CAPTIVE CULTURE AND HUSBANDRY OF NORTH AMERICAN FISHES

Ray Katula

Onalaska, Wisconsin

I have been breeding native fishes in captivity for 55 years starting when I was 10 years old. In that time, I have successfully spawned 166 species in 18 families (Appendix I). My first species was the Rio Grande Cichlid *Herichthys cyanoguttatus*.

My fish room currently contains thirty aquariums ranging in size from five to 70 gallons. It is in an extra room behind my detached garage (Figure 1), which is handy for keeping smells and free-flying fruit flies out of the house, which in turn sustains a healthy marriage. My primary source of aeration and filtration is a regenerative blower with an overhead PVC system of valves providing air; 90% of the tanks have under-gravel filtration systems. In addition, I use some powerheads and box filters when the need arises.

All aquarium lights are on timers. During the winter the aeration blower provides most of the heat necessary to maintain native fishes. During the summer I use a window air conditioner to keep water temperatures from getting too warm.

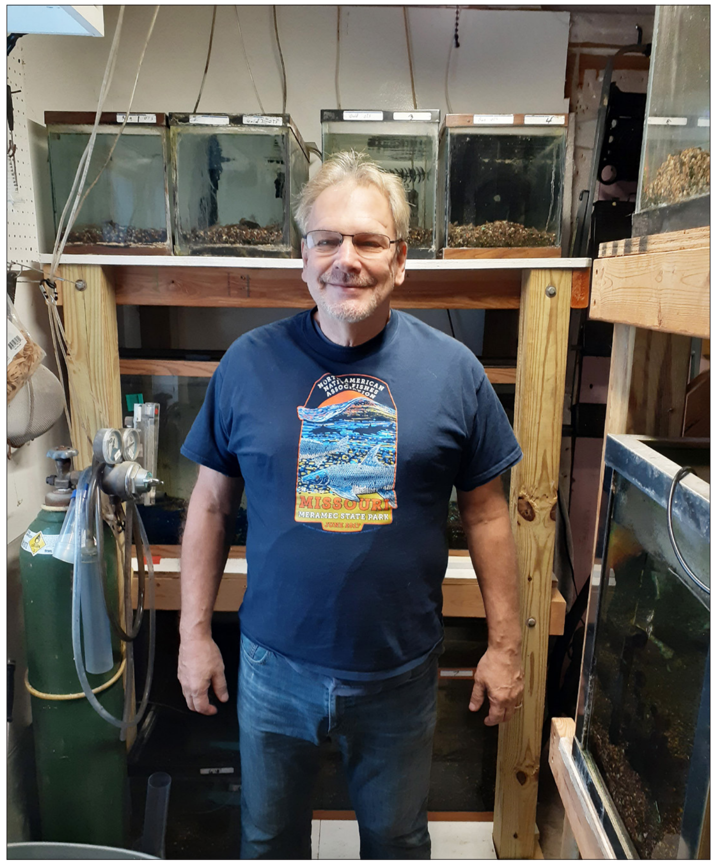
What I do with my fish seems to work for me and whatever works for others is great. I generally try to follow the KISS method: "keep it simple stupid." I have at times implemented fancy fry extraction methods but honestly the simple methods work very well for me.

I believe that three primary parameters help induce or "condition" fish to spawn: diet, temperature, and to a lesser extent, photoperiod.

Diet is extremely important for spawning and maintaining fish in good health. Live foods are sometimes necessary for certain species. However, where applicable, prepared dried foods enhanced with vitamins will deliver the same results. I have used

Photos by the author unless otherwise indicated.

NANFA Fellow (and past president) Ray Katula is an R&D Technician at Celanese Corporation. He has a degree in Business Management from Minnesota Southeastern Technical College. He had his first exposure to North American fishes while growing up literally on the banks of the Mississippi River. Ray is a charter member of NANFA: he joined at age 11 and at 13 attended NANFA's first annual meeting with founder John Bondhus, who flew them in his private plane. In the 1970s he dabbled in selling fish for the aquarium trade. Ray lived for several years in California and Oregon, where he collected and studied native fishes of the west coast and traded when possible for eastern species. He has written several scientific publications and contributed articles to *Tropical Fish Hobbyist, Freshwater and Marine Aquarium Magazine,* and, last but not least, *American Currents.* He has kept fish for 55 years and was John Bondhus' fish hatchery manager in southeastern Minnesota. Ray's primary focus is studying fish behavior and breeding native fishes.



