, but the pandemic intervened. Finally, in fall 2022 I felt comfortable taking long-distance trips again, and my wife and I drove out to see our oldest daughter, who lives near Denver. We had a great time there and then headed south to northern

Figure 11. Rio Hondo near Taos Ski Resort.

Figure 13. Costilla Creek just below the barrier dam.

Figure 12. Brown Trout from Rio Hondo.

New Mexico for a few days. Finding Rio Grande Cutthroat was a priority, but not the only one, so once again my fishing time was limited, and a long hike into the back country was not in the cards. However, unlike for the Gila Trout, I could find no online information that directed me to an easily accessible stream that had Cutthroats. Finally, I called the Fly Shop in Taos where we were to stay for a couple of nights. The fishing guide I talked to was very helpful but a bit unsure and it took a while before he came up with a recommendation: the Rio Hondo, which originates on the slopes of the Taos Ski Resort about 25 miles north of town.

The first morning in Taos I was up before dawn and on my way to the Rio Hondo while my wife slept in. The stream flowed along the road and looked great (Figure 11), but I resisted the urge to stop and, as advised, drove all the way up to the resort before I started fishing. The first cast I made, a trout rose to my dry fly but turned away at the last second. As one does in these situations, I tied on a different fly and, after a couple of casts, the trout came back and took it. Now this was what I had hoped for! After a brief fight, I excitedly brought the fish to shore and netted … a Brown Trout (Figure 12). My heart sank. From what I'd read, if Browns were present, then it was likely Cutthroats were scarce at best. I dutifully fished for three hours over several hundred yards of stream but only caught a few more Browns. The elevation was 9,000 feet and walking the stream was tough going, steep and full of boulders and downed trees. By the end I was gassed.

When I got back to Taos, I went to the Fly Shop for more advice. I talked to a different guide who was equally helpful but seemed more knowledgeable. He confirmed my suspicion that the Rio Hondo had few Cutthroats and recommended instead Costilla Creek, two hours away. I had read about this stream, which had been "rehabilitated" for Rio Grande Cutthroat Trout restoration a few years before. Rehabilitation consisted of poisoning the entire upper part of the creek and all its tributaries to kill all the fish present, mostly Rainbow Trout and Rainbow Trout x Cutthroat Trout "Cutbow" hybrids. A barrier dam was constructed at the lower end of the rehabilitation area to keep invaders out, and the creek was then restocked with pure Rio Grande Cutthroat Trout. Apparently, the restoration had been a success, but the rehabilitation area was still closed to fishing to allow the new trout population to become firmly established. But the guide told me that in the fly-fishing-only water right below the new barrier there were

Figure 14. Costilla Creek just below the barrier dam.

Figure 15. The barrier dam on Costilla Creek that prevents non-native trout from recolonizing upstream.

Figure 16. Rio Grande Cutthroat Trout, drawn by Joe Tomelleri and used with permission.

good numbers of "almost pure" Cutthroats and that they were my best chance without a long difficult hike.

I was pretty worn out from the Rio Hondo, but I resolved to go to Costilla Creek early the following morning before we left for Santa Fe. My wife was incredulous, given how tired I was, that I wanted to fish some more, but she's become used to my eccentricities and obsessions concerning fish and just shook her head. The next morning I was up by 4 a.m., bleary eyed and achy, and was soon on my way so that I could arrive at Costilla Creek at dawn. The drive was quite enjoyable, climbing from high desert into juniper foothills and through a narrow canyon to reach the high mountain valley of Costilla Creek just as the sun rose. The stream was beautiful (Figures 13, 14), a trout angler's dream, and my spirits were high. I was glad I had made the trip.

But the fish were uncooperative: I fished hard for an hour without any action. Finally, I reached the plunge pool below the barrier dam (Figure 15). I cast a weighted nymph, recommended by the guide at the shop, without much hope. To my amazement, a fish struck and was hooked and, low and behold, it was a Rio Grande Cutthroat! Maybe it wasn't completely pure, with a few too many Rainbow-Trout-like smaller spots along its flanks, but it was spectacular. Orange-greenish sides with large dark spots concentrated towards the tail, bright red gill covers, and an even brighter red slash under the jaw. I was enthralled. I quickly fumbled with my phone to take a picture. But the fish had other ideas and, in a flash, did an Olympics-quality twirling backflip out of the net, caromed off my lunging hands, and escaped back into the stream. I couldn't believe it.

OK, I'd caught one fish, so I could catch another. I fished the stream with grim determination. But despite covering lots of great-looking water with all sorts of flies, I never had another strike. My time ran out. As I drove downstream out of the fly-fishing-only stretch, I passed another angler, the first I'd seen all day, fishing worms with his kids below a bridge. A glutton for punishment, I couldn't resist stopping and asking how he was doing. Not too bad he replied. A couple of Rainbows and a bunch of Cutthroats …

I was a bit frustrated and angry at missing the photo. It had been such a pretty fish. But as I drove back towards Taos I soon felt better. The scenery was wonderful, and it was a gorgeous day. I had met my goal and caught a Rio Grande Cutthroat Trout, a magnificent species, and the memory was clear in my mind and captured well in a great Joe Tomelleri drawing (Figure 16). And maybe I'd be able to come back some day and catch another.

THE LOG FROM KOTZEBUE SOUND: CHASING ANADROMOUS FISHES ALONG THE ARCTIC CIRCLE

Nate Cathcart

Alaska Freshwater Fish Inventory, Alaska Department of Fish & Game

BACKGROUND

Alaska state law mandates the Alaska Department of Fish and Game (ADF&G) to define waterbodies with anadromous fish habitat throughout the state. To be listed, habitats must have direct, unambiguous observations and documentation by a qualified observer. These habitats gain protections regulating land use policies such as those directing stream crossings requiring bridges to allow fish passage or the timing of mining to not coincide with sensitive spawning or juvenile rearing periods. To provide this knowledge of habitats, the ADF&G curates the "Catalog of Waters Important for the Spawning Rearing or Migration of Anadromous Fishes," known colloquially as the Anadromous Waters Catalog, or AWC. To inform the AWC, ADF&G established the Alaska Freshwater Fish Inventory (AFFI) in 2002. The AFFI program represents the state's primary annual effort to revise the AWC. Fish community sampling occurs most often in waterbodies that have had limited to no documentation via western science methods. As such, the locations of most of these efforts are in remote areas of Alaska. During these projects, as funding and time allows, we augment our standard electrofishing protocols with opportunistic methods to expand our sampling area as well as targeting species with different gear or observation methods (e.g., Cathcart 2019). The following represents how opportunistic sampling improves fish habitat protections in Alaska through revising the AWC. Each revision to the AWC is called a *nomination* and is specific to a waterbody that represents habitat for the anadromous species and their life stages found there. Nominations to the AWC may add a species or more, a newly documented upstream distribution, a newly documented waterbody (distinct slough, lake, or stream), a newly documented life stage of a species, back-up information to substantiate historical AWC data that lacked evidence (they were based on historical observations), or a combination of these.

Photos by the author unless otherwise indicated.

Nate Cathcart leads the Alaska Freshwater Fish Inventory (AFFI) program as a Habitat Biologist with the Alaska Department of Fish & Game in Anchorage. He joined the AFFI program in 2018 and served as the technician for two seasons before being promoted to project biologist. Earning a Bachelor's degree from Colorado State University and a Master's degree from Kansas State University, Nate has performed various conservation-minded research spanning suckers, minnows, and salmon. His newest project is exploring the distribution of Pacific Lamprey in Alaska.

STUDY DESIGN AND AREA

In 2019, the AFFI program had money remaining from a grant from the Healthy Waters Consortium, a US Environmental Protection Agency (EPA) affiliated endowment that bankrolls conservation-minded organizations for watershed or landscape-level projects. This grant funded work in the upper Koyukuk and Kobuk rivers in 2018 in a study area that straddles the Arctic circle just south of the Brooks Range. This work was described by AFFI staff in two articles (Cathcart 2019; Cathcart and Giefer 2020). To expand the project's footprint and expend remaining money, we executed late-season aerial surveys based out of Kotzebue, AK, to investigate anadromous fish presence in tributaries of the lower Kobuk River, lower Noatak River, Hotham Inlet, and the Chukchi Sea (Figure 1).

These streams flow through ancestral and current territories of Inupiaq people; these territories are managed as native, state, and federal lands. Many of these waters drain, or are adjacent to, the following National Park Service units (from east to west): Gates of the Arctic National Park & Preserve, Kobuk Valley National Park, Noatak River National Park & Preserve, and Cape Krusenstern National Monument. Understanding which waterbodies sustain anadromous fishes in this region is important since these streams support regional ecological economies including several subsistence communities, animal communities (e.g., fishes, Brown Bear, birds that exploit the marine subsidies delivered by salmon or other anadromous fishes) and riparian vegetation (Quinn 2018). However, this region is challenged by climate change and regional development, such as road building and mining, that can affect the amount and quality of fish habitat (Cathcart 2019).

Qikiktaġruq, the historic name for the city of Kotzebue, sits on the north end of a flattened tied island connected to the base of the Seward Peninsula by a narrow land bridge called a *tombolo*. Kotzebue is named after Otto von Kotzebue, who sought the Northwest Passage for the Russian empire in the early 1800s. This seaside community of about 3,000 people is significant geographically, culturally, and economically. Its location among three major river systems (Noatak, Kobuk, and Selawik rivers) and the sea once provided a hub for trading and travel among other coastal or inland communities. Today, it is still a bustling travel hub that has grown through the addition of large airport. Bisecting the lagoon, the airport runway is one of the only paved parts of town. Boats come and go from a small harbor attached to the lagoon as Boeing 737s and bush planes land and take off from the runway. A hotel is one of the tallest buildings, if not the tallest building, in town, and it overlooks houses with yards

Figure 1. Map of the study area. Numbers correspond to the sites in Table 1.

Figure 2. Male Coho Salmon caught at the mouth of the Pah River, September 2017. (Photo by Mark McKinstry)

occupied by sled dogs and snowmachines eager for winter. Scattered throughout the community are eateries selling similar assortments of food (sushi, pizza, etc.), churches of all (or the most popular) denominations, federal buildings such as the National Park Service (NPS) Western Arctic Parklands visitor center, schools (home of the Huskies), and the clinic. In the middle of town near city hall, the police department, and the liquor store lies the cemetery, ringed by worn bike and foot paths as dead whaling captains are memorialized by arching Bowhead Whale jaws.

THE WORK

I jumped at the chance to execute this mission for a couple reasons. By mid-September in Alaska, desperation to enjoy what's left of the field season builds as sunlight is fast whittled away by each passing day. Fall is our most fleeting season yet is advantageous in some regards. There are no (or fewer) mosquitoes or biting flies as early frosts have killed them, the streams have generally low and clear water levels, and many large-bodied anadromous fishes are still migrating or spawning and are able to be seen before the ice and darkness take over. Another reason I set this adventure up is because of Coho Salmon *Oncorhynchus kisutch*. During a personal rafting trip on the Kobuk River in early September 2017, a friend caught a Coho Salmon at the mouth of the Pah River (Figure 2). Coho Salmon are known for often being the latest spawning salmon; thus, a later-timed survey effort. Winter was coming, the fish were out there, and I was headed north to find them.

September 18: If there's one thing I learned about this trip as far as logistics go, being upfront with what you're carrying for fish or genetic sample preservatives to the airlines can avoid going through expensive, laborious hazardous material shipping. I packed triple-contained (Nalgene bottle inside a Ziploc bag inside a dry box) ethanol, formalin, and Longmire solution (an eDNA preservative) in my checked luggage. Before I fly, when I'm working with a gate or baggage agent checking my luggage with liquids such as these, I make it clear to identify them as unpressurized, triple-contained preservatives. Otherwise, since my work was aerial surveys, my gear was minimal. I had a bag of clothes, my

Figure 3. Kimber the office dog working hard at Golden Eagle Outfitters' hangar.

Figure 4. The first stream surveyed, the sinuous Situkoyuk Creek on Cape Krusenstern.

Figure 5. Cape Krusenstern beach landing. The Chukchi Sea, part of the Arctic Ocean, is on the left. The water along the right-side horizon is Kotlik Lagoon, where Kilikmak Creek (number 10 in Table 1) drains.

fishing gear, and a medium-sized Action Packer tote with sampling equipment such as a GPS unit, data book, the preservatives, minnow traps for opportunistic sampling of juvenile fishes in the lagoons, waders and boots, and a seven-pack of beer.

Beer is not necessary for science, but if there's one thing I learned about beer before this trip, it's BYOB to Kotzebue. Many remote Alaskan communities are dry, meaning the import or sale of alcohol is prohibited and punishable by steep fines. Kotzebue is not dry but has strict regulations to combat alcohol abuse. In Kotzebue, there is a $10 daily admission to the liquor store before one can purchase a $30 six-pack.

I arrived in Kotzebue to a golden sunny day and prepared for flying the next day. I checked-in with the pilot before checking into my hotel room. The pilot was Jared Cummings of Golden Eagle Outfitters, a flight operation that flies hunters, scientists, and locals throughout the region. Like any trustworthy outfit, they always have a dog or two in the office, and unlike most Alaskans, they are comfortable with any sized dogs (Figure 3). Their motto exemplifies the bravado of bush aviation: "Trust us with your life, not your daughter or wife." However, their respected reputation extends multiple generations, with Jared's dad founding the company and operating hangars in Kotzebue and Delta Junction along with Jared's brother. They have been a go-to aviation outfit trusted by ADF&G (and other agency) biologists for decades.

After checking into my hotel, I stopped at the Bayside Inn next door for a sushi dinner in view of the Chukchi Sea. Along with hotel breakfasts while the skies were still dark, this sums up the quotidian parts of my trip: hot breakfast mornings and sushi nights.

September 19: Though I had worked the past two field seasons in remote parts of Alaska, our protocol had involved helicopter travel. This would be my first experience with aerial surveys performed the traditional way: small fixed-wing aircraft such as the Super Cub and a Cessna 206. We first worked out of a Piper PA-18 Super Cub, a standard of Alaskan bush aviation—especially in the hunting community. However, instead of Dall Sheep or bull Caribou, we were hunting fishes in the coastal streams draining into the Chukchi Sea, starting on Cape Krusenstern (a National Monument on Inupiaq territory). Yellow leaves and red brush still clung to the more coastal landscapes as the smell of exhaust fumes clung to my nose.

The first creek surveyed wound itself through tundra, which was radiant in the soft September sunlight (Figure 4). Following the stream from its headwaters toward its mouth, I spotted a bold red fish. Then another. With my goal being Coho Salmon, I wanted to call them that but, as vultures spiral around an animal until its death, we rotated around the fish until I recognized enough of the contrast between the red body and green head: Sockeye Salmon *O. nerka*. Throughout the survey, Sockeye Salmon spawned over redds cleared in the streambed, a lone carcass showing the annual reproductive ritual wasn't over yet. Good signs for things to come.

