NEW RECORDS FOR SLIMY SCULPIN *COTTUS COGNATUS* AND NORTHERN SUNFISH *LEPOMIS PELTASTES* IN THE BOUNDARY WATERS

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This survey was a continuation of Konrad Schmidt's surveys of fishes in the Boundary Waters Canoe Area Wilderness (BWCAW) with a previous trip in 2018 (Olson 2019), three trips in 2019, and two in 2020 (one in July and one in August). Although Kon has said that the long distances and frequent portages to reach some BWCAW lakes made them "a bridge too far" (Schmidt 2018), his recruitment of fellow NANFA members Bob Hrabik, Jay Hatch, George Cunningham, and myself has put at least some within reach. The goals of our August 2020 trip (other than to emerge alive from the BWCAW) were to establish new records for Northern Sunfish *Lepomis peltastes* in lakes of the Rainy River/Hudson Bay drainage and to establish, after two previous attempts, a record for Slimy Sculpin *Cottus cognatus* in the western portion of Lac la Croix that forms the border between Canada and Minnesota. The North American distributions of these species are summarized in Figure 1.

THE AUGUST 2020 FORAY

Kon and I entered the BWCAW on August 19th at Entry Point 14 north of the Echo trail. We spent six days paddling, portaging, and sampling eight lakes over the 44-mile route that Kon had charted. The area we traveled is about 25 miles northwest of Ely, MN, in the western portion of the BWCAW (Figure 2). The 24 portages that totaled a little over 6 miles were a challenge for us somewhat older biologists (Figure 3).

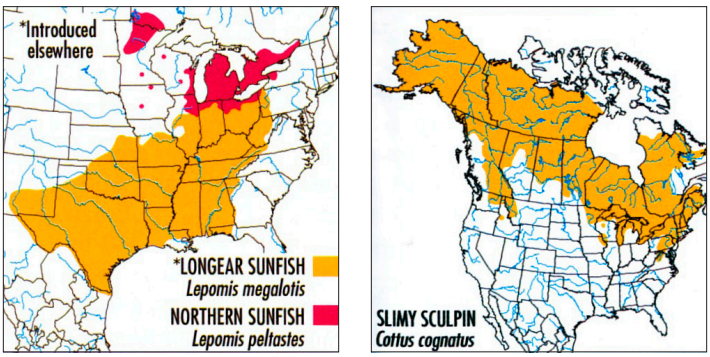

Figure 1. Distributions of the Northern Sunfish, Longear Sunfish *Lepomis megalotis,* and Slimy Sculpin. Maps from Page and Burr 2011:505; 475.

Photos by the author unless otherwise indicated.

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 1981–1984. He has a degree in Animal Ecology from Iowa State with an emphasis in fisheries biology. He assisted with fish surveys while at Iowa DNR, and he continues to pursue his interest in Iowa fishes (and, occasionally, Minnesota fishes) in retirement.

SAMPLING GEARS

In terms of sampling gear, Kon was very well equipped. He and NANFA member Jenny Kruckenberg had constructed two microfyke nets during winter and spring 2020 (Figure 4), and he had purchased two Chinese-made minnow traps for the trip (Figure 5). Ten double-funnel minnow traps (Figure 6) were packed specifically for sampling Slimy Sculpin in Lac la Croix later in the week. In addition, we had Kon's 6x20-foot seine along as well as his dip net for his always effective kick-netting. My lone contribution to our arsenal of sampling gear was my collapsible microfishing pole, a bit of accompanying tackle, and a few dozen waxworms and earthworms.[1] Right or wrong, I used size 22 hooks for microfishing because the smaller sizes—which are recommended by NANFA member and microfishing guru Tim Aldridge—are difficult for me to use with my 67-year-old eyes (even with cheaters) and fat fingers.

All this sampling gear, along with our personal packs, made for a fully loaded canoe. In fact, before we left Kon's home in St. Paul,

Figure 2. Travel path for our 44-mile August 2020 foray into the Boundary Waters Canoe Area Wilderness of northeastern Minnesota. We entered and exited the BWCAW at Entry Point 14. The area shown is approximately 30 X 15 miles.