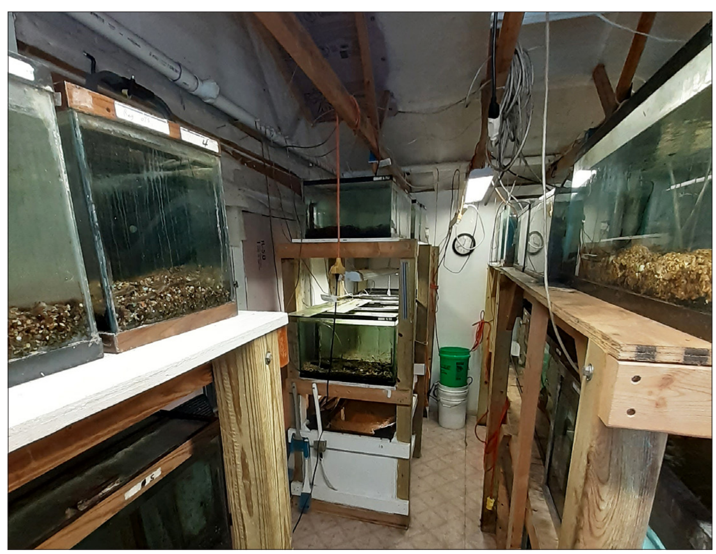


Figure 1. Top: Ray Katula in his fish room (photo by Lisa Katula). Bottom: Ray's fish room.

Figure 2. Bleeding Shiner with tubercles.

Figure 3. Male Gilt Darter. (Photo by Konrad Schmidt)

prepared foods made at home to induce Bleeding Shiner *Luxilus zonatus* to develop tubercles and spawn in the fall (Figure 2).

I once depended heavily on several live foods including blackworms, brine shrimp, glassworms (phantom midge larvae), fruit flies, daphnia, mosquito larvae, mealworms, and earthworms. However, I have found the availability of many of these live foods to be intermittent and seasonal. Cultured live foods (e.g., white worms) required more time and effort than I could spare.

Most of the species I keep are darters. They will not consume dried foods, and I use frozen foods often to condition them. The menu options include brine shrimp, bloodworms, and what I call my secret weapon: glassworms. Besides regular worms (i.e., annelids) glassworms contain more protein than any other source of food. The other benefit of glassworms is that they drift throughout the water column rather than sink and therefore are more likely to be consumed before fouling the water. Most native fishes from temperate zones in North America annually experience a cooling period when they become much less active and require fewer feedings. During the winter my fish room hovers around 40° F, and I'll feed a small amount once a week.

Temperature conditioning is required to mimic winter. Without a winter period many species will not spawn or will produce eggs prematurely or will produce insufficient numbers to raise offspring successfully. In the past I have used unorthodox methods to simulate overwintering periods. I confess that, in the past when I kept my fish in the basement, I have left windows open to cool down my fish rooms. Hello heating bills!! When I lived in northern California, I would keep natives in my garage, which was well insulated, and every evening I would leave the door open for a while or a service door with a fan to cool the garage. Northern California would always get cool winds at night and these winds helped the tanks remain cool throughout the next day.

As mentioned before, my current fish room is an extra room off the back of my garage, and which cools down somewhat in winter. It is well-insulated and the regenerative blower gives off some heat, but during periods of extreme cold, I use a small heater that may be needed two weeks a year. In the summer I tend to use a window unit air conditioner and rarely need anything more to maintain preferred temperatures. Having said that, manipulating temperatures can induce spawning in most species. I have seen many species, either in my set-up or those of friends, that were induced outside their normal spawning times by modifying temperatures. I have seen several species of darters that typically spawn in the fall be temperature-induced to spawn outside their normal spawning time: Lollypop Darter *Etheostoma neopterum,* Arkansas Darter *E. cragini,* and Slabrock Darter *E. smithi.* In addition, Rainbow Shiner *Notropis chrosomus* and, as I mentioned above, Bleeding Shiner can also be induced to spawn outside their normal spawning times through temperature manipulation.