As we flew to the next stream, a pair of stolid Musk Ox trundled along the tundra, their feet hidden under a wooly sheet. Ice formed on small ponds and the white silhouettes of ptarmigan spooked off ridges by our flightpath, signs of impending winter. Our next survey, on the Kilikmak River, produced more Sockeye Salmon. After running out of creek to survey, we landed along the lagoon it empties into and stretched our legs (Figure 5).

Figure 6. Flying in Super Cub surveying Uvgoon Creek, a tributary to the Noatak River. Moments after this photograph was taken, we spotted spawning Sockeye Salmon in Paluktak Creek. Fish were in a reach with a series of beaver dams, often spawning just downstream of the dams.

Figure 7. Looking upstream South Fork Agashashok River from the back of a Super Cub.

Figure 8. Female Sockeye Salmon caught from South Fork Agashashok River.

Figure 9. Male Chum Salmon from the South Fork Agashashok River.

We hatched a plan to work clockwise through the air toward the Noatak River drainage. Black Spruce and taller vegetation populated the tundra as we moved inland. Chum Salmon *O. keta* spawn throughout the Noatak River and its tributaries, attracting hordes of gulls, patient Bald Eagles perched in streamside trees, and Grizzly Bears plodding gravel bars. The western Arctic Caribou herd, Alaska's largest, dotted the landscape. Among the multitudes of Chum Salmon, a handful of ruby red Sockeye Salmon stood out on their redds. In the upper parts of the Eli River, Sockeye Salmon spawned below Beaver dams—an emerging regional phenomenon as Sockeye Salmon and Beaver expand their ranges (Figure 6; Tape et al. 2022).

We tried to fly north to reach upstream parts of tributaries such as the Kelly River that have spring-fed lakes. However, we aborted this plan for the day as a snowstorm forced us to turn around. Instead, we shifted our sights to a downstream tributary of the Noatak River, the Agashashok River (Figure 7). More Sockeye Salmon were spawning in the clear water. Jared had mentioned hunters that he had flown out to a nearby camp were saying they had caught silvers (meaning Coho Salmon). We took this opportunity to get on the ground and, after deflecting the offer to enjoy the hunters' well-stocked bush bar (it was noon), I was led to the mouth of a creek where I could see Sockeye and Chum salmon staged for spawning. This is why you leave the hunting to hunters and the fish identification to fish biologists. A couple of large dark Dolly Varden *Salvelinus malma* cruised among the salmon. I took my boots off to cross the creek for better fishing angles, hence the given name for one of the nominated streams that previously lacked one (Table 1). I verified aerial observations by catching fish with large flies (Figures 8–11).

Taking off again, Jared pointed the Super Cub eastward toward the largest tributary system of the Kobuk River: the Squirrel River (drainage area 4,226 km^2). The village of Kiana sits at the mouth of the Squirrel River, an advantageous spot to intercept Inconnu (AKA sheefish or bush bass) *Stenodus leucichthys*, other whitefishes, and salmon fresh from the sea. Kobuk River tributaries

Table 1. Waterbodies surveyed during September 2019 and nominated to the Catalog of Waters Important for the Spawning Rearing or Migration of Anadromous Fishes (AWC). Georeference provided within the WGS83 coordinate system. Species occurrence types are as follows: P = Presence; S = Spawning. Asterisk indicates species was observed in the waterbody during these surveys but was already in the AWC. Italicized waterbody names indicate stream was unnamed per the United States Geological Survey and was given a name (Paluktak is Inupiaq for beaver).

No.	Waterbody	Drains into	Latitude	Longitude	Sockeye Salmon	Chum Salmon	Dolly Varden
1	Agashashok River [2,3,5]	Noatak River	67.35977	-162.39000	S [2,3]		
2	South Fork Agashashok [1]	Agashashok River	67.49157	-161.89116	P	P	P
3	*Barefoot Creek* [1]	South Fork Agashashok River	67.46326	-161.97588	S		
4	Avan River [2,3]	Noatak River	67.95556	-162.28239	S	S	
5	Bear Lake [3,4]	Kelly River	68.02225	-162.36472		S	
6	Eli River [4]	Noatak River	67.65687	-162.73163		S	
7	*Hotdish Creek* [1]	Squirrel River	67.19946	-161.43120	P	P	
8	Kallarichuk River [4]	Kobuk River	67.17430	-159.80320		P	
9	*Kallifornia Creek* [1]	Kallarichuk River	67.11270	-159.87248		P	
10	Kilikmak Creek [1]	Kotzebue Sound	67.29836	-163.45378	S	P	P*
11	Kokopuk Creek [4]	Hotham Inlet	67.04595	-161.90368		P	
12	Omikvorok River [2,3]	Arctic Ocean	67.71913	-163.99486	S	P	P*
13	Pick River [1]	Kobuk River	66.71812	-156.91425		P	
14	Singauruk Creek [1]	Hotham Inlet	67.05728	-161.72259		S	
15	Situkoyuk River [1]	Kotzebue Sound	67.12626	-163.18982	S		P
16	Squirrel River [2,3,4]	Kobuk River	67.16493	-161.07755	P [2]	S [3]	
17	Tutak Creek [2]	Wulik River	67.87476	-163.38512	S	S	P
18	*Paluktak Creek* [1]	Eli River	67.81301	-162.32796	S		

[1] added waterbody to Anadromous Waters Catalog (AWC)
[2] added species to AWC-listed waterbody
[3] added life history event (e.g., spawning) for species existing in AWC-listed waterbody
[4] substantiated inclusion of a waterbody in the AWC that previously lacked documentation
[5] extended upper reach of existing AWC waterbody

are some of the prettiest waters I've seen. The Squirrel River did not disappoint. We flew over broad spruce-filled valleys carved by clear streams flowing through abundant instream woody debris and over cobble, gravel, and sand. The Chum Salmon were in, but apparently so fresh they were not spawning yet.

Hopping from creek to creek led us over a massive bull Moose bedded down with a rack well over 60 inches along with his harem of 6 cows. Not far away we flew over two large bull Moose skulls locked together by their broad antlers. Love, as in life, has winners and losers, Moose included.

After all that flying, it was no surprise that we needed gas. Turning westward toward Kotzebue, we had enough fuel to survey a couple short systems emptying into Hotham Inlet. More Chum Salmon were spawning and dying, though a bit more difficult to see in the dark tannic water. Seal heads stuck out of the lagoons, drawn to the migrating fish. When we crossed Hotham Inlet, hundreds of Tundra Swans staged for their southward migration in the nearshore waters below us. Fall is a flurry of activity as everyone seems to be trying to beat winter: salmon seek to spawn, wildlife from birds to bears eat as many calories as possible to fuel their migrations and hibernations, and biologists try to survey what they can before the ice comes.

During our pit stop, Jared switched aircraft. We climbed into the Cessna 206, a larger, faster, more comfortable plane than a Super Cub. Though we sacrificed a wider range of potential landing areas—and although we could not fly as low and slow (critical factors when trying to identify fish species from the air)—the 206 would allow us to cover more ground each day. And, after all, we were, for the most part, chasing large, colorful fish in clear water. We headed back east toward the Kobuk River to survey during the remaining daylight.

The trees became more skeletal and the landscape drabber the farther east and inland we flew. Our surveys culminated with finding Chum Salmon swimming in the Pick River's dark waters south of Shungnak and in a clear tributary to the Kallarichuk River at the west end of Kobuk Valley National Park. With surveys finished, our return to Kotzebue included three Black Bears (a sow and a cub, and a separate boar) and once again, the swarm of swans in the sound.

Before leaving the hangar, Jared told me to take beer from the stack (more like a pile) inside. They had flown an owner of an Alaskan brewery, who had donated a lot of beer. A lot. I picked up a six-pack but was told to grab more. Free beer is free beer; so, what the hell.

Figure 10. Male Chum Salmon from the South Fork Agashashok River.

Figure 12. The tannin-stained Pah River (left) empties into the clear Kobuk River (right).

Figure 11. Male Sockeye Salmon from the South Fork Agashashok River.

Figure 13. Cessna 206 gravel bar landing along the Kobuk River upstream of the Pah River. We sampled eDNA samples and cast for sheefish here.

September 20: The next day we worked with an eye toward the Kobuk River. Our first stop was to collect eDNA samples around the mouth of the Pah River (Figure 12), the site of where I observed a Coho Salmon in 2017 and a hotspot for the spawning migration of sheefish. The Pah River is home to the world record sheefish weighing in at 53 lbs. It's also about 180 miles from Kotzebue. The long flight took us over the Kobuk sand dunes and past the villages of Ambler, Shungnak, and Kobuk. As we flew over the river to land on a gravel bar, a swarm of large shadows in the water darted away from the aircraft.

After landing on the dry gravel bar (Figure 13), we put our waders on as fast as we could but for different tasks. Jared got to head straight to fishing whereas I had to do science first. By the time I had taken three eDNA samples, Jared had caught a few sheefish (Figure 14), with one on the bank. Sheefish have delicious, white, firm, oily meat with large muscle fibers. I interpret it as an oily version of Pacific Halibut *Hippoglossus stenolepis* that you can catch in fresh water. While not everyone agrees, I think it is great baked, grilled, smoked, and fried.

With no time to waste, I spurned my fly rod for a conventional casting rod and my trusty 1-ounce bucktail jig. I waded into the stream a couple yards, the cold water above my ankles, and cast. Ripping the jig across the river like the bassmaster himself, Kevin VanDam, produced heavy strikes. Repeating this process brought in a couple large females and a few small males (Figure 15). Call me the "bush bassmaster," eh? On average, males are smaller, often 35–39 in., whereas females range 40–50 in.. After dispatching two for my limit, fishing was over almost as quick as it began (Figure 16). With eDNA samples and fresh fish packed, we took off westward.

Once refueled in Kotzebue, we were determined to survey the system of spring-fed lakes in the Kelly River drainage, tributary to the Noatak River, that we couldn't reach due to snow yesterday. Our aerial prospecting gave a sense of anticipation as Bear Lake materialized on the tundra (Figure 17). Looping around the lake in several circles, we spied hundreds of fresh-looking Chum Salmon finning over redds pockmarking a submerged beach (Figure 18). Seeing these fish and remembering how the Chum Salmon

Figure 14. Pilot Jared Cummings holds a large sheefish.

Figure 15. Average sheefish from Kobuk River.

Figure 16. Sheefish after science.

Figure 17. Bear Lake, part of the Kelly Lakes in the Kelly River watershed, a tributary to the Noatak River.

from the Agashashok River looked, I was struck at how golden these Chum Salmon were compared to other western Alaskan conspecifics that wore more traditional flanks of crimson and green. Accomplishing our aerial mission, we turned back under blue skies, enjoying scenery while salmon spawned (Figure 19). After landing, I acquired 12 beers.

I pulled on my canvas pack stuffed with minnow traps and hiked dirt streets through town to the lagoon (Figure 20). The ghosts of the year's last big fish migrations lay in piles of dry gillnets spread along the shore. After setting four minnow traps baited with radioactive-pink-colored cured salmon roe, I hiked back to the hotel (Figure 21). Tomorrow was the survey's finale.

September 21: On our last day of surveys we flew farther north along the coast. We first targeted the Omikviorok River, a river with Red Dog Mine in its headwaters. Red Dog Mine is known for its zinc and lead mining. The lead and zinc are trucked to a port on the coast where it is barged away to be processed. The Omikviorak River is now known for supporting Sockeye and Chum salmon.

We also made our way to the Wulik River, home of the world and state record Dolly Varden, a sea-run fish weighing over 20 pounds. The sunshine and Dolly Varden were too good to pass up. We landed on a huge gravel bar to take a few casts, producing many 12–18-inch fish (Figures 22, 23, 24). Though it's truthful that I love all fish, I still play favorites. *Salvelinus* has long been my favorite fish genus because, big or small, the species represent bedazzled icons of plastic iteroparous life histories spanning clear rivers, deep cold lakes, and coastal seas. Their having ravenous appetites and tasty flesh (especially in spring when their oils are in their flesh, not their gaudy spawning attire as in fall) doesn't hurt as I find it easier to appreciate that which I can interact with. Alas, all the Dollies were released, and we surveyed a tributary where we documented Sockeye and Chum salmon spawning among swarms of Dolly Varden.

On our way back we surveyed another Hotham Inlet stream, with more success finding Chum Salmon. We made it back to Kotzebue with plenty of daylight remaining. I gained 18 more beers and a bunch of Golden Eagle Outfitters swag such as hats and hoodies before leaving the hangar.

Though I got skunked in two traps, the other two each had a

Figure 18. Spawning grounds of Chum Salmon in Bear Lake. Fish and their redds were concentrated to the middle right of this photo. Looking closely, one can see a ring made by a splashing fish and the silhouettes of spawning salmon over their redds dug into the gravelly lake bottom.

Figure 19. View from the office window.

fish. Though I knew their families and had an inkling about what the gadid was, I vouchered both for identification. Upon closer examination, Plain Sculpin *Myoxocephalus jaok* (Figure 25) and Saffron Cod *Eleginus gracilis* (Figure 26) were added to the fish list. Though non-anadromous, documenting these species is useful to understand local fish communities.

On my last night, I ate a couple sushi rolls at the Bayside Inn and took a brief walk along the sea wall before retiring to my hotel room. It was time to pack up.

September 22: I had arrived with cured salmon roe, seven beers, and visions of Coho Salmon. I left with formalin-pickled fishes, two cases of beer, some swag from Golden Eagle Outfitters, and a lot of nominations for the AWC, though none for Coho Salmon. The Boeing 737 felt detached from the world compared to riding inside a small plane the past few days. Now Anchorage-bound, my destination was an office until next field season.

RESULTS

We added 123 km to the AWC across 18 waterbodies (Table 1). Chum Salmon (14) were the most-nominated species, followed by Sockeye Salmon (11) and Dolly Varden (5). This breakdown can be attributed to several factors including: Dolly Varden have already been documented in more waters throughout western Alaska than other species, potentially emergent Sockeye Salmon populations in the region (or small latent populations that have gone undetected), and some waters listed in the AWC lacked documentation, thus warranting substantive evidence from these surveys.

Figure 20. North end of the Kotzebue Lagoon system. Note the boat in the main channel exiting to Kotzebue Sound (middle upper right of the photograph). The northern edge of town is in the upper left.

Figure 21. Setting minnow traps in Kotzebue Lagoon. A discarded boot served as the anchor to two traps. The Ziploc bag holds bait canisters full of cured salmon roe.

EPILOGUE

One of the first things I did after donating the new beer collection to friends and getting the AWC nominations submitted was to investigate the phenomenon of lake-spawning Chum Salmon. Turns out, Bear Lake supports one of five documented lake-spawning Chum Salmon populations in the world and one of two in North America (Arostegui and Quinn 2019). Populations exhibiting this behavior are not only few, but they are also disjunct: three lakes in Russia, Kluane Lake (upper Yukon River in Yukon Territory, Canada), and Bear Lake. In 2021 we may have found another such population, but that story is for another time.