[1] Keeping worms and waxworms alive in the summer heat of the BWCAW was a challenge. The worms expired by the end of the second day. Although I entered the BWCAW with over three dozen waxworms, by Day 4 only about a half dozen were alive.

Figure 3. Left, the first of the 24 portage trails of the trip. Above, Kon double-packing his personal gear (on front) and the micro-fyke nets (on back) at a portage. The shortest portage was less than two rods (31 feet); the longest two were 240 rods (0.75 miles).

Figure 4. Kon's two micro-fyke nets fishing in Fall Lake, Lake County, MN, on his July 2020 BWCAW trip with George Cunningham. This set did capture a Northern Sunfish, the only one of Kon and George's BWCAW trip. (Photo by Konrad Schmidt)

MN, we took the canoe to a nearby lake, loaded it with all our gear, and paddled around a bit to see whether the canoe would float and handle well. Kon's 17-foot Old Town Penobscot (aka, the *SS Darter*) handled all our gear and the two of us with no problem (Figure 7).

SPECIES COLLECTED IN THE BWCAW: NORTHERN SUNFISH

Relative to other sunfishes within its range, the Northern Sunfish is small with total lengths usually less than 100 mm (~4 inches) and maximum lengths seldom greater than 130 mm (~5 inches). The cheek and operculum have wavy blue lines, and the long ear flap is angled upward toward the dorsal fin and has a red or orange margin. There are 8–12 vertical bars on the body. The pectoral fin is short and rounded. Breeding males have red eyes and orange to red median fins and blue-black pelvic fins. Although now known to be locally common and secure, the Northern Sunfish is currently listed as a species of Special Concern in Minnesota due to its limited distribution, lack of distribution data, and due to its status as "threatened" in Wisconsin (MNDNR 2013). Its dependence on stands of submersed aquatic vegetation, whether in lakes with relatively undisturbed shorelines or in clear rivers, suggests that lakeshore development and other habitat alterations may cause declines in the distribution of Northern Sunfish. The sensitivity of Northern Sunfish to habitat alterations makes them an indicator of high-quality aquatic habitat and overall waterbody health (Porterfield and Ceas 2008, 2012).

We collected specimens of Northern Sunfish from two BWCAW lakes, Pocket and Finger, both sampled on August 22, 2020 (Figures 8 and 9). All specimens of Northern Sunfish were taken with microfishing gear using waxworms. Pocket Lake appeared to have the stronger population of Northern Sunfish, as six specimens were caught in less than half an hour. About an hour of microfishing at two locations on Finger Lake, however, produced only one Northern

Figure 5. Kon at our Shell Lake campsite showing his Chinese-made, 12-hole, double-layer, portable, foldable fish trap nets.

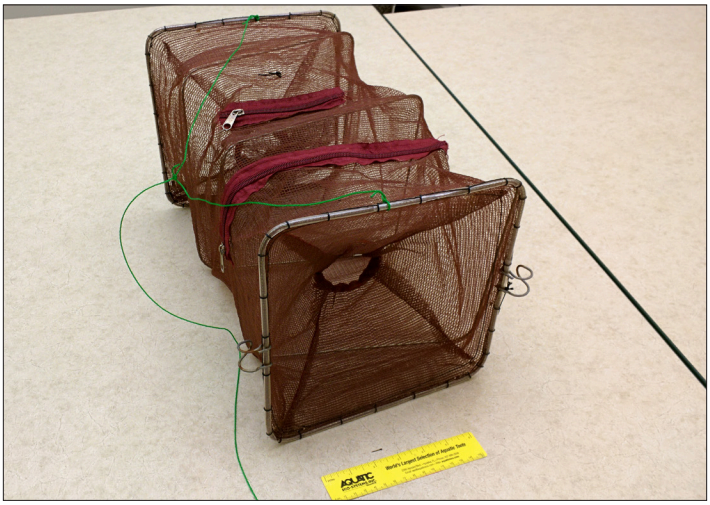

Figure 6. Double-funnel minnow trap used for Slimy Sculpin in Lac La Croix. (Photo by Jeff Eibler; from Schmidt 2018)

Figure 7. Kon on Day 1 in the fully loaded SS Darter on the BWCAW's Little Indian Sioux River ready to begin our trip.