Another way of lowering temperatures is using an aquarium chiller. I believe these units are useful for cooling tanks to keep coldwater fish at preferred temperatures and to have fish display better colors. If the intention of using a chiller is to simulate wintering conditions it may not be that effective in a typical household environment since most chillers maintain an ambient temperature of ten degrees cooler then surrounding temperatures. Many species will require more than this to "condition" them for spring spawning. Another shortfall is that the affordable models are typically designed for just one aquarium and are thus useless for multiple aquariums in a fish room.

Lighting, in my opinion, is one of the least important catalysts for spawning fish. Extending hours of light to duplicate longer hours of daylight in the spring into summer obviously would be more "natural" to the fish, but is it completely necessary? I do not believe so. Even though not a critical factor I try to mimic the change in seasons by altering the photoperiod four times a year in my fish room. More importantly, a rich diet and warming temperatures are essential for triggering most species to spawn whether they receive 4 or 16 hours of light a day. However, modifying the intensity of light is useful for maximizing species' coloration. Most minnows prefer low light levels. Darters, on the other hand, seem to display better with brighter lighting, and sunfish, well, they are called sunfish for a reason. Some species wear only one suit all year but prefer low light levels (e.g., Burbot *Lota lota,* Trout-perch *Percopsis omiscomaycus,* Pirate Perch *Aphredoderus sayanus,* madtoms *Noturus* spp., and sculpins *Cottus* spp.).

Another minor parameter in inducing spawning behavior is water flow. Some species require fast flows to maintain health (e.g. Gilt Darter *Percina evides* (Figure 3), saddled darters, Blue Sucker *Cycleptus elongatus,* and some species of madtoms). Conversely, slow flows are the preference for pygmy sunfish *Elassoma* spp., killifish (topminnows), and mudminnows. Topeka Shiner *N. topeka* proved to be a little tricky in terms of cracking their spawning code. The species typically inhabits quiet pools of streams but would not spawn until water flow was added to the aquarium.

Water chemistry, particularly pH and water hardness, is often crucial to assure spawning in many species. As a general rule, species from soft water can often adjust to harder water,

Figure 4. Spotfin Shiner eggs in driftwood crevice.

but species from hard water do not fare as well when acclimating to soft water.

Over the years I have found several spawning structures or props that greatly improve egg viability and hatching success. The structures provide surfaces for adhesive eggs or protection from parents and other aquarium associates. Spotfin Shiner *Cyprinella spiloptera* are cavity nesters, and the crevices in driftwood are natural surfaces where the species can deposit their eggs (Figure 4).

Many species will readily use artificial spawning structures as alternatives. Spotfin Shiner will also utilize my favorite design of spawning mops, plastic lids, and pebble nests (Figure 5). Johnny Darter *E. nigrum* will deposit eggs on the ceiling of a cave. They will also use mussel shells, and once I found eggs in a suspended sponge filter, which actually worked well with continual aeration provided from water flowing through the porous surface. Last but not least, I have had Johnny Darter lay eggs on the bare slate bottom of an aquarium and the male remained there to guard the eggs without a shred of cover.

Northern Redbelly Dace *Chrosomus eos* used spawning grass and green yarn mops as substitutes for aquatic plants but "settled for" pebbles when no plants were provided. I have Flame Chub *Hemitremia flammea* often spawn over pebbled nests. However, *Fishes of Tennessee* (Etnier and Starnes 1994) reported what appeared to be a spawning aggregation in a flooded pasture. I simulated both habitat types, and the Flame Chub did seem to prefer the grass. Topeka Shiners are considered obligate sunfish nest spawners leaving the sunfish to guard the eggs. I found that Topekas will spawn in sunfish-less pebble nests. However, as mentioned earlier, the other trigger needed was providing current using a powerhead. Many species have ancient evolutionary preferences where they spawn but will hop in a different bed when necessary.