In the winter of 2019–2020, a pandemic started. You may have heard about it. This shut down the federal lab that was to analyze our eDNA samples. The samples we had taken during these surveys, as well as dozens of other samples from throughout Alaska, expired and were disposed down a drain.

We began a new project in the Kobuk River in 2022. Before our August trip, I coordinated travel through Kotzebue in route to the village of Kobuk. I used our state travel service to book a room at the

Figure 22. Female Dolly Varden from the Wulik River.

Figure 23–24. Female (left) and male (right) Dolly Varden from the Wulik River.

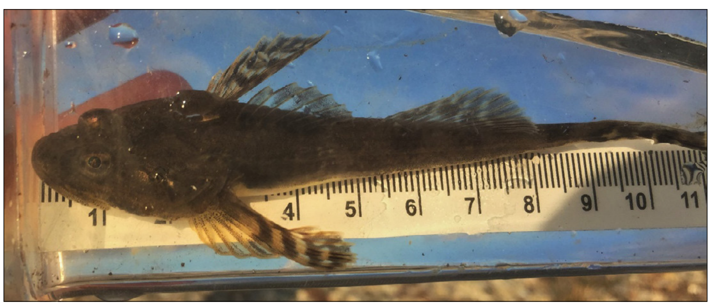

Figure 25. Plain Sculpin trapped in Kotzebue Lagoon.

Figure 26. Saffron Cod trapped in Kotzebue Lagoon.

Bayside Inn, figuring I would eat sushi before bush living began. I saw emails from the travel service show up in my inbox, but I knew the drill, it was my itinerary, everything was set. Most sampling and camp gear had already arrived at the Golden Eagle Outfitters hangar. I just needed to get to my hotel. Standing with the remaining equipment in front of the airport, a curious taxi driver asked if I needed a ride. I did and we loaded the cargo into her van.

She asked, "Where to?," I said, "The Bayside Inn." She laughed and asked, "Really?"

"Yeah," I replied, now unsure, "Why?"

"Oh, you'll see."

We drove to the Bayside and pulled up out front. What remained of the hotel and restaurant was a lower-level unit in varying degrees of disrepair or construction, not renovation. The Bayside Inn had burned down in November 2020. I ended up staying at the taxi driver's aunt-in-law's bed and breakfast before shipping out to Kobuk. As of January 2023, the State of Alaska's travel service still offers the Bayside Inn as a lodging option in Kotzebue.

This current study has more budget left. We will return in October 2023 to chase Coho Salmon out of Kotzebue, along with a week in late August targeting spawning Chum Salmon from Kiana. This time, we have our own eDNA sampler, long-term storage, and multiple analysis options.

As for the scientific souvenirs, they all found homes. The Plain Sculpin and Saffron Cod now reside in the ichthyology collection of the Museum of the North at the University of Alaska Fairbanks. The collection is curated by Dr. Andres Lopez and serves as the repository for our vouchered specimens. The nominations to the AWC were accepted and are published on our online mapper system, which you can find at: http://www.adfg.alaska.gov/index.cfm?adfg=ffinventory.interactive

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FIRST-YEAR BIOLOGY STUDENTS INVESTIGATE MICROPLASTICS IN A UNIVERSITY ICHTHYOLOGICAL COLLECTION

Jayden Winsel, Noeline Boardman, Flora Camboly, Camilla Carrillo, Cassie Lane, Jace McCormick, Lizzy Murdock, Elissa Nelson, Heaven Phillips, Logan Shearer, Lisandro Billegas, and Erika C. Martin

Emporia State University Department of Biological Sciences, Emporia, Kansas

INTRODUCTION

Microplastics have been found across most environments and have become a focus of scientific research as their potential effects are just beginning to be described. Microplastics are extremely small pieces of broken-down plastic which the National Oceanic and Atmospheric Administration (NOAA) has defined as measuring < 5 mm. Microplastics are made of polymers such as polyethylene, polystyrene, polypropylene, rayon, nylon, polyester, cellophane, acrylonitrile, and natural fibers (e.g., Zimmermann et al., 2020). They can be found in almost all parts of the environment, including the land, air, and water, and have become one of the most important pollutants in some environments (Karami et al., 2017; Galafassi et al., 2021; Chang et al., 2022). Depending on characteristics of the microplastic particles, the environment, and ecosystem processes, plastic particles can disperse across aquatic systems or settle in substrates where microplastics have the potential to build up in river sediments. Additionally, microplastics may become momentarily or permanently confined by physical obstacles like dams or algal mats. Microplastics from these sediments can be released by disturbance events and begin their ecosystem cycle anew (Parker et al., 2021).

Most studies on aquatic microplastic pollution have been conducted in marine ecosystems but more diverse environments are being assessed (Eerkes-Medrano et al. 2015; Martin et al., 2019; Chang et al., 2022). There is evidence of ingestion of microplastics by both marine (Karami et al., 2017) and freshwater fishes (Galafassi et al., 2021); however, the majority of microplastic diet analysis research has been on freshwater fishes, particularly the Zebrafish *Danio rerio* (Galafassi et al., 2021). In the US, in the Muskegon, Milwaukee, and St. Joseph rivers, the concentration of microplastics varied significantly among fish species where microplastic concentration in Round Goby *Neogobius melanostomus* was substantially higher than that in Fathead Minnow *Pimephales promelas* and White Sucker *Catostomus commersonii* (McNeish et al., 2018). Historical studies on ingestion of microplastics by freshwater fishes have used museum specimens to demonstrate that fishes did not ingest microplastics prior to ~1950, and that ingestion rates have generally increased over time (Hou et al., 2021); however, other studies only found microplastics in rare instances or only in recent (< 30 years ago) samples (Toner and Midway, 2021).

Preliminary evidence of microplastic ingestion by fish emerged in 2010 after an analysis showed stomach contents of fish from the North Pacific Central Gyre contained microplastics (Galafassi et al., 2021). Many factors affect microplastic ingestion including fish species' traits, microplastic morphology, abiotic habitat factors, and time. Larger sizes of microplastics cannot be fully digested and thus contribute to the number of plastics found in the intestines of fish (Gamarro et al., 2020). Smaller plastics can be either retained, excreted, or incorporated into tissues. For example, retention times and rate of excretion for Mummichog *Fundulus heteroclitus* and Red Seabream *Pagrus major* were different depending on fish species as well as size and shape of microplastics (Ohkubo et al., 2020). Mummichogs excreted the plastics at a faster rate than Red Seabream, but both species had excreted > 95% of all ingested microplastics sized 250–850 µm after a 25-hour period. Another study assessed retention time of polyethylene microspheres of five different colors (red, blue, yellow, green, or gray) across four fish species (two freshwater [Japanese Medaka *Oryzias latipes* and Zebrafish] and two marine species [Indian Medaka *Oryzias melastigma* and Clown Anemonefish *Amphiprion ocellaris*], Okamoto et al., 2022). The study found that the color preference differed by fish species: Zebrafish and Clown

Photos by the author unless otherwise indicated.

Jayden Winsel is the lead author of this study and an undergraduate student at Emporia State University. Dr. Erika Martin is an Associate Professor of Aquatic Biology and Biology Education at Emporia State University. The rest of the authors are introductory biology students—primarily freshman biology majors—and their graduate student teacher. These experiments were integrated into the classroom. Through this project, students gained hands-on experience in scientific research.

Anemonefish preferred any color, but Japanese Medaka preferred blue or green, and Indian Medaka preferred red or green. Okamoto and colleagues (2022) also found that excretion rate differed among species, and after 24 hours, most individuals had excreted > 90%; however, one Zebrafish only excreted 10%, demonstrating that some individuals might be more likely to retain microplastics. While evidence is mounting to understand the extent and effects of microplastic pollution, predictable mechanisms will remain unclear until substantial data are available. This report is a small addition in the pursuit of the accumulation of data.

The destination of microplastics when ingested by fish is highly variable. Post-ingestion, microplastics can be excreted, as described above. However, microplastics that are retained have been found in the gastro-intestinal (GI) system and gills, and there is evidence that microplastics can accumulate in fish body tissues (Gamarro et al., 2020; Galafassi et al., 2021), including stomach, muscle, liver (Collard et al., 2018), or skin (Abbasi et al. 2018). Retention of microplastics in fish tissue is of particular importance for human consumption of fishes. Although there are limited studies on microplastics in species that are often canned or consumed whole, 14%-15% of European Pilchards *Sardina pilchardus* and European Anchovies *Engraulis encrasicolus* caught along the Mediterranean coast had microplastics in their GI tract (Fossi et al., 2018). An investigation on the presence of microplastics in 20 different canned sardine and sprat products found that 16 brands contained no microplastics, but microplastics were detected in the four remaining brands (Karami et al., 2018). Microplastics in canned products can either come from contamination of the fish or from contamination during the canning process (Gamarro et al., 2020). Other organisms are affected by microplastic ingestion. In fact, an investigation of Norway Lobsters *Nephrops norvegicus* revealed that 83% contained microplastics, mostly filaments, in the stomach. It has already been demonstrated that microplastics occur in human blood (Leslie et al., 2022). Given that microplastics are found in the body of organisms, it is of interest to understand the effects the presence of these particles might have on organisms that ingest them. In 2013, Galafassi and colleagues (2021) conducted a literature review over the toxicological effects on fishes exerted by chemically absorbed microplastics. They found effects that range from no effect up to physical problems related to ingestion/excretion due to blockage, changes in feeding behavior, inflammation, alteration of metabolism, altered immune system function, and growth. Likelihood of microplastic ingestion affecting fish is multifaceted and depends on type of plastic, fish species, amount ingested, and other factors like age and size of the plastic and the fish.

The most common type of microplastic ingested is dependent on factors including species' traits and habitat type or location; however, the top three plastic types are generally considered to be polyethylene, polypropylene, and polystyrene (de Haan et al., 2019). Similarly, the most abundant type of microplastic present in the gut of four species of fish (Indian Mackerel *Rastrelliger kanagurta*, Spotty-face Anchovy *Stolephorus waitei*, Greenback Mullet *Liza subviridis*, and Belanger's Croaker *Johnius belangerii*) was polypropylene (47.2% of particles), and the second most common was polyethylene (41.6%) (Karami et al., 2017). These microplastic types were the most common because industries use those types of plastic polymers in their productions, and plastics with a lower density than seawater can float on the surface, which may be a factor dictating which organisms are affected (Karami et al., 2017). The broad goal for this study was to determine if fish in Kansas have ingested microplastics. This was done by analyzing the gut contents of museum specimens of fish collected in Kansas to determine the presence of microplastics.

Figure 1: Students dissecting museum samples of Kansas fishes in the laboratory room.

Figure 2: Students dissecting museum samples of Kansas fishes.

METHODS

Museum specimens were acquired from Emporia State University. Fish species were selected if there were at least three individuals of the same species available for dissection. After initial selection, three species were identified that had enough individuals: Bluntnose Minnow *Pimephales notatus*, Largemouth Bass *Micropterus nigricans*, and Longear Sunfish *Lepomis megalotis*. All fish were collected between 1970–2020; however, due to insufficient museum labeling, e.g., missing collection date and/or precise location, we could only assess differences in microplastic levels among species identity and not over time or by location (see Hou et al., 2021 for a more comprehensive museum study). Individuals were cut open from the anus to the bottom of the jaw, taking care not to cut into the fish's internal organs (Figure 1). The stomach and intestines were then removed (Figures 2 and 3). Gut contents were

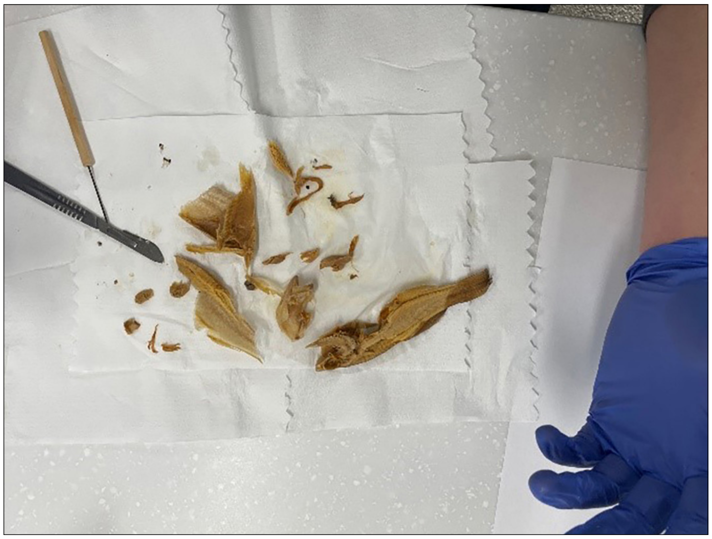

Figure 3: An Emporia State University student's sample of a dissected Largemouth Bass.

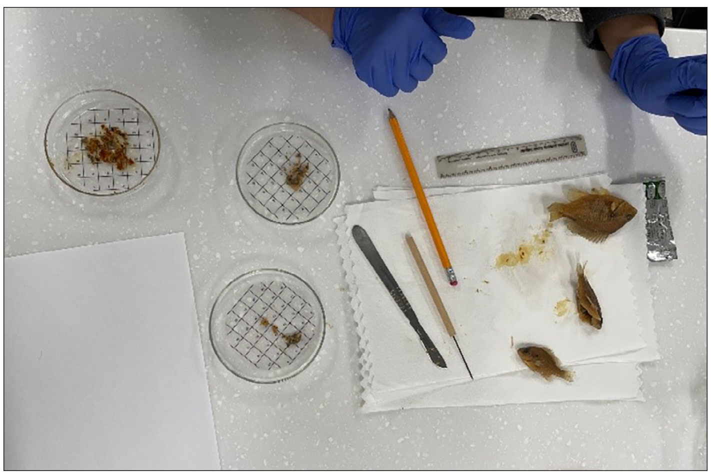

Figure 4: Several samples of students' dissected fishes, and the gut contents from each fish in its own petri dish.

removed and placed on a gridded petri dish (Figure 4) and were spread as thinly as possible on the petri dish, by either using a pick or gloved fingers.

A petri dish was then placed under a microscope at either 100 or 400 magnification (Figure 5). The microplastics within the gut contents were counted across the grid. Data were analyzed using a chi-square test on the average count of microplastics among species.

RESULTS

A total of eight Bluntnose Minnow, three Largemouth Bass, and 16 Longear Sunfish were analyzed. We found differences among the groups, where Longear Sunfish had more microplastic particles than the other two species. Mean counts of microplastics in Bluntnose Minnow was 2.5 (standard deviation [SD] + 2.56), Largemouth Bass was 2 (+ 1.73), and Longear Sunfish was 25.75 (+ 40.24) (Figure 6). Data were non-normal and skewed, and median counts found Bluntnose Minnow at 1.5, Largemouth Bass at 3, and Longear Sunfish at 13 microplastic particles per individual. The range of data for species was as follows: 0 to 7 particles for Bluntnose Minnow, 0 to 3 for Largemouth Bass, and 0 to 142 for Longear Sunfish.