Sunfish. Three specimens from Pocket Lake (63–74 mm standard length) were entered into the fish collection of Iowa State University, Ames, Iowa (ISUA 4178). One specimen from Finger Lake (54 mm SL) was entered into the Iowa State collection (ISUA 4180). Habitats supporting Northern Sunfish at both lakes were similar, with lily pads over relatively sparse growth of rooted aquatic vegetation in approximately 2–3 feet of water (Figures 10 and 11).

TAXONOMIC ISSUES: TO BE OR NOT TO BE A SPECIES, THAT *WAS* THE QUESTION

The Northern Sunfish is a member of the Longear Sunfish complex, which has been described as the most polytypic group in the sunfish family (Centrarchidae) (Bauer 1980). Long-standing controversy has been generated by proposals to elevate the Northern Longear Sunfish subspecies *Lepomis megalotis peltastes* to species level as *L. peltastes*, the Northern Sunfish. That the Northern Sunfish might deserve species status was suggested by Trautman (1957) and Smith (1979), both of whom reported no evidence of intergradation between populations of Longear Sunfish *L. m. megalotis* and Northern Longear Sunfish *L. m. peltastes* in their respective states of Ohio and Illinois. Trautman suggested that *L. m. megalotis* and *L. m. peltastes* "might be an incipient species rather than well-marked subspecies." More recent authors suggesting species status for Northern Sunfish include Bailey et al. (2004) and Page and Burr (2011).

Based on early 1990s genetic analysis, Jennings and Philipp (1992) found no genetic difference between the Northern Sunfish subspecies from IL, MI, and WI and Longear Sunfish from IL, KY, TN, and AL. More recent and more sensitive genetic analysis, however, suggested differences in Northern Sunfish from MN and WI compared to Longear Sunfish from IL, MO, and TN (Porterfield and Ceas 2008). Despite this more recent work, Jennings (2013:2) considered the proposed elevation of Northern Sunfish to species status as having "little justification." Page et al. (2013:221), however, apparently considered the removal of Northern Sunfish from synonymy with Longear Sunfish by Bailey et al. (2004) as sufficient justification to elevate Northern Sunfish to species level.

A visual comparison of Northern Sunfish from northern Minnesota to what is believed to be a Longear Sunfish *L. megalotis* from central Illinois certainly suggests differences between the two taxa. Figure 12 compares a Northern Sunfish specimen from our August 2020 BWCAW survey with a Longear Sunfish from Lake George, near Rock Island, Illinois. Lake George is an approximately 160-acre impoundment located along the Mississippi River about 12 miles

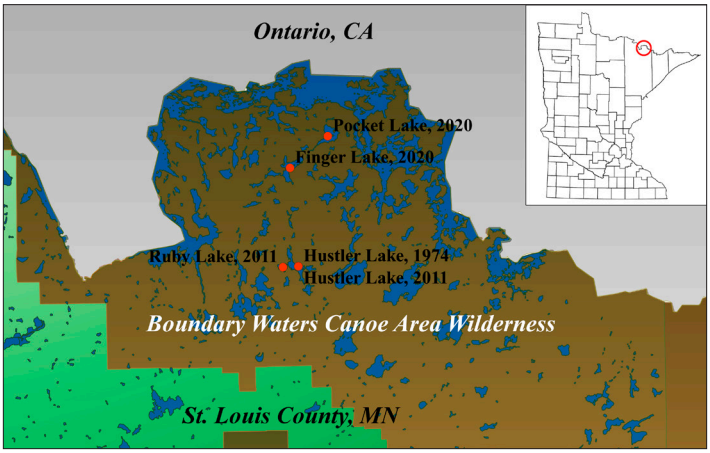

Figure 8. Records for Northern Sunfish in the lakes of the BWCAW we surveyed in 2020. The Pocket Lake and Finger Lake 2020 records are from this trip.

Figure 9. Northern Sunfish microfished from Pocket Lake (top) and Finger Lake (bottom), August 22, 2020.