I have also modified the pebble nest using a container with an air stone and filled with variety of substrates. Pebbles simulate sunfish and chub nests. Gravel can be substituted (instead of larger pebbles) for darters and several species of minnows and sand for several species of pupfish. I have found that loose sand actually works better than spawning mops for pupfish. The pupfish find it more difficult to locate and consume their eggs in sand versus a spawning mop; therefore, I achieve greater yields of fry. Several types of spawning props are also available in pet stores such as the "ages-old" spawning mops and plastic grass-like clumps. Both work for killifish and mudminnows which attach eggs to plants and algae (Figure 6).

Rocks with numerous holes and crevices are ideal for snubnose darter species. Many snubnose lay eggs in a straight line, but the problem is if one egg starts to fungus, it soon spreads to all the eggs. PVC pipe cut with grooves can limit fungus infections to a single row. A plastic grid matrix covered with rocks will achieve the same results (Figure 7). A version of this prop worked well on Trout-perch.

Once the eggs hatch, the next step is feeding the fry. As they grow, I advance them through several food stages. For the smallest of fry, I start with green water rich in phytoplankton and zooplankton. I have tried many methods for culturing green water but always found them cumbersome and cultures were difficult to keep active or they became contaminated. After much trial and error, I found that my outdoor ponds produce ample volumes of green water. I have also used five-gallon buckets of water with a green water "starters" of alfalfa pellets, dried grass, or hardwood sticks. Before feeding fry, I pour some of the green water through a 500-micron sieve (Figure 8), which removes any organisms the size of brine shrimp or larger that the fry cannot yet consume. As the fry grow, I switch to foods in the following order: microworms, freshly hatched brine shrimp, frozen cyclops, and finely chopped brine shrimp, glassworms, or bloodworms. Once fry accept the latter foods, I wean minnows onto flake foods and darters onto slightly larger but still diced frozen foods. The fry of many species will accept microworms and brine shrimp without the requirement of starting with green water.

It is problematic maintaining good water quality with fry present. Siphoning when changing water inadvertently risks removing fry. Adding Ramshorn Snails is one trick I use to help clean the nursery tanks. The snails serve as substrate scavengers removing debris, but this debris could also include newly hatched fry that congregate on the surface of the gravel. Minnows and many darters begin free swimming within days of hatching and snails can safely be added at that time.

Figure 5. Alternative spawning structures: spawning mop, plastic lid for pebbles, and pebble nest.

Figure 6. More alternative spawning structures: substrate nest box, typical spawning mop, plastic grass-like clumps.

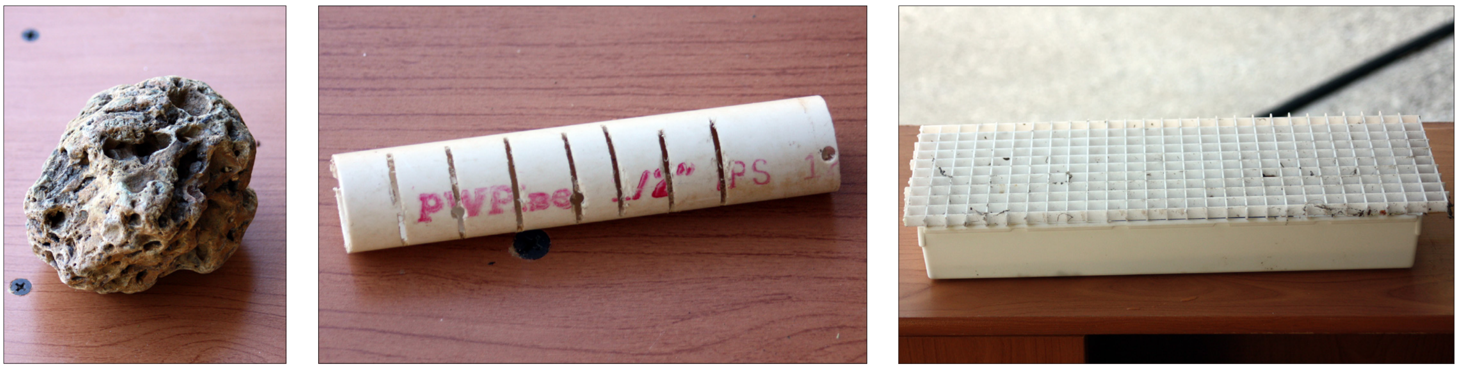


Figure 7. More alternative spawning structures: crevice and hole-riddled rock, PVC pipe with spawning grooves, plastic grid matrix.