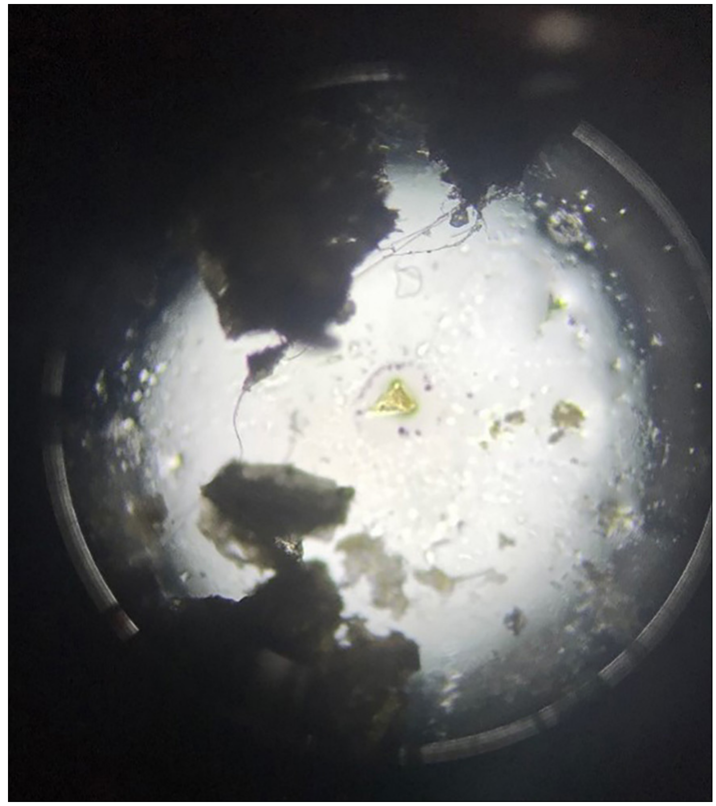

Figure 5: Fish gut contents seen through a microscope at 100 X.

DISCUSSION

We found that microplastic density in gut contents varies by species. Here, we find that the leuciscid/cyprinid (Bluntnose Minnow) and centrarchid (Largemouth Bass) had fewer microplastics particles than the centrarchid Longear Sunfish. Due to restrictions inherent from our data, we are unable to state with certainty why these differences occur; however, we will discuss potential key explanatory factors of abiotic habitat and species traits.

It has been suggested that the number of microplastics is positively associated with urbanization (Peters and Bratton 2016), where more people equal more plastics. This relationship, however, does not always occur (Dikareva and Simon 2019). The number of plastic particles ingested by two species of sunfish (Bluegill *Lepomis macrochirus* and Longear Sunfish) from a Texas river basin were correlated with urbanization, where the number of plastic particles in the gut of fish increased as urbanization increased (Peters and Bratton 2016). Conversely, across three rivers feeding into Lake Michigan with different dominant land-use (forest, urban, agriculture), the total concentration of microplastics across rivers was similar, but the concentration within fish differed significantly (McNeish et al., 2018), thus demonstrating that the total amount of plastics in the environment might not be a good indicator of ingested microplastics. Instead, species' traits, like feeding ecology or habitat preferences, are important. Other key traits might be fish size, as researchers have demonstrated that the number of ingested plastic particles can be positively correlated with individual fish length (Peters and Bratton 2016). In this same study, the number of plastics ingested was also positively correlated with ingestion of other food items, suggesting that ingestion of microplastics is incidental (Peters and Bratton 2016). All individuals assessed in our study were small enough to fit in-

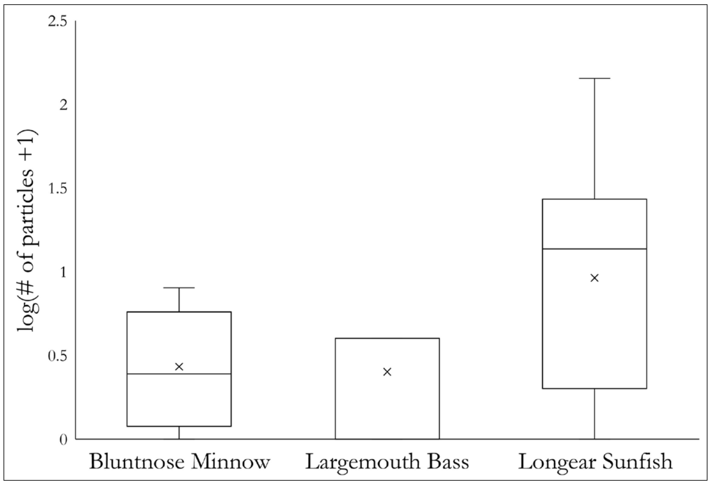

Figure 6: Log+1 mean (x) and median (line) amount of microplastics found in three different species of Kansas fish with standard deviation.

side glass jars to be preserved, so while Largemouth Bass in nature would have the potential to be larger than the Bluntnose Minnow, all individuals analyzed here are fairly small (~2 to 5 inches total length). While the two centrarchids were larger, the size differences and number of individuals do not provide enough information to make definitive conclusions whether individual size influences microplastic ingestion. Similarly, without consistent location information, we are unable to know which individuals might have been captured at sites with more or less microplastic pollution. One characteristic we can discuss to some is species traits. Largemouth Bass can be found in diverse habitat types from ponds to rivers but prefer vegetation and are opportunistic obligate carnivores (Kansas Fishes Committee, 2014). Longear Sunfish are generally found in small to medium-sized rivers and are opportunistic invertivores but also feed on small fish and fish eggs (Kansas Fishes Committee, 2014). Finally, Bluntnose Minnow prefer low-flow pools and backwaters in large rivers and are herbivores/detritivores, feeding on organic matter like algae. It is possible that the feeding preferences and strategy are determining factors in microplastic ingestion. It is interesting that the Longear Sunfish, a species that prefers items like fish eggs, also has the highest microplastic count in the gut. Though again, with such a small sample size, strong conclusions are not possible.

While we demonstrated that three species of Kansas fishes ingest microplastics at varying amounts, we are limited in scope due to lack of information provided on museum labels and sample size. Information provided on labels varied substantially, from as little information as just a common name, to complete information of common and scientific name, location, date, and collector name. Should readers be interested in pursuing this work with students or citizen science projects, it is worth noting that some students had difficulty getting the gut contents to be spread thin enough to analyze for microplastics using the microscope. This difficulty suggests that estimates of microplastics here are likely conservative. For comparison of microplastic counting methods, see work by Wagner et al. (2017), which includes use of standard light microscopy as well as other methods: scanning electron microscopy plus energy-dispersive X-ray spectroscopy, Fourier transform infrared micro-spectroscopy, and Raman micro-spectroscopy. Regardless of the limited scope of this study, it is clear that microplastics are in Kansas and are being ingested by our native fishes. Future work will assess the composition, source, and ecological impacts of microplastics in the Great Plains.

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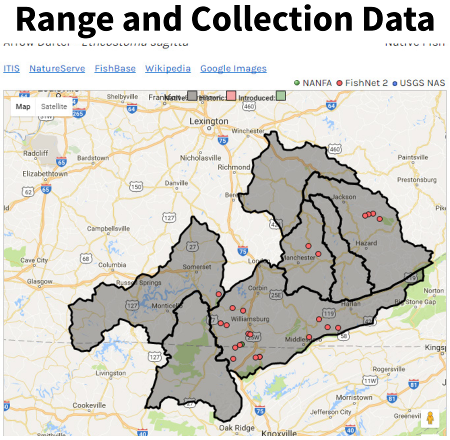
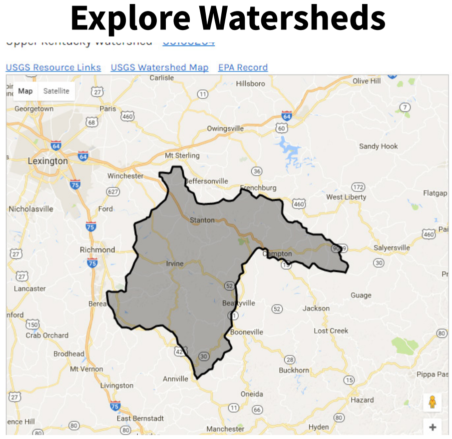
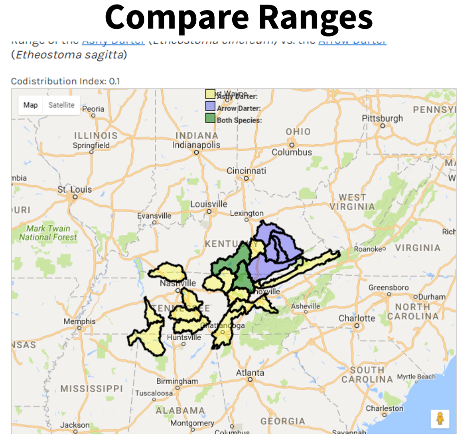






THE STATUS OF THE REDFIN SHINER *LYTHRURUS UMBRATILIS* IN IOWA: ANOTHER ONE BITING THE DUST?

John R. Olson

Ankeny, Iowa

INTRODUCTION

I have been interested in the distributions of Iowa fishes since the early 1980s when I participated in a statewide fish survey sponsored by Iowa State University. By the time of my retirement from Iowa DNR in 2017, my impression was that the Redfin Shiner *Lythrurus umbratilis* (Girard) had undergone a significant reduction in its Iowa range. I had found this species to occur with moderate frequency in northeast Iowa streams in the early 1980s. Since that time, however, despite implementation of two relatively intensive fish survey efforts in Iowa in the mid-1990s,[1] relatively few records for Redfin Shiner had been reported. In addition, a recent study of the status of Iowa's fish species of greatest conservation need (SCGN) (Sindt et al. 2011) referred to the status of the Redfin Shiner as one of "extreme decline." Thus, in 2020, I submitted a proposal for a small grant to the Iowa DNR's Wildlife Diversity Program to update the status of the Redfin Shiner in Iowa; my proposal was approved for funding in spring of 2021.[2] The objectives of my project were to (1) update, through a review of historical records and additional field sampling, the historical and current distributions of the Redfin Shiner in Iowa and (2) provide an assessment of the status of Iowa's populations of the species. The final report (Olson 2022) was submitted to Iowa DNR in April 2022. This article is excerpted from that report.

The Redfin Shiner (Figure 1) is a small minnow (Family Leuciscidae) that is distributed throughout the Mississippi River and Great Lake basins (Figure 2). A summer spawner, Redfin Shiners typically spawn over nests of *Lepomis* spp., especially Green Sunfish *L. cyanellus* (Hunter and Hasler 1965; Snelson and Pflieger 1975). The Redfin Shiner is a species of flowing waters and is known as a deep run or pool-dwelling species (Smith 1979, Becker 1983, Pflieger 1997, Triplett 2014), whether the pool habitat is within the stream (more typical of low gradient streams with low base flow) or in overflow pools or at stream inlets (more typical of higher gradient streams with high base flows) (Snelson and Pflieger 1975). The species is typically found in smaller steams versus larger rivers (Forbes and Richardson 1909, Harlan and Speaker 1956, Smith 1979, Robison and Buchanan 2020).

There are two recognized subspecies of Redfin Shiner (Snelson and Pflieger 1975). The western subspecies, *L. u. umbratilis*, occurs throughout the state of Missouri, in western Arkansas, and in eastern portions of Oklahoma and Kansas; its northern extent occurs in extreme south-central Iowa (Figure 2). The eastern subspecies, *L. u. cyanocephalus*, occupies most of the species' distribution in North America and is the subspecies that occurs in the north-central and northeastern portion of Iowa. In states adjacent to Iowa, the eastern subspecies occurs in eastern Missouri, southeastern Minnesota, the southern half of Wisconsin and the entire state of Illinois.

Eddy and Surber (1947) described the male Redfin Shiner's breeding coloration as "quite spectacular," and referred to the species as "a perfect gem of a minnow."

Background on the Redfin Shiner in Iowa: The eastern subspecies—the focus of my project—has an historical distribution in Iowa that included a large portion of the state's drainage to the Upper

Figure 1. A male *L. u. cyanocephalus* that Konrad Schmidt and I collected in June 2021, from Bear Creek, Cedar River basin, Buchanan County, IA.

[1] The Iowa DNR Fisheries Bureau's rivers and streams investigations and the Iowa DNR's Water Quality Bureau's biological monitoring program.

[2] Iowa Department of Natural Resources Wildlife Diversity Program Small Project Grant #21CRDWBKKINK-0004.

Photos by the author.

John Olson retired from the Iowa DNR, where he worked for 30 years in the Water Quality Assessment Section, in 2017. He has been involved with stream fish survey work in Iowa since attending Iowa State University, where he participated in a statewide survey of Iowa fishes from 1981–84. He has a degree in Animal Ecology from Iowa State with an emphasis in fisheries biology. He continues to pursue his interest in Iowa (and, occasionally, Minnesota) fishes in retirement.