Figure 10. The author microfishing in the area of Finger Lake, where Northern Sunfish was captured. This area is near the portage from Finger Lake to Thumb Lake. (Photo by Konrad Schmidt)

downriver from Rock Island (~450 miles south of the BWCAW). A Longear Sunfish was collected in June 2014 from a recently flooded rearing pond at the Iowa DNR's Fairport Fish Hatchery along the Mississippi River upriver from Muscatine, IA. This is believed to be the first Iowa record of a fish in the Longear Sunfish group in at least 60 years. Follow-up work by Kon and others suggests that the likely source of the Longear at Iowa's Fairport Fish Hatchery was Lake George, the outlet of which to the Mississippi River is about 3 miles upriver from the Fairport hatchery (Schmidt 2016b).

NORTHERN SUNFISH IN MINNESOTA & ONTARIO SWIMMING BELOW THE ICHTHYOLOGICAL RADAR

The Northern Sunfish made its presence known in Minnesota relatively late compared to other fishes. In their 1974 edition of *Northern Fishes*, Eddy and Underhill (1974:358–359) mention a late 19th century report of "Longear Sunfish" from Big Stone Lake and Pomme de Terre River in southwestern Minnesota by Cox (1897), but they doubted the records' validity.[2] After noting that many early records of Longear Sunfish were due to misidentification, these authors identified a single specimen of Longear Sunfish collected in 1945 from Little Rock Lake in Morrison County in central Minnesota (Mississippi River drainage) by the Minnesota Department of Conservation as the only accepted record for the state. Their acceptance of this record was based on identification of the specimen by Dr. Raymond E. Johnson, who they considered "a most competent ichthyologist."

That 1945 Northern Sunfish record, however, is now considered problematic and probably in error. There is no Little Rock Lake in Morrison County in the Minnesota DNR's Lakefinder database (https://www.dnr.state.mn.us/lakefind/index.html). Although the Fishes of Minnesota database shows that considerable sampling was conducted in mid-August 1945 on Little Rock Lake in Benton County (the county adjacent to the southeast of Morrison County) by Smith and Johnson (presumably Lloyd Smith and Raymond E. Johnson, both with the Minnesota Department of Conservation at the time), no Northern Sunfish were reported. With the 1945 Little Rock Lake record discounted, the earliest currently accepted Minnesota record for Northern Sunfish in the database comes from another August 1945 collection by Smith and Johnson on Trout Lake in Itasca County in northern Minnesota (Mississippi River drainage). (Jay Hatch, personal communication, Nov. 16, 2020.)

Even with the location error for the 1945 Little Rock Lake/Morrison County record, there remained only one accepted Minnesota record for Northern Sunfish at the time of Eddy and Underhill's 1974 *Northern Fishes*. These authors concluded that, although an isolated population existed north of International Falls, MN, in Ontario (Gruchy and Scott 1966), "we know of no other Longear Sunfish north of Iowa." Between the time of Gruchy and Scott's report of a 1960 collection of Longear Sunfish in an Ontario lake and the 1974 edition of *Northern Fishes*, however, there were 32 additional Ontario records for Longear Sunfish from 23 separate waterbodies. The fact that Eddy and Underhill were apparently unaware of these post-Gruchy and Scott records for Ontario likely reflects the traditional lack of databasing fish records as well as the sometimes-slower pace of communication in the pre-digital age.

Prior to the mid-1970s, the distribution of the Northern Sunfish in Canada was also poorly understood. In their *Freshwater Fishes of Canada*, Scott and Crossman (1973) note that the presence of Northern Sunfish in Ontario was unknown until reported by Gruchy and Scott (1966)[3]. Scott and Crossman cite the Gruchy and Scott paper as providing an explanation of the presence of Northern Sunfish in

Figure 11. Typical vegetated, shallow-water habitat where Northern Sunfish were captured in Pocket and Finger lakes on August 22. This photo is from Hustler Lake.

Figure 12. Comparison of Northern (top, from Finger Lake) and Longear (bottom, from Lake George, Rock Island County, IL) sunfishes. The origin of the Longear Sunfish population in Lake George is unclear. (Longear Sunfish photo by Konrad Schmidt)

[2] Despite being rejected by Eddy and Underhill, Cox's (1897:58) description of *"Lepomis megalotis"* appears mostly accurate for *L. peltastes;* for example: "pectoral fins short; gill rakers short and soft, an abundance of bright colors; cheeks orange crossed with blue lines; blue lines in front of eye; caudal and anal blue, the connecting membranes orange; opercular flap very long and broad in the adult, edged with blue or red. To 8 inches."