Figure 8. 500-micron sieve for filtering large zooplankton from green water.

Figure 9. Pirate Perch. (Photo by Konrad Schmidt)

Several problems, including belly sliders and scoliosis, can be encountered when culturing fish. Belly sliders are often blamed on inbreeding, but I have observed it in larval fry when they fail to take their first gulp of air at the surface to inflate their swim bladders. A common cause of belly sliding is an oily film on the surface of the aquarium water. I have seen this from time to time in the fry of Pirate Perch (Figure 9) and Arrow Darter *E. sagitta*.

Another problem that frequently occurs is scoliosis, which is the curvature of the spine that deforms the body. Inbreeding may again play a role, but I have seen this condition in the first generation of many species from wild populations. One batch of Ninespine Stickleback *Pungitius pungitius* exhibited scoliosis in nearly half of the offspring (Figure 10). Darters and killifish

Figure 10. Ninespine Stickleback. (photo by Konrad Schmidt)

suffer less from this condition.

I have tried, tested, and achieved a great deal of success using the methods described here. I have published 35 articles about captive culture and husbandry in many publications such as *Tropical Fish Hobbyist, Freshwater and Marine Aquarium, Copeia,* and the *Virginia Journal of Science*. However, most of my articles have been published in *American Currents* and are available for viewing on the magazine's archives page at http://nanfa.org/ac2.shtml. A Google search of my name will also return many articles on the site.

Literature Cited

Etnier D.A. and W.C. Starnes. 1994. Fishes of Tennessee. University of Tennessee Press 681 p.

Appendix I: Ray Katula's captive culture species list. Note: * indicates multiple populations; † indicates multiple subspecies.

Common Name	Scientific Name
Minnow Family—Leuciscidae	
Northern Redbelly Dace	*Chrosomus eos*
Southern Redbelly Dace	*Chrosomus erythrogaster**
Finescale Dace	*Chrosomus neogaeus*
Mountain Redbelly Dace	*Chrosomus oreas*
Redside Dace	*Clinostomus elongatus*
Rosyside Dace	*Clinostomus funduloides†*
Lake Chub	*Couesius plumbeus*
Bluntface Shiner	*Cyprinella camura*
Blue Shiner	*Cyprinella caerulea*
Whitetail Shiner	*Cyprinella galactura*
Red Shiner	*Cyprinella lutrensis*
Spotfin Shiner	*Cyprinella spiloptera*
Tricolor Shiner	*Cyprinella trichroistia*
Gravel Chub	*Erimystax x-punctatus*
Flame Chub	*Hemitremia flammea*
Cardinal Shiner	*Luxilus cardinalis*
Common Shiner	*Luxilus cornutus*
Duskystripe Shiner	*Luxilus pilsbryi*
Bleeding Shiner	*Luxilus zonatus*
Orangefin Shiner	*Notropis ammophilus*
Rainbow Shiner	*Notropis chrosomus*
Ozark Minnow	*Notropis nubilus*
Carmine Shiner	*Notropis percobromus**
Saffron Shiner	*Notropis rubricroceus*
Topeka Shiner	*Notropis topeka*
Bluntnose Minnow	*Pimephales notatus*
Fathead Minnow	*Pimephales promelas*
Bullhead Minnow	*Pimephales vigilax*
Broadstripe Shiner	*Pteronotropis euryzonus*
Sailfin Shiner	*Pteronotropis hypselopterus*
Orangetail Shiner	*Pteronotropis merlini*
Flagfin Shiner	*Pteronotropis signipinnis*
Longnose Dace	*Rhinichthys cataractae*
Umpqua Dace	*Rhinichthys evermanni*
Leopard Dace	*Rhinichthys falcatus*
Western Blacknose Dace	*Rhinichthys obtusus*
Speckled Dace	*Rhinichthys osculus*
Tetra Family—Characidae	
Mexican Tetra	*Astyanax mexicanus*
North American Catfish Family—Ictaluridae	
Yellow Bullhead	*Ameiurus natalis*
Tadpole Madtom	*Noturus gyrinus*
Least Madtom	*Noturus hildebrandi lautus*