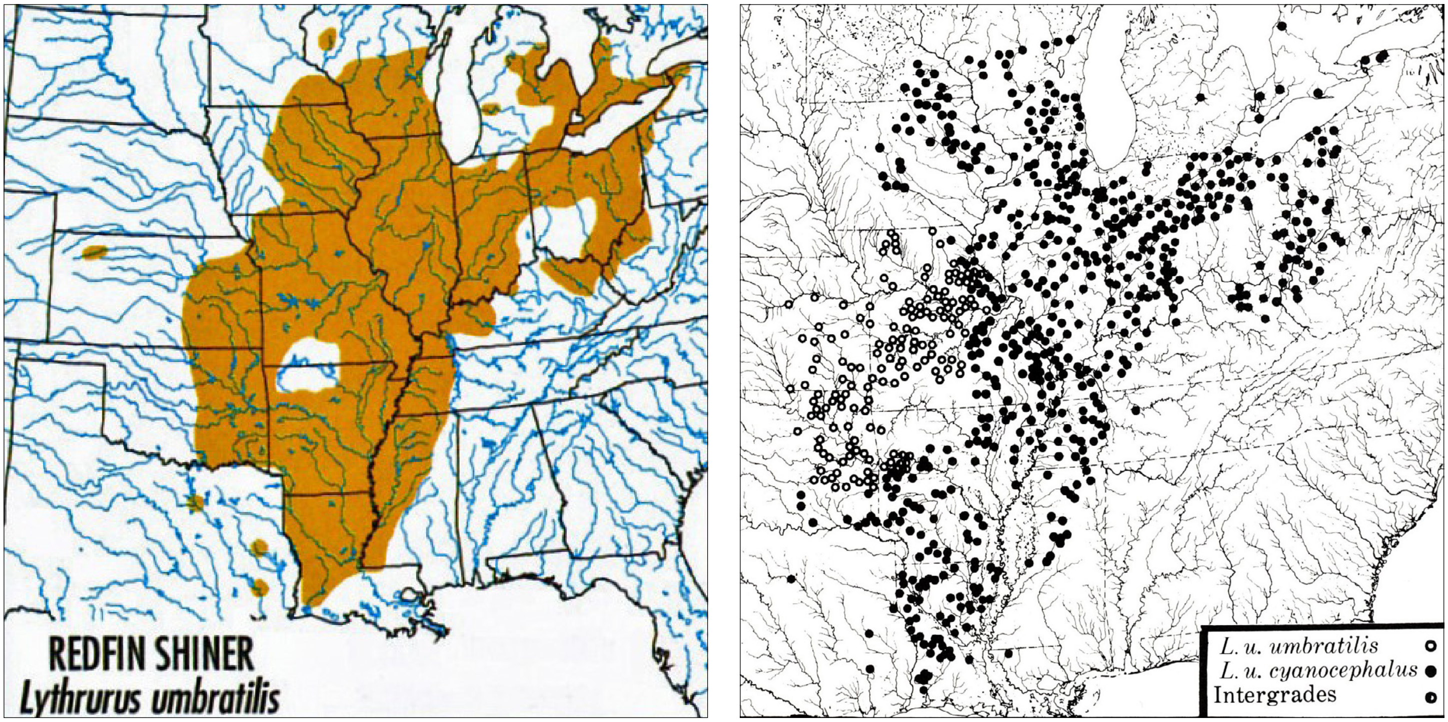


Figure 2. Distribution of the Redfin Shiner in North America. Left: distribution of both the eastern and western subspecies (from Page and Burr 2011); right: the distributions of the eastern and western subspecies of the Redfin Shiner (from Lee et al. 1980). Open circles show the distribution of the western subspecies (*L. u. umbratilis*) and the solid circles show the distribution of the eastern subspecies (*L. u. cyanocephalus*).

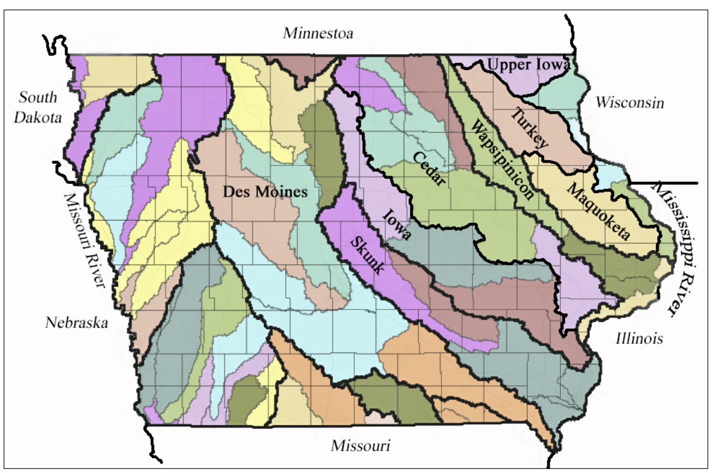
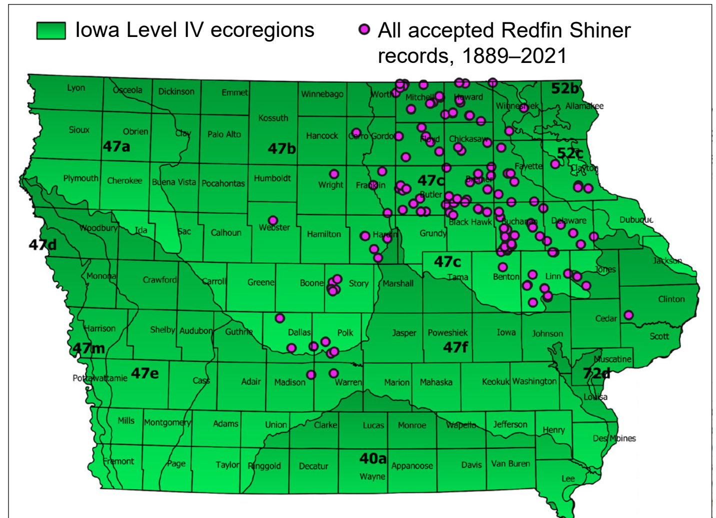


Figure 3: River basin in central and northeastern Iowa with historical records for Redfin Shiner (*L. u. cyanocephalus*).

Mississippi River, including the Des Moines, Skunk, and Iowa river basins in central Iowa as well as portions of the Cedar, Wapsipinicon, Maquoketa, Turkey, and Upper Iowa river basins in northeast Iowa (see Figure 3 for the location of these river basins in Iowa). Historically and currently, the center of distribution of species in Iowa is in the basins of the middle and upper Cedar River and the Wapsipinicon River in northeastern Iowa with most populations occurring in the Eastern Iowa and Minnesota Drift Plains Level IV ecoregion, 47c (Figure 4). The species appears to avoid the Driftless Area Level III ecoregion of extreme northeast Iowa (ecoregion 52), possibly due to the predominance of spring-fed streams there and the Redfin Shiner's avoidance of cooler waters (Snelson and Pflieger 1975). While there have been no studies focused on this species in



No.	Ecoregion Name
40a	Loess Flats & Till Plains
47a	Loess Prairies
47b	Des Moines Lobe
47c	Eastern Iowa & Minnesota Drift Plains
47d	Missouri Alluvial Plain
47e	Steeply Rolling Loess Prairies

No.	Ecoregion Name
47f	Rolling Loess Prairies
47m	Western Loess Hills
52b	Blufflands & Coulees
52c	Rochester/Paleozoic Plateau
72d	Upper Mississippi Alluvial Plain

Figure 4. Level IV ecoregions in Iowa and records for Redfin Shiner, 1889–2021.

Iowa, the species accounts written for Redfin Shiner published in the 1956 and 1987 editions of *Iowa Fish and Fishing* (Harlan and Speaker 1956, Harlan et al. 1987) mention its "widely scattered" distribution and its rarity in Iowa collections. The species is not state-listed in Iowa (IAC 2003), but it is one of 79 fish species identified as "species of greatest conservation need" (SGCN) in Iowa's Wildlife Action Plan (Iowa DNR 2015).

A poorly known species in Iowa: Even among state fisheries biologists, the Redfin Shiner is not a well-known fish species in Iowa. Several persons familiar with the fish fauna of the northeastern quarter of Iowa have never knowingly collected the Redfin Shiner. Former NANFA member Jim Russell (1949–2009), who grew up in Cedar Rapids, IA, collected statewide and was an authority on rare fishes in Iowa. In a 1981 interview (Russell 1981), he noted that he had never collected the Redfin Shiner. Neil Bernstein of Mount Mercy University in Cedar Rapids (retired)[3] has collected fishes in the Cedar Rapids area for many years (an area with historical records for Redfin Shiner) and has surveyed streams across the state, yet he has never encountered the Redfin Shiner (Neil Bernstein, personal communication, February 16, 2022). Iowa DNR fisheries research biologist Greg Gelwicks and his river research team have sampled many streams and rivers across Iowa over the last 20 years, but they have not encountered a Redfin Shiner (Greg Gelwicks, personal communication, April 12, 2022). The lack of familiarity with the species may stem from its rarity and its infrequent occurrence within its Iowa range. The lack of encounters with the species in recent decades may also reflect its ongoing decline in Iowa.

Field sampling: To determine the current distribution of the Redfin Shiner in Iowa, I developed a list of the 37 stream/river sites where the species was collected from 1981 to 1983 as part of Iowa State University's statewide fish survey conducted from 1981–1984.[4] My rationale was that a targeted sampling of sites known to have supported Redfin Shiners in the past could serve as the basis for updating the Iowa distribution of this species.

The 37 historical sites are distributed across twelve Iowa counties in river basins in central, east-central, and northeastern Iowa (Figure 5). Twenty-three of these stream sites are on private land. Thus, I conducted site reconnaissance in April and May 2021 for all potential sample sites to determine stream access points and, if necessary, to obtain permission from landowners to sample streams on their land. Most landowners that I contacted were cooperative and granted permission to sample on their property.

Fish sampling in 2021 was conducted under authority of a state of Iowa scientific collector's permit. The initial round of sampling of the 37 stream sites began on June 2, 2021, and continued through June 30. Follow-up sampling was conducted at nine sites in September and October 2021 and included re-sampling at four of the 37 sites as well as at five new sites with post-1995 records for Redfin Shiner. Thus, a total of 46 fish surveys at 41 sites were conducted in 2021 to help determine the current distribution of the Redfin Shiner in Iowa. Sampling conditions in Iowa streams in summer and fall 2021 were generally good, with average to low streamflow conditions encountered at nearly all sample sites.

Typically, about an hour was spent sampling at each site. This per-site level of effort was similar to that used for Iowa State University's 1981–84 statewide survey of fishes. The primary sampling gear was a 4-foot by 15-foot (⅛-inch mesh) seine. Seines were used

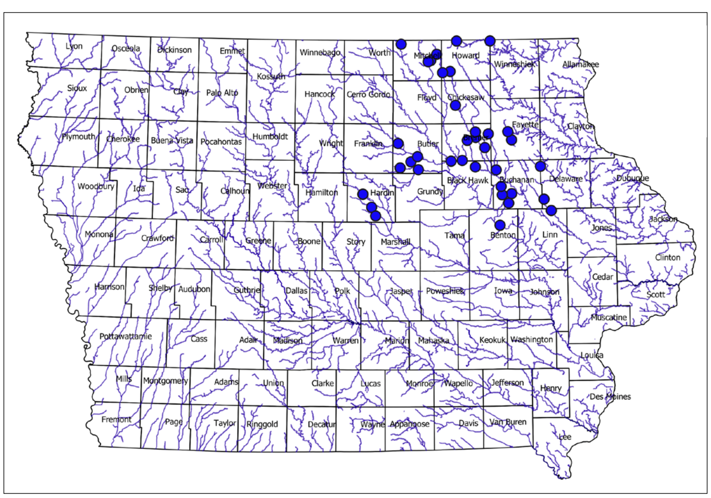


Figure 5. **Locations of the 37 sample sites where Redfin Shiners were collected from 1981–83 during Iowa State University's statewide fish survey.**

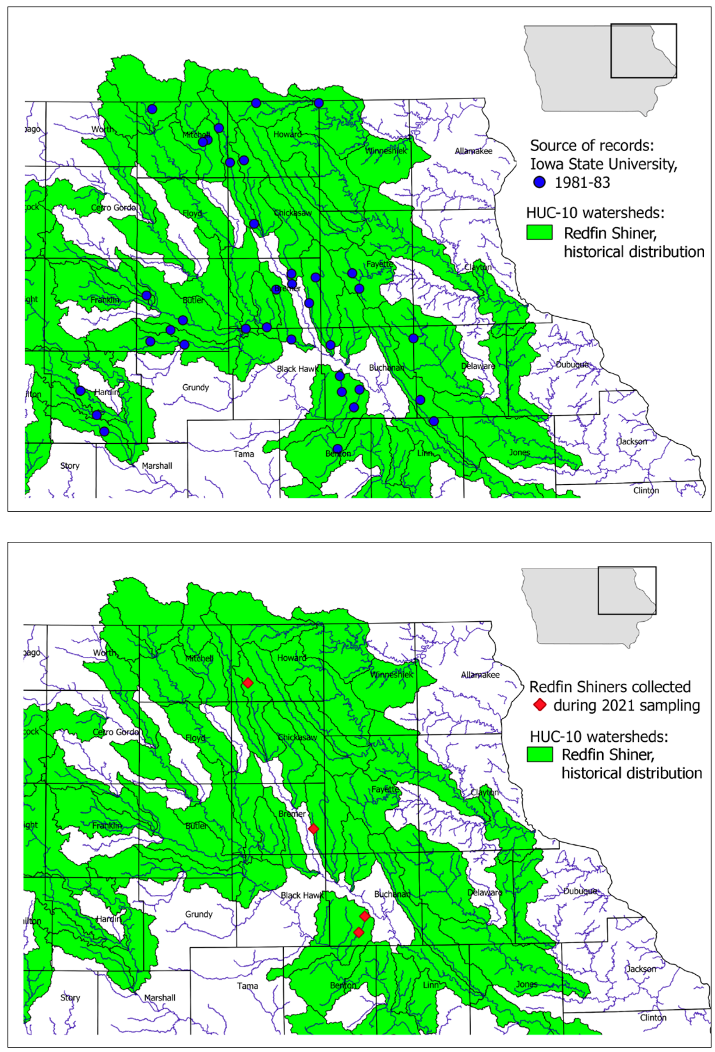


Figure 6. Top: the 37 sites where Redfin Shiners were collected from 1981–83; bottom: the four of the resampled 37 sites where Redfin Shiners were collected in 2021.

[3] Now adjunct professor, Department of Earth and Environmental Sciences, University of Iowa.

[4] In 1981 and 1982, as part of my participation in this statewide survey, I collected Redfin Shiners at 21 of the 37 sites that I designated for resampling in 2021. Other statewide survey records for Redfin Shiner from 1982, and all the 1983 records, resulted from surveys by another Iowa State student.

Figure 7. Field photographs of specimens of Redfin Shiners collected in 2021 at the four of 37 historical (1981–83) sites where Redfin Shiners were found. Top left: Little Waspsinicon River, 2.3 mi. NW of Elma, Howard Co., IA, 9 June 2021. Top right: Bear Creek, 3.5 mi. S of Independence, Buchanan Co. IA, 23 June 2021. Bottom left: Bear Creek, 4 mi. WSW of Rowley, Buchanan Co., IA, 23 June 2021. Bottom right: Buck Creek, 4.5 mi. NE of Readlyn, Bremer Co., IA 30 June 2021.

at 43 of the 46 sites. At sites with deeper water, a 6-foot by 15-foot (⅛-inch mesh) seine or a 6-foot by 20-foot (⅜-inch mesh) seine was used. Backpack electrofishing was also conducted, with both seining and backpack electrofishing used at 23 of the 46 survey sites. Electrofishing alone was used for three of the 46 surveys.

Based on information in field notes, an attempt was made to sample the same stream segment (usually, either upstream or downstream from a road crossing) that was sampled during the 1981–83 surveys. All habitat types were sampled at each site (e.g., pools, riffles, runs, eddies, and shoals). The literature suggests that the Redfin Shiner is a pool-dwelling species whether in protected inlets, backwaters, or overflow pools, and it is often found in association with aquatic vegetation. My experience collecting this species in Iowa streams is consistent with the literature; that is, I have most often collected the Redfin Shiner from slow, deep runs and pools; some specimens have been collected near woody debris in pools. Iowa streams where I have found Redfin Shiners have typically had at least small amounts of aquatic vegetation. Thus, sampling for Redfin Shiners in 2021, although it included sampling of all habitat types present at a given location, was focused on deeper and slower runs, pools, backwaters, and stream inlets that I considered most likely to hold Redfin Shiners.