[3] W.B. Scott, the senior author of *Freshwater Fishes of Canada* (1973) was the co-author of the 1966 paper reporting the first record of Northern Sunfish in Ontario (Gruchy and Scott, 1966).

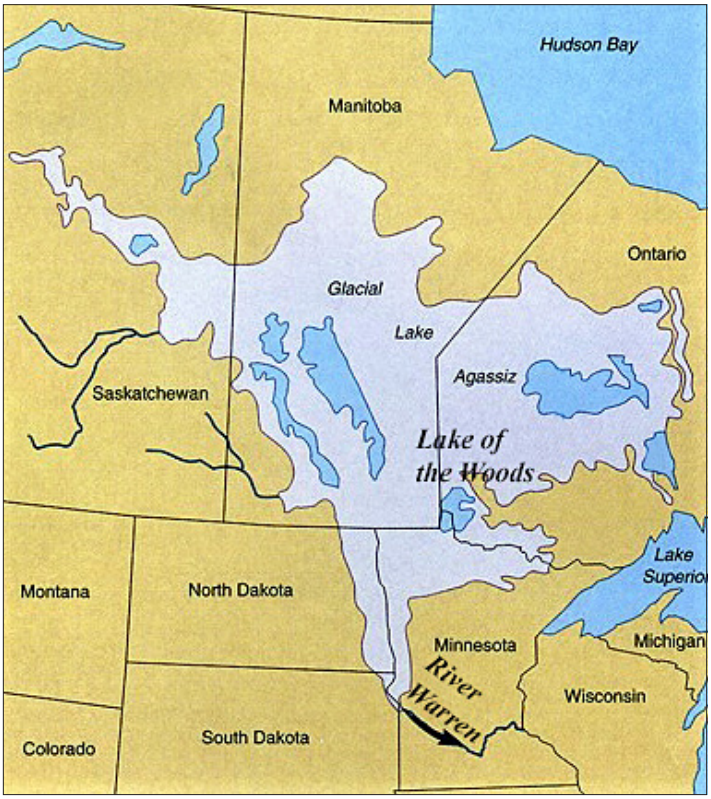

Figure 13. Maximum extent of Glacial Lake Agassiz (light blue) formed approximately 13,000 years ago by glacial meltwater near the end of the Pleistocene Epoch's Wisconsinan glacial period. Present-day lakes are in dark blue. Lake Agassiz's outlet to the south, the Glacial River Warren, flowed through today's Minnesota River valley to the Mississippi River. Modified map from University of Notre Dame (2007).

the Hudson Bay Drainage. That is, glacial Lake Agassiz, which occupied today's Lake of the Woods region in the Hudson Bay drainage (including both the Red River and Rainy River drainages), was connected to the south to the Mississippi River drainage by the glacial River Warren (Figure 13). Based on their known presence in the Mississippi River drainage, Gruchy and Scott believed that Northern Sunfish moved north in the River Warren to Lake Agassiz. With the retreat of glaciers at the end of the Pleistocene, the level of Lake Agassiz dropped such that this hydrological connection between the Hudson Bay and Mississippi drainages was severed. Gruchy and Scott (1966) cite Underhill's (1957) analysis of the influence of post-Pleistocene drainage networks on distributions of Minnesota fishes as supporting evidence for their hypothesis of a River Warren dispersal route for Northern Sunfish.

About the time that Eddy and Underhill's 1974 edition of *Northern Fishes* was published, additional records of Longear Sunfish in Minnesota waters were being reported. The first was a 1974 record by Steve Hirsch of the Minnesota DNR for Hustler Lake (St. Louis County, Rainy River drainage) in the western portion of the BWCAW. Kon and I sampled Hustler Lake during our trip but did not find Northern Sunfish. In 1975, Minnesota DNR staff collected Northern Sunfish from Kidd Lake in Cass County and Three Island Lake in Beltrami County (both in the Mississippi River drainage). Although the number of records for Northern Sunfish in Ontario continued to increase from 1975–85 (45 new records from 23 separate waterbodies, all lakes), there was only one additional report in Minnesota during that period: the identification by Steve Hirsch of a 1978 angler-caught specimen from Keller