Common Name	Scientific Name
Trout and Salmon Family—Salmonidae	
Rainbow Trout	*Oncorhynchus mykiss**
Brown Trout	*Salmo trutta*
Brook Trout	*Salvelinus fontinalis*
Mudminnow Family—Umbridae	
Olympic Mudminnow	*Novumbra hubbsi*
Central Mudminnow	*Umbra limi*
Eastern Mudminnow	*Umbra pygmaea*
Trout-perch Family—Percopsidae	
Trout-perch	*Percopsis omiscomaycus*
Sand Roller	*Percopsis transmontana*
Pirate Perch Family—Aphredoderidae	
Pirate Perch	*Aphredoderus sayanus†*
Cod Family—Gadidae	
Burbot	*Lota lota*
Goodeid Family—Goodeidae	
Butterfly Goodeid	*Ameca splendens*
White River Springfish	*Crenichthys baileyi†*
Topminnow Family—Fundulidae	
Banded Killifish	*Fundulus diaphanus*
Northern Studfish	*Fundulus catenatus*
Golden Topminnow	*Fundulus chrysotus*
Banded Topminnow	*Fundulus cingulatus*
Russetfin Topminnow	*Fundulus escambiae*
Lined Topminnow	*Fundulus lineolatus*
Blackstripe Topminnow	*Fundulus notatus*
Blackspotted Topminnow	*Fundulus olivaceus*
Plains Topminnow	*Fundulus sciadicus**
Southern Studfish	*Fundulus stellifer*
Pygmy Killifish	*Leptolucania ommata*
Bluefin Killifish	*Lucania goodei*
Rainwater Killifish	*Lucania parva*
Pupfish Family—Cyprinodontidae	
Desert Pupfish	*Cyprinodon macularius*
Salt Lake Pupfish	*Cyprinodon salinus*
Sheepshead Minnow	*Cyprinodon variegatus*
Amargosa Pupfish	*Cyprinodon nevadensis*
Flagfish	*Jordanella floridae*
Livebearer Family—Poeciliidae	
Western Mosquitofish	*Gambusia affinis*
Eastern Mosquitofish	*Gambusia holbrooki*
Least Killifish	*Heterandria formosa*
Amazon Molly	*Poecilia formosa*
Sailfin Molly	*Poecilia latipinna*

Common Name	Scientific Name
Stickleback Family—Gasterosteidae	
Brook Stickleback	*Culaea inconstans*
Threespine Stickleback	*Gasterosteus aculeatus*
Ninespine Stickleback	*Pungitius pungitius*
Sculpin Family—Cottidae	
Mottled Sculpin	*Cottus bairdii*
Banded Sculpin	*Cottus carolinae*
Slimy Sculpin	*Cottus cognatus*
Reticulate Sculpin	*Cottus perplexus*
Spoonhead Sculpin	*Cottus ricei*
Sunfish Family—Centrarchidae	
Blackbanded Sunfish	*Enneacanthus chaetodon*
Bluespotted Sunfish	*Enneacanthus gloriosus*
Banded Sunfish	*Enneacanthus obesus*
Pumpkinseed	*Lepomis gibbosus*
Orangespotted Sunfish	*Lepomis humilis*
Bluegill	*Lepomis macrochirus*
Dollar Sunfish	*Lepomis marginatus*
Longear Sunfish	*Lepomis megalotis**
Redear Sunfish	*Lepomis microlophus*
Redspotted Sunfish	*Lepomis miniatus*
Perch and Darter Family—Percidae	
Sharphead Darter	*Etheostoma acuticeps*
Redspot Darter	*Etheostoma artesiae*
Mud Darter	*Etheostoma asprigene*
Cumberland Snubnose Darter	*Etheostoma atripinne*
Emerald Darter	*Etheostoma baileyi*
Splendid Darter	*Etheostoma barrenense*
Orangefin Darter	*Etheostoma bellum*
Greenside Darter	*Etheostoma blennioides†*
Blenny Darter	*Etheostoma blennius*
Brook Darter	*Etheostoma burri*
Rainbow Darter	*Etheostoma caeruleum**
Bluebreast Darter	*Etheostoma camurum*
Greenfin Darter	*Etheostoma chlorobranchium*
Creole Darter	*Etheostoma collettei*
Coosae Darter	*Etheostoma coosae*
Arkansas Darter	*Etheostoma cragini*
Golden Darter	*Etheostoma denoncourti*
Blackside Snubnose Darter	*Etheostoma duryi*
Meramec Saddled Darter	*Etheostoma erythrozonum*
Cherry Darter	*Etheostoma etnieri*
Iowa Darter	*Etheostoma exile*
Fantail Darter	*Etheostoma flabellare*
Saffron Darter	*Etheostoma flavum*
Barrens Darter	*Etheostoma forbesi*
Slough Darter	*Etheostoma gracile*
Harlequin Darter	*Etheostoma histrio*
Blueside Darter	*Etheostoma jessiae*

Common Name	Scientific Name
Perch and Darter Family—Percidae (continued)	
Greenbreast Darter	*Etheostoma jordani*
Yoke Darter	*Etheostoma juliae*
Stripetail Darter	*Etheostoma kennicotti*
Longfin Darter	*Etheostoma longimanum*
Redband Darter	*Etheostoma luteovinctum*
Brighteye Darter	*Etheostoma lynceum*
Redlips Darter	*Etheostoma maydeni*
Least Darter	*Etheostoma microperca*
Sunburst Darter	*Etheostoma mihileze*
Lollipop Darter	*Etheostoma neopterum*
Blackfin Darter	*Etheostoma nigripinne*
Spangler Darter	*Etheostoma obama*
Dirty Darter	*Etheostoma olivaceum*
Candy Darter	*Etheostoma osburni*
Stippled Darter	*Etheostoma punctulatum*
Firebelly Darter	*Etheostoma pyrrhogaster*
Orangebelly Darter	*Etheostoma radiosum†*
Kentucky Snubnose Darter	*Etheostoma rafinesquei*
Alabama Darter	*Etheostoma ramseyi*
Redline Darter	*Etheostoma rufilineatum*
Arrow Darter	*Etheostoma sagitta*
Tennessee Snubnose Darter	*Etheostoma simoterum*
Slabrock Darter	*Etheostoma smithi*
Orangethroat Darter	*Etheostoma spectabile**
Cumberland Plateau Darter	*Etheostoma spilotum*
Spottail Darter	*Etheostoma squamiceps*
Plateau Orangethroat Darter	*Etheostoma squamosum*
Speckled Darter	*Etheostoma stigmaeum*
Gulf Darter	*Etheostoma swaini*
Swannanoa Darter	*Etheostoma swannanoa*
Missouri Saddled Darter	*Etheostoma tetrazonum*
Tippecanoe Darter	*Etheostoma tippecanoe*
Variegate Darter	*Etheostoma variatum*
Redfin Darter	*Etheostoma whipplei*
Banded Darter	*Etheostoma zonale**
Bandfin Darter	*Etheostoma zonistium*
Yellow Perch	*Perca flavescens*
Tangerine Darter	*Percina aurantiaca*
Logperch	*Percina caprodes*
Gilt Darter	*Percina evides*
Blackside Darter	*Percina maculata*
Walleye	*Sander vitreus*
Pygmy Sunfish Family—Elassomatidae	
Everglades Pygmy Sunfish	*Elassoma evergladei*
Okefenokee Pygmy Sunfish	*Elassoma okefenokee*
Banded Pygmy Sunfish	*Elassoma zonatum*
Cichlid and Tilapia Family—Cichlidae	
Rio Grande Cichlid	*Herichthys cyanoguttatus*
Unsuccessful attempts: Oregon Chub, Southern Cavefish, Spring Cavefish, Swampfish, Mud Sunfish, Tule Perch, and Crystal Darter	