Results of surveys for the Redfin Shiner in 2021: Redfin Shiners were found at four of the 37 Iowa stream sites sampled in 2021 where this species had been collected from 1981–83 (Figure 6). Follow-up sampling in September and October 2021 at nine sites (repeat sampling at four of the 1981–83 sites and sampling at five new sites) did not produce Redfin Shiners. Field photographs were taken of specimens of Redfin Shiners from all four sites (Figure 7); Figure 8 shows the four Iowa streams and habitats from which Redfin Shiners were collected. Although sampling at all four sites was conducted with both seines and a backpack electrofisher, seining resulted in capture of Redfin Shiners at three of the four sites. At three of the four sites where Redfin Shiners were collected in 2021, sampling had been conducted from about 45 minutes to over an hour before specimens of Redfin Shiner were encountered. This pattern is similar to that mentioned 130 years ago by Call (1892) in his account for Redfin Shiner (as *Notropis umbratilis*) found in the Des Moines River basin in central Iowa: "This small but well-defined form is common in occurrence but somewhat rare in point of numbers, three or four specimens alone rewarding patient and continued search."

Review of historical records: Updating the status of a species requires careful review of historical records of its occurrence. A review of Iowa's fish databases,[5] as well as a review of both non-databased records from the literature and field notes, produced a total of 194 Iowa records for Redfin Shiner from 1889 to 2021. My review of these 194 historical records produced several questionable unvouchered records. Most of the questionable records were generated as part of fish surveys after 1950, with several reports of Redfin Shiner from watersheds where the species had neither been reported before nor

[5] Iowa's Aquatic Gap database (Loan-Wilsey et al. 2005) and the Iowa DNR's BioNet database (https://programs.iowadnr.gov/bionet/).

Figure 8. The four (of the 37 historical) sample sites where Redfin Shiners were collected during June 2021.

Little Wapsipinicon R. at Lylahs Marsh Pk., 3.2 mi. NW of Elma, Howard Co, IA. One Redfin Shiner was collected on 9 June 2021 below the marsh outflow in pool at left.

Bear Creek 3.5 mi. S of Independence, Buchanan Co., IA. Nineteen Redfin Shiners were collected on 23 June 2021 but only under the bridge.

Bear Creek, 4 mi. WSW of Rowley, Buchanan Co., IA. Five Redfin Shiners were collected on 23 June 2021 from a pool near where Konrad Schmidt is standing in the photo on the right.

Buck Creek, 4.5 mi. NE of Readlyn, Bremer Co., IA. Four Redfin Shiners were collected on 30 June 2021 but only in an isolated bridge pool.

Figure 9. Similar species: comparison of field photos of Redfin Shiners (top row) and Red Shiners (bottom row). Left photos show breeding colors; right photos show non-breeding colors.

had it been reported since, despite relatively good sampling coverage both before and after the questionable occurrence. In contrast, records from before 1950, including those from the late 1800s, were often supported by preserved specimens in fish collections including those of the Chicago Field Museum, the University of Michigan Museum of Zoology, and Iowa State University. I place all 194 historical records into one of four categories: vouchered, accepted, provisional, and rejected.

1. **Vouchered (57 records):** a record supported by preserved material cataloged in a museum collection.
2. **Accepted (99 records):** an unvouchered record within the known Iowa range of the Redfin Shiner as defined in Harlan et al (1987); no concerns regarding correct identification.
3. **Provisional (of questionable validity but used for this project) (16 records):** unvouchered record within the known Iowa range of the Redfin Shiner with evidence suggesting the possibility of misreporting.
4. **Rejected (not used for this report) (22 records):** a geographically and historically isolated and unvouchered record occurring outside the known historical Iowa range of the Redfin Shiner where there are no accepted or provisional post-1900 records occurring in the same HUC-10 watershed.[6]

Based on a review of individual fish survey records, my presumption is that the majority (20 of 22) of the rejected records for Redfin Shiner were erroneous reports due to presence in surveys of morphologically similar and commonly occurring *Cyprinella* species in Iowa (Red Shiner, *C. lutrensis* and Spotfin Shiner, *C. spiloptera*) (Figure 9). A contributing problem—and possibly the primary problem—appears to have been the use by fisheries biologists of the informal common name "redfin shiner" for Iowa's *Cyprinella* species, especially the Red Shiner. Persons databasing fish records from field notes or unpublished lists of fish species may have entered the informal "redfin shiner" as *L. umbratilis*.

PRESUMED AND POTENTIAL EXTIRPATIONS OF THE REDFIN SHINER IN IOWA WATERSHEDS:

The poor success of finding Redfin Shiners in 2021 where they were collected from 1981–83 (found only at four of 37 sites) raises the issue of whether their absence at these historical sites indicates an actual decline in the distribution of the species. As the saying goes, *absence of evidence is not evidence of absence*. In addition to actual absence from an historical site, other reasons for failing to find the species could include gear selectivity or disrepair, the known pattern of scattered occurrence of Redfin Shiners within a watershed, or the variation in population size from year to year.

For purposes of this report, however, the Redfin Shiner was presumed extirpated from HUC-10 watersheds that lacked a valid record for the species during the last 65 years (i.e., since 1955). Potential extirpations were identified in HUC-10 watersheds that lacked a valid record since 2005. HUC-10 watershed with valid records for Redfin Shiner from 2006 to 2021 were included in the current distribution of the species. Based on the results of field work in 2021 and my review of historical fish survey records, I considered the Redfin Shiner as "presumed extirpated" from 23 of the 63 HUC-10 watersheds in Iowa with historical records and as "potentially extirpated" in an additional 29 watersheds (Table 1, Figure 10). The relatively thorough post-1955 fish survey coverage

[6] A HUC (hydrologic unit code) is a unit in a hierarchical system of watersheds created by the US Geological Survey and refined by individual states. Hydrologic unit codes range from two digits (HUC-2) for very large river basins (e.g., the entire Missouri River basin of more than 500,000 square miles) down to 12 digits (HUC-12) for very small subwatersheds that, nationwide, average about 40 square miles in size. HUC-10 watersheds average about 225 square miles in size. Source: Wikipedia.

Table 1. Approach used to identify Iowa HUC-10 watersheds where the Redfin Shiner is presumed extirpated, is potentially extirpated, or is currently distributed.

Watershed Status	Criteria	No. of Iowa HUC-10 watersheds
Presumed extirpation	Valid record from 1890–1955 but no valid records after 1955	23
Potential extirpation	Valid record from 1956–2005 but no valid records after 2005	29
Current distribution	Valid record from 2006–2021	11

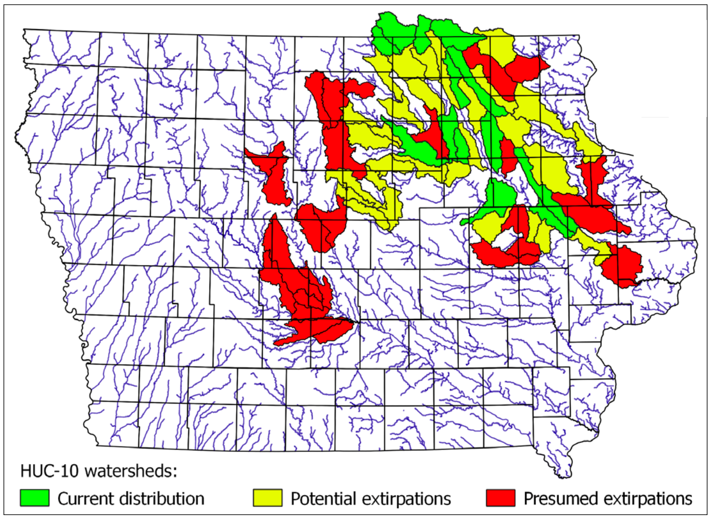


Figure 10. HUC-10 watersheds in Iowa where the Redfin Shiner is either currently distributed, considered potentially extirpated, or considered presumed extirpated.

of Iowa's watersheds suggests that, if the Redfin Shiner was extant in those presumed and potentially extirpated HUC-10 watersheds, it would have been reported as part of post-1955 fish survey work.

My level of confidence in identifying Iowa HUC-10 watersheds as either presumed extirpated or potentially extirpated for the Redfin Shiner varies with (1) the number of years since the most recent record, (2) the number of subsequent fish surveys conducted since the last record for Redfin Shiner, and (3) the source of the information. My confidence is much higher for watersheds where over 100 years have elapsed since the most recent record for the Redfin Shiner. My confidence is lower for lightly surveyed watersheds identified as potentially extirpated with a post-1995 record for Redfin Shiner but no record after 2005. Given the relatively large amount of fish survey work in Iowa, however, especially since the mid-1990s, I feel justified in identifying a potential extirpation for HUC-10 watersheds with an historical record for Redfin Shiner but with no record after 2005. Admittedly, the 15-year timeframe (2006–2021) for identifying the current distribution of the Redfin Shiner in Iowa is brief. Nonetheless, this species has a history in Iowa of relatively rapid elimination from watersheds (e.g., present in the early 1940s in the upper Skunk River basin near Ames and apparently gone by 1950s (Harrison 1950); present in three tributaries of the Iowa River in Hardin County in the early 1980s and apparently gone by 1995 (Kaminski et al. 1995). That is, based on my experience, presence of the Redfin Shiner in a watershed in 2000 in no way suggests that it will be present in 2020. Thus the 15-year window seems reasonable.

CURRENT DISTRIBUTION OF THE REDFIN SHINER IN IOWA

By my estimate, the Redfin Shiner now occupies 11 HUC-10 watersheds: six in the middle and upper portions of the Cedar River basin, three in the Wapsipinicon River basin, and one each in the upper Turkey River basin and the upper portion of the Upper Iowa River (Figure 11). All these HUC-10 watershed are in Level IV ecoregion 47c (Eastern Iowa & Minnesota Drift Plains) (Figure 12). My estimate of the current distribution is possibly too restrictive, and I expect (hope) that records for the species will be produced in future fish surveys in watersheds I have identified as potentially extirpated for Redfin Shiner. Nonetheless, considerable fish survey work has been conducted in these watersheds in recent decades, and the results of those surveys suggest the limited distribution of the Redfin Shiner shown in Figure 11.

Based on a comparison of the number of HUC-10 watersheds in Iowa known to have historically supported Redfin Shiner (63) and the number that currently support the Redfin Shiner (11), the areal decline in its Iowa range likely approaches 80 percent. This is a worst-case scenario. A best-case scenario is that the Redfin Shiner continues to occur in all 29 HUC-10 watersheds where I identified it as potentially extirpated (Figure 10). Although unlikely, this best-case scenario would still suggest an approximately 35 percent areal decline (i.e., gone from 23 of 63 HUC-10 watersheds with historical records).

Potential causes of decline: Although several authors have noted a decline in the distribution of the Redfin Shiner in their respective states, few have offered specific reasons for its decline. Typically, causes identified for declines of Redfin Shiner are the same causes identified for declines of other Midwestern fish species: increasingly intensive agricultural activity in watersheds causing degradation to stream habitats through excessive sediment delivery to, and accumulation in, stream channels (e.g., Smith 1979). The Minnesota DNR, notes that the Redfin Shiner is a peripheral species in the state and acknowledges a "definite decline in both distribution and abundance" of the species in southeastern Minnesota (Minnesota Rare Species Guide). In its list of species of greatest conservation need, the Minnesota DNR describes the status of the Redfin Shiner as follows: "extensive surveys indicate a decline of unknown cause" (Minnesota DNR 2015).

Some authors have suggested more specific causes that are related to the decline of the Redfin Shiner. For Wisconsin, Becker (1983) attributed the elimination of the Redfin Shiner from portions of the upper Rock River system to widespread use of toxicants in a carp control program. Harlan and Speaker (1956) identified the decline in aquatic vegetation in Iowa streams as a factor causing the range of the species in Iowa to decline: "the species has an affinity for stream vegetation, which probably limits its distribution because vegetation in Iowa streams is very rare." Almost certainly, aquatic vegetation in Iowa streams is rarer today than it was in the 1950s. Other authors have also mentioned the association between the Redfin Shiner and aquatic vegetation (e.g., Tomelleri and Eberle 2011, Pflieger 1997, Trautman 1981, and Balon 1975[7]). Trautman (1981) emphasized the importance of riffle

[7] Balon (1975) identifies the Redfin Shiner as a representative of the phytolithophilous guild of non-guarding fishes, thus suggesting an association with both aquatic vegetation and coarse (rocky) substrates.

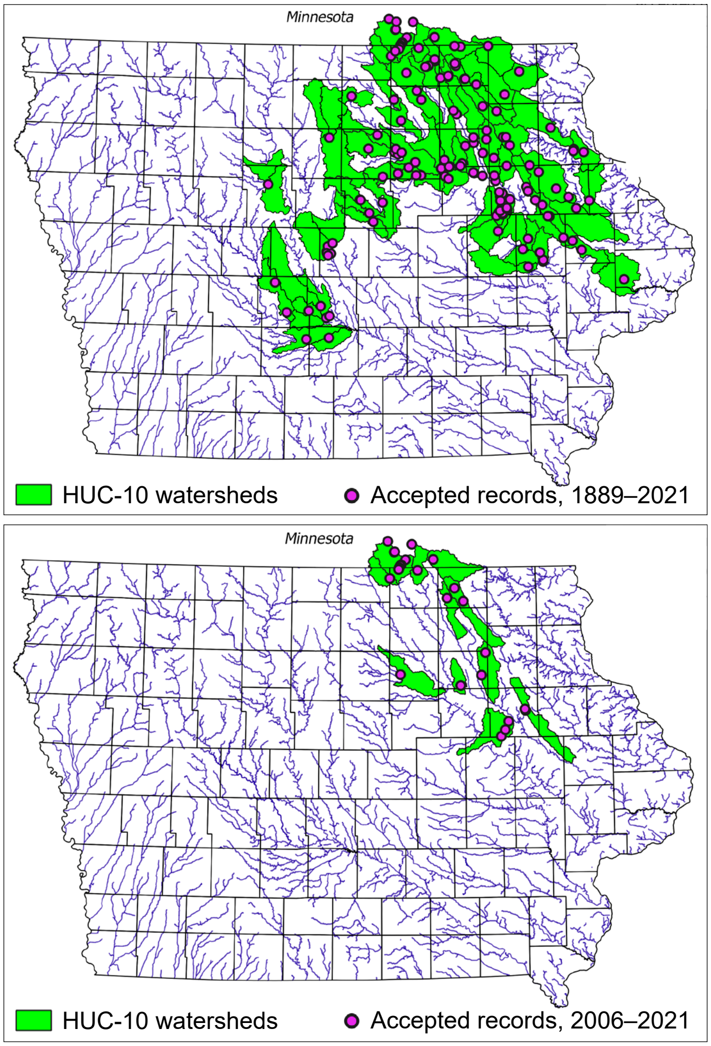


Figure 11. Comparison of historical distribution of the Redfin Shiner in Iowa (top) to the current distribution (bottom). In addition to this project, Iowa records from 2006–2021 are from Berendzen et al. (2008), Sindt et al. (2011), and Iowa DNR Bio-Net. Minnesota records are from 2006–2021 on both maps.

quality to the Redfin Shiner's spawning success:

> It spawned over sand and gravel in sluggish riffles and in pools having currents, apparently utilizing the swifter riffles only when the slower ones had their bottoms silt-covered. It was essentially a pool species after spawning and displayed a preference for submerged aquatic vegetation. When not spawning, it was rather tolerant of turbidity and silted bottoms and displayed marked decreases in abundance in a locality only after the faster riffles became silt-covered.

Given the typically high silt loads of Iowa streams and the resulting embeddedness of riffle substrates, even in higher quality streams, Trautman's statements regarding the spawning success of Redfin Shiners may help explain both the low numbers of specimens per site and the decline of the species in Iowa since the late 19th century.

Although not mentioned in the literature on potential declines in the Redfin Shiner, altered hydrology may play a role in the demise of this species in Iowa. Having sampled 21 of the 37 stream

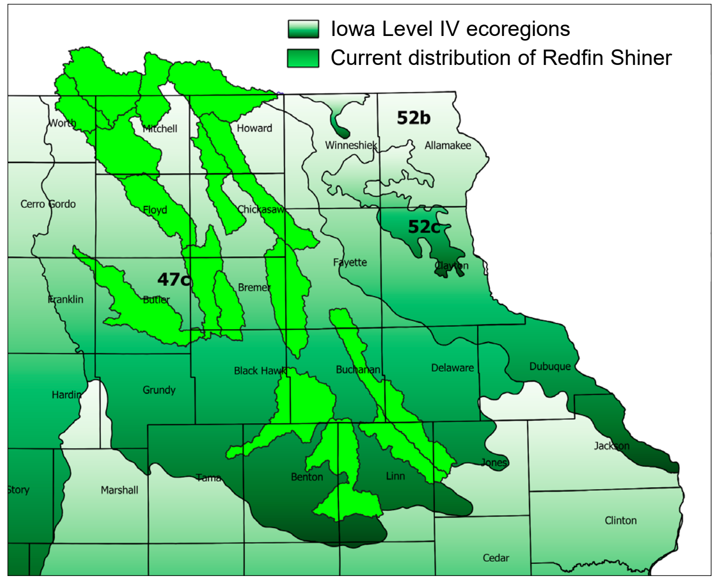


Figure 12. Relationship between the current distribution of the Redfin Shiner in Iowa and Level IV ecoregion 47c (Eastern Iowa & Minnesota Drift Plains).

sites where Redfin Shiners were found in 1981, my impression on revisiting these sites in 2021—approximately 40 years later—was that a general widening and shallowing of the streams had occurred. Descriptions of negative impacts to Iowa fishes from the widening and shallowing of the state's streams go back to the late 19th century (Meek 1892) and have continued through the 20th century (Menzel et al. 1984). The exceptionally high and prolonged stream flows during Iowa's recent record flood events (for example, in 1993 and 2008) may have further altered (widened) stream channels. Increased base flows in Iowa streams in the last half of the 20th century, as described by Schilling (2004) and Ayers et al. (2019), may also adversely affect the Redfin Shiner. Changes in channel form and flow regime may disrupt Redfin Shiner spawning or reduce the quantity of its preferred habitat (slow, deep runs and pools) at critical times of the year.

CONCLUSIONS

The lack of familiarity in Iowa with the Redfin Shiner has allowed the species to decline without much notice. The species has no state listing and was placed on Iowa's list of SGCN species in 2015 primarily due to my recommendation. Based on a worst-case (but certainly plausible) scenario, the distribution of the Redfin Shiner in Iowa has declined to the point that, given a decline over the next 30 years commensurate with the decline over the last 30 years, extirpation from the state's waters is possible. Results of ongoing fish survey programs in Iowa showing few records for Redfin Shiner add support to my conclusions that the Iowa range of this species has decreased significantly since 1990 and that the species is vulnerable to extirpation. An alternative scenario is that the Iowa distribution of the Redfin Shiner has not declined to the degree suggested by my project. That is, this species seems to occur in low numbers at scattered locations within a watershed and thus can be difficult to locate during fish surveys. Thus, Redfin Shiners may be extant in several, if not a significant number, of the HUC-10 watersheds where I have identified the species as potentially extirpated, and its current distribution in the state may thus exceed that presented in Figure 11.

Nonetheless, the factors that have led to the Redfin Shiner's decline in Iowa—a decline that began approximately 100 years ago—will likely continue to adversely affect the species. I feel that listing the Redfin Shiner as state-threatened would be appropriate. Future fish survey work will hopefully improve the accuracy of the distributional picture for this species in Iowa.

ACKNOWLEDGEMENTS

Thanks go to those who assisted with my fish surveys in 2021 for this project: Kelly Poole (Iowa DNR), Konrad Schmidt (Saint Paul, MN), George Cunningham (Omaha, NE), Jay Hatch (Saint Paul), and Iowa State University undergraduate students Megan Fleming and Matt Parry. This project could not have happened without their help. I also appreciate the willingness of the following Iowa DNR Fisheries biologists to respond to and discuss my inquiries regarding historic records for the Redfin Shiner: Scott Grummer, Greg Gelwicks, Dan Kirby, Paul Sleeper, Mark Flammang, Mike Siepker, Andy Fowler, and Adam Thiese.

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DNA UNVEILS NEW FRESHWATER FISH SPECIES IN CALIFORNIA

Peter B. Moyle and Matthew A. Campbell

No doubt you have watched a crime show where DNA analysis reveals the identity of a victim or criminal. Or, you have read accounts of how Neanderthal genes are part of our DNA. It is still astonishing to think that such uses of DNA did not exist until the Human Genome Project, finished about 20 years ago at the cost of millions of dollars. Even more astonishing is that low-cost methods of examining the genome of any animal or plant are now available. Specifically, the genomes of fishes can be examined to determine evolutionary relationships among species and to identify new "cryptic" species of fishes that otherwise are hard to identify. This means that ancient fish biologists (like Moyle) can team up with geneticists steeped in new methodologies (like Campbell) to explore fish genomes. We can identify "new" (to us) species and confirm (or deny) species identified by standard methods, such as counting scales and fin rays.

Moyle's first venture into the genomic world, with postdoc Jason Baumsteiger as his guide, was to explore the genome of California Roach *Hesperoleucus symmetricus*, a small fish endemic to much of central and coastal California. They found that the single species recognized when they started was actually five species (Baumsteiger et al. 2019). In this article, we summarize our findings that the Riffle Sculpin *Cottus gulosus* is also multiple species based on analysis of the genome (genomics) but supported by other genetic, distributional, and meristic studies (Moyle and Campbell 2022).

Freshwater sculpins as a family (Cottidae, 42+ recognized species) are good subjects for genomic analysis because the species are naturally hard to tell apart, being small (usually less than 80 mm in length), with no scales, and with habits and color patterns that keep them camouflaged. Most species are indicators of high-water quality, inhabiting cool, clear streams and lakes throughout the northern hemisphere. Their frequent preference for permanent headwaters leads to isolation and formation of new species, some with ironically hilarious scientific names such as *Cottus perplexus* and *C. confusus*. They are typically abundant and important parts of the ecosystems they inhabit, coexisting with diverse trout and salmon species, as well as other endemic fishes.

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Peter Moyle is an Emeritus Professor and Associate Director of the Center for Watershed Sciences, UC Davis; Matthew Campbell is a Research Scientist in the Genomic Variation Laboratory, UC Davis.

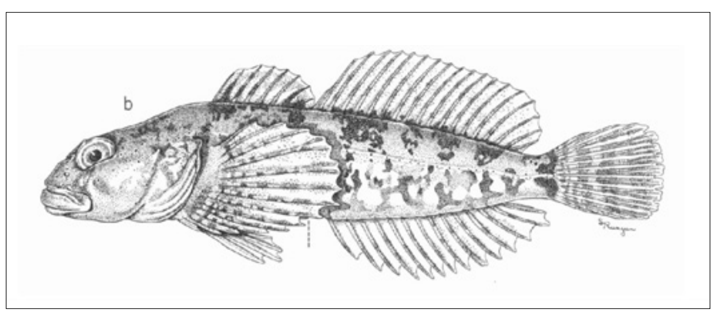
The Riffle Sculpin species "complex" we discuss here consists of the following three species and four subspecies:

Cottus pitensis: Pit Sculpin Bailey and Bond 1963
Cottus gulosus: Inland Riffle Sculpin (Girard 1854)
C. g. gulosus: San Joaquin Riffle Sculpin (Girard 1854), nominate subspecies
C. g. wintu: Sacramento Riffle Sculpin, Moyle and Campbell 2022, new subspecies
Cottus ohlone: Coastal Riffle Sculpin Moyle and Campbell 2022, new species
C. o. ohlone: Ohlone Riffle Sculpin Moyle and Campbell 2022, new subspecies
C. o. pomo: Pomo Riffle Sculpin Moyle and Campbell 2022, new subspecies.

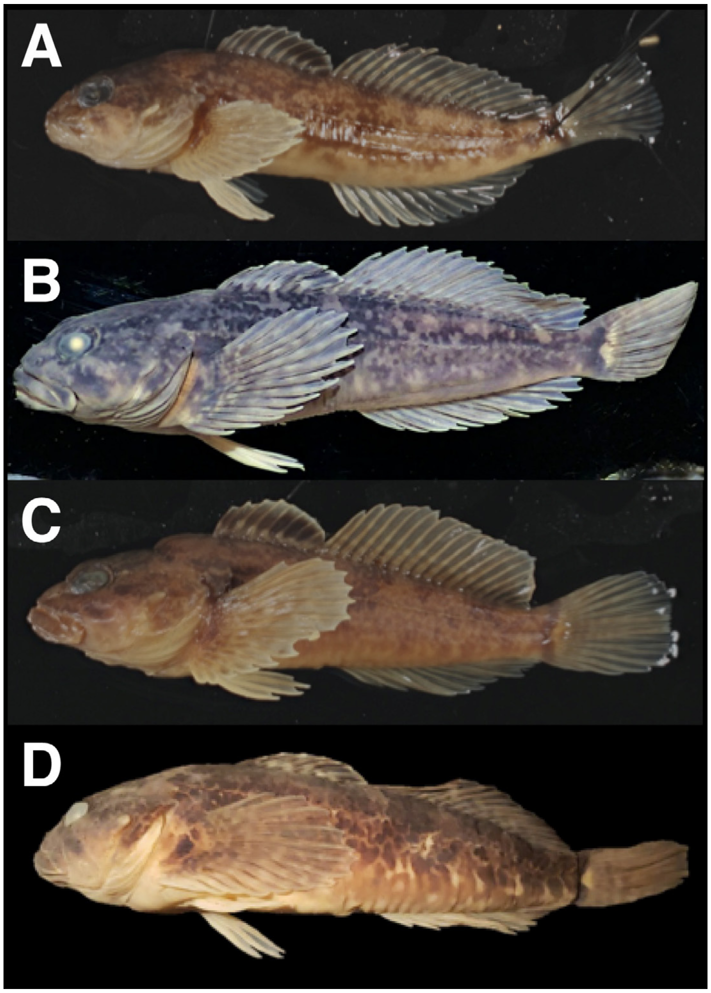
The **Pit Sculpin** was described as a distinct species in 1963 using conventional taxonomic techniques, but its distinguishing features were minor, indicating its close relationship to the Inland Riffle Sculpin. Our genomic study showed that it did indeed merit continued recognition as a separate species. This is the only sculpin species in the Pit River watershed of northeastern California and the tributaries to Goose Lake in Oregon.

The **Inland Riffle Sculpin** was described in 1854 by pioneering ichthyologist Charles Girard. His description was brief and confusing and was applied to all Riffle Sculpins in California (including the Pit Sculpin). Our genomic study showed that Girard's sculpins in the Pit, Sacramento, and San Joaquin rivers and their tributaries, as well as in San Francisco Bay tributaries and the Russian River, were distinct from each other. Girard's description seems to have been mainly based on fish from the San Joaquin River, so *C. gulosus* was retained as the scientific name of the Inland Riffle Sculpin.

Our genomic analysis indicated that the Inland Riffle Sculpin contained two distinct evolutionary lineages that we designated as subspecies because the genetic differences were less than we found between species-level lineages in our data set. Yet the differences



Pit Sculpin, from Bailey and Bond (1963).



Four species/subspecies of riffle sculpin endemic to California. A. San Joaquin Riffle Sculpin, B. Sacramento Riffle Sculpin, C. Ohlone Riffle Sculpin, D. Pomo Riffle Sculpin. (Photos by Irene Englis)

are substantial and correspond to the major river basins, so we recognized the **San Joaquin Riffle Sculpin** *C. g. gulosus* and the **Sacramento Riffle Sculpin** *C. g. wintu*. One outcome of our genomics study was finding that the Sacramento Riffle Sculpin is a hybrid lineage of ancient origin, with a nuclear genome largely of the Inland Riffle Sculpin lineage but with maternally-inherited mitochondrial DNA of the Pit Sculpin type. Surveying only mitochondrial DNA with barcoding approaches would be misleading in this case and is an argument to apply genomic approaches when possible.

Baumsteiger et al. (2012, 2014), in part by using mitochondrial DNA, found that the sculpins in San Francisco Bay drainages were quite different genetically from the inland sculpin populations. This finding is what prompted our study using the more complete genetic picture provided by genomics, which examines the entire genome. Our study led to the designation of coastal and SF Bay populations as a new species **Coastal Riffle Sculpin** *C. ohlone*, with two subspecies, **Ohlone Riffle Sculpin** *C. ohlone ohlone* and **Pomo Riffle Sculpin** *C. o. pomo*. The two subspecies were named to honor the native peoples that lived in the watersheds they occupied, coexisting with the fishes for thousands of years.

Today, the Ohlone Riffle Sculpin lives mostly in the headwater streams of the Guadalupe River, which drains the Santa Clara Valley. These streams flow through and are highly altered by urban areas of San Jose. They also are found in a few small streams that flow directly into the Bay (e.g., Coyote Creek). The Pomo Riffle Sculpin is present in the upper Russian River watershed, above the mouth of Mark West Creek. Their range includes the East Fork Russian River, as well as tributaries to northern San Francisco Bay: Napa River, Petaluma River, Sonoma Creek, and smaller tributaries. These SF Bay streams had connections in the past to the Russian River, via the shifting headwaters of Sonoma Creek. For both subspecies the exact distribution needs to be clarified, as does the status of each isolated population.

Our finding of "new" species and subspecies of sculpin is an example of how genomics can be used to identify cryptic species in the California fish fauna. The five sculpin lineages we have identified cannot, for the most part, be told apart using non-genetic techniques. Furthermore, the use of mitochondrial barcoding techniques would also not have captured the entire picture of sculpin diversity in California. These discoveries increase our appreciation of the uniqueness of California fish fauna, where over 80% of the species are endemic to the state or shared with parts of watersheds in Oregon or Nevada (Moyle 2002, Leidy and Moyle 2022). If these special species are going to be around for future generations to admire, including the species and subspecies of Riffle Sculpin, a way must be found to systematically protect aquatic habitats statewide while surveying for cryptic diversity. There are other cryptic species waiting to be discovered!

Further Reading

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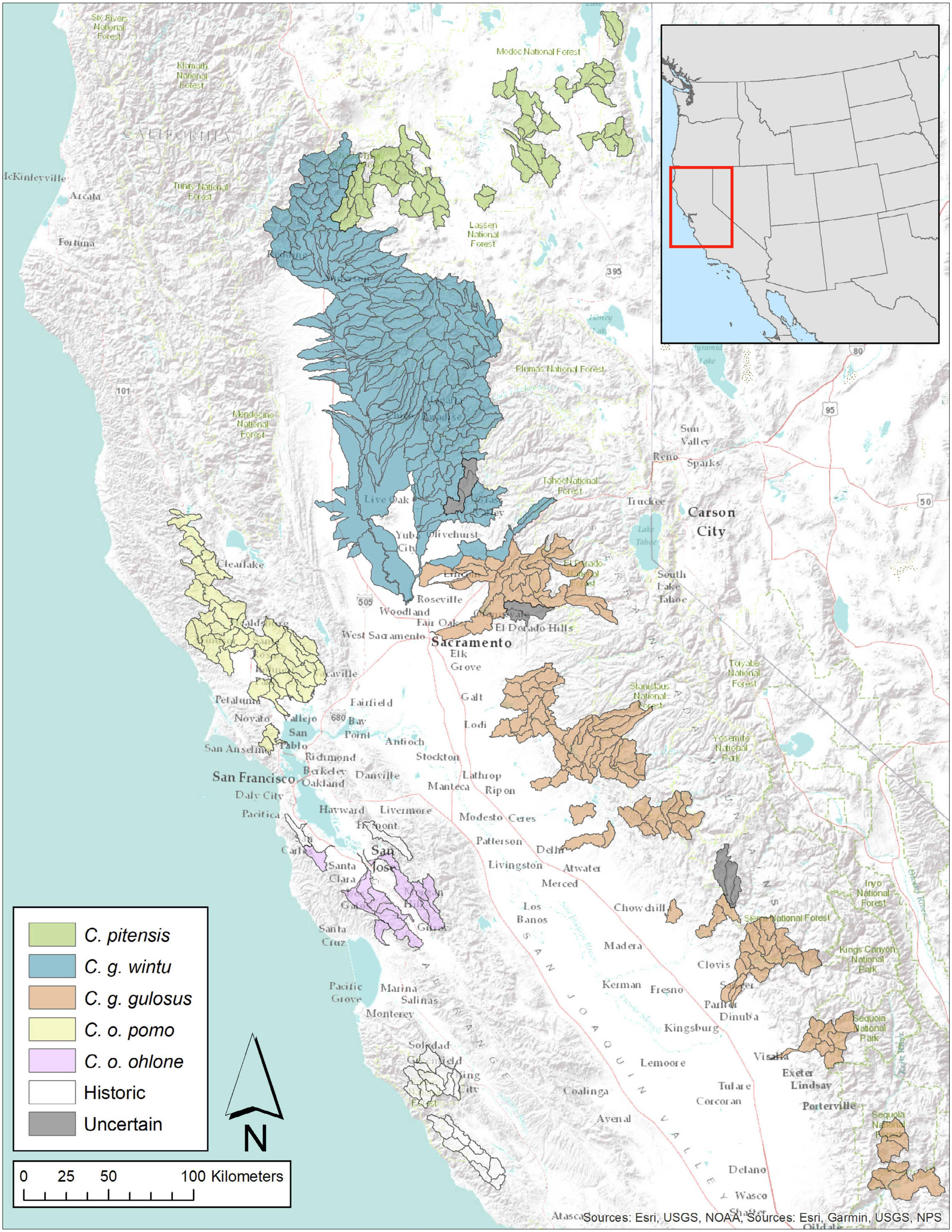
Opposite: Map of current distribution of Riffle Sculpin species/subspecies. Note the fragmentation of distributions, which is the result of habitat alteration by people. From Moyle and Campbell 2022. Map by CWS staff.


C. pitensis
C. g. wintu
C. g. gulosus
C. o. pomo
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Sacramento
San Francisco
Carson City
Reno
Stockton
Fresno
Modesto
Merced
Visalia
San Jose
Monterey
Salinas
Roseville
Lodi

CONSERVATION FISHERIES, INC.: A LIFELINE FOR ENDANGERED AND THREATENED SPECIES

Shannon Murphy

Conservation Fisheries, Knoxville, Tennessee

ABOUT CFI

Conservation Fisheries, Inc. is a non-profit, 501(c)3 organization in Knoxville, Tennessee. Founded in 1986 and incorporated in 1992, CFI is a captive propagation hatchery dedicated to the preservation of aquatic biodiversity in our streams and rivers. Over the last few decades, we have developed techniques to propagate more than 75 non-game fishes, including some of the most imperiled species in the southeastern United States. We were the first private facility in the Southeast to propagate rare, non-game fishes for recovery work.

Our primary goal is to restore fish populations that have been eliminated due to various anthropogenic impacts such as habitat destruction and fragmentation, development and impoundments, unregulated agricultural practices, and sedimentation. Our restoration efforts typically include propagation, rearing, releases, surveying, monitoring, or any combination of these. We also produce many rare or difficult-to-collect species for other purposes related to aquatic conservation such as to be used as hosts for mussel propagation, research projects, and assurance colonies.

We look forward to sharing information about the species we are working with, impacts of our restoration efforts, and how those passionate about native fish conservation can get involved with and support our efforts as a leading conservation organization.

THE HISTORY OF CFI

The catalyst for CFI's work happened years before our organization was founded. In 1957 Abrams Creek in the Great Smoky Mountains National Park was poisoned as part of a misguided reclamation project. To make a more hospitable environment for non-native trophy trout, the poison was introduced in Abrams Creek to remove large fishes thought to be competition. While this effort did clear out the carp, buffalo, and other intended species, it also killed off the smaller fishes in the stream, such as madtoms and darters. While many resistant fish species were able to return to the stream, several smaller and more sensitive species were found to be extirpated.

After a handful of preserved specimens from the misguided Abrams Creek reclamation project made their way to the University of Michigan Museum of Zoology, madtom expert William "Ralph" Taylor discovered that there was a madtom specimen that was previously undescribed. In other words, new to science! It was first assumed to be a Brindled Madtom *Noturus miurus*, but after realizing that the Brindled Madtom range didn't extend to that part of the Smoky Mountains, Ralph knew it must be a different species. Calling them Smoky Madtom *Noturus baileyi*, Ralph traveled to Tennessee in 1959 to see if he could find any existing populations. Unfortunately, no populations were found, and the Smoky Madtom was assumed extinct.

About 20 years later, Gerry Dinkins, a graduate student at the University of Tennessee, Knoxville, was leading a seining crew of the Young Adult Conservation Corps workers and discovered a population of Smoky Madtom in nearby Citico Creek—the only population of this species ever found! In the same creek, while snorkeling at

Evan Poellinger photographing fish while snorkeling. (Photo by Derek Wheaton)

Yellowfin Madtom. (Photo by Evan Poellinger)

Smoky Madtom. (Photo by Derek Wheaton)

Crystal Darter. (Photo by Derek Wheaton)

night he later found a population of Yellowfin Madtom *N. flavipinnis*, which was also thought to be extinct at that time.

Elsewhere, our eventual co-founders, Pat Rakes and J.R. Shute, both had environmentally fueled childhoods. While Pat started keeping aquariums at a younger age, J.R.'s first personal aquarium was during his college years. They each eventually moved to Knoxville, Tennessee, to receive their Masters in Zoology at UT-Knoxville, working under the famed ichthyologist Dr. David Etnier. As the two were finishing up their respective degrees, Dr. Etnier approached them about reintroducing the Smoky Madtom and Yellowfin Madtom back into Abrams Creek by way of propagation. This project was to be funded by the US Fish & Wildlife Service in an attempt to restore some of the original biodiversity to this stream. As Pat and J.R. were both avid aquarists and trained ichthyologists, they seemed like the perfect pair for the job!

From there, a passion was born in the two biologists who both noticed a need for native fish propagation—a niche that they decided to fill. Thirty-seven years later CFI has grown from being a few tanks in a graduate student's office at the University of Tennessee, Knoxville, journeying through many other temporary locations including the back of J.R.'s aquarium store, and finally ending up in our current 5,000 square-foot building just a few minutes down the road from the university. Several years ago we added Derek Wheaton and Evan Poellinger to our team, both incredible biologists who credit NANFA with their lifelong passion for native fishes and who likely wouldn't be a part of our team today without NANFA's influence. CFI has been steadily growing as an organization, adding even more biologists to our team, and we look forward to a facility expansion in the near future to allow us to work with even more native, non-game species.

SPECIES SPOTLIGHT: CRYSTAL DARTER
CRYSTALLARIA ASPRELLA

The Crystal Darter is not federally listed but is listed as Endangered in the states of Wisconsin, Florida, and Missouri. In Minnesota and Arkansas it is listed as a Species of Concern, and is considered extirpated in Illinois. Its native range includes portions of the Mississippi River Basin from Wabash River, Indiana, to southeast Oklahoma, and south to southern Mississippi, northern Louisiana, and southeast Oklahoma. It can also be found in the Gulf Slope in Escambia, Mobile Bay, Pascagoula, and the Pearl River drainages in Florida, Alabama, and Mississippi.

CFI's work with Crystal Darter ran from 2014–2017, and again from 2021–2022 to develop propagation protocols for a surrogate species for the federally Endangered Diamond Darter *C. cincotta*. Crystal Darter and Diamond Darter are the only members of the *Crystallaria* genus, so although Crystal Darter is a species of concern, it is more ethical to develop propagation protocols using this more common species before working with the extremely rare Diamond Darter.

To develop propagation protocols, we first needed to set them up in tanks in a way that mimics their natural environment, both in terms of water quality and habitat. Most species require an adequate amount of cover in their tanks, but Crystal Darter is different in that it burrows in the substrate rather than use structures for cover. Therefore, their tanks were void of cover, but with plenty of specialty, uniformly sized substrate to allow for sufficiently oxygenated water flow throughout, both for the burrowing adults and their eggs.

We passively collected larval fish, meaning we allowed the eggs to hatch in the tanks with their parents, then collected the pelagic larval fish via a drain flow system. Larval fish would then be transferred to large, round, black tubs for rearing. We observed a high number of larval mortalities in their rearing tubs, which led us to observe that they were not feeding well. To fix this, we added green water (diluted algae) to their tubs, which we believe allowed for less light to be reflected into the rearing tub, allowing the larval fish to see their food better while also decreasing stress. After this change, we noticed a significant decrease in larval mortality. Past this point, the Crystal Darter gave us little trouble, and we ended the spawning season with hundreds of juvenile fish.

As larval fish, Crystal Darter started out eating marine rotifers. As they became a few days old, we supplemented brine shrimp into their diets. Both of these live foods require some level of saltwater, so when they were added to a freshwater recirculating system, they would eventually die and begin to decompose if not eaten by the larval fish. This required meticulous cleaning of the rearing tubs. To combat this, we also fed freshwater *Ceriodaphnia* to our larval fish, which, if not eaten, will stay alive in the rearing tubs. As the Crystal Darter got larger, we began feeding them *Daphnia* and Grindal Worms. Adult Crystal Darter were fed Daphnia, blackworms, and frozen bloodworms.

CFI doesn't anticipate working with this species again because we feel confident about the propagation protocols that we've developed, but we hope to be able to try our hand at propagating Diamond Darter very soon.

KEEP IN TOUCH:
Website: conservationfisheries.org
Facebook: facebook.com/cfishinc
Instagram: @conservation.fisheries

WELCOME, NEW MEMBERS!

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FISHES OF WISCONSIN POSTERS

The University of Wisconsin Zoological Museum has some amazing fish posters for sale. The 13-foot canvas poster shows all 183 species found in the state, at life size, and costs $150. Nine smaller posters, each depicting a subset (eight show families: the sunfishes, the pikes, the perches, the gars, the suckers, the salmonids, the catfishes, and the minnows; "The Little Fishes of Wisconsin" includes 16 families) are also available. The excellent art is by Kandis Elliot, UW-Senior Artist Emerita, and reference photos were provided by NANFA member John Lyons. See https://charge.wisc.edu/zoology/items.aspx for more info.

THE NORTH AMERICAN NATIVE FISHES ASSOCIATION

DEDICATED TO THE APPRECIATION, STUDY AND CONSERVATION OF THE CONTINENT'S NATIVE FISHES

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The North American Native Fishes Association is a 501(c)(3) not-for-profit, tax-exempt corporation that serves to bring together professional and amateur aquarists, anglers, fisheries biologists, ichthyologists, fish and wildlife officials, educators, and naturalists who share an interest in the conservation, study, and captive husbandry of North America's native fishes. A portion of each member's dues helps support three important initiatives: NANFA's Conservation Research Grant Program, which funds research on the biology and conservation of North America's most neglected and imperiled fishes; the Gerald C. Corcoran Education Grant, which funds educational outreach programs aimed at children and the general public; and the John Bondhus Conservation Grant, which supports organizations and groups working to conserve native fish populations.

MEMBER BENEFITS

- ***AMERICAN CURRENTS,*** a quarterly publication featuring articles and news items on collecting, keeping, observing, conserving, and breeding North American fishes.
- **REGIONAL NANFA CHAPTERS.** State and regional aquarium groups where members may get together to collect and discuss native fishes, remove exotics, and perform conservation and stream restoration work.
- **NEW MEMBER PACKET.** An 8-page newsletter that's sent to new NANFA members introducing them to NANFA, and to the fascinating world of collecting, keeping and conserving North America's native fishes.
- **ANNUAL CONVENTION.** Where NANFA members from around the country meet for lectures, collecting trips, auctions, fun and finship.
- **GRANT FUNDING.** Only NANFA members can apply for NANFA's Conservation Research Grant and Gerald C. Corcoran Education Grant programs. For details, see NANFA's website (www.nanfa.org), or contact Dr. Bruce Lilyea, Conservation Grant Chair, 863-513-7611, bruce.lilyea@gmail.com, or Scott Schlueter, Education Grant Chair, scott_schlueter@hotmail.com.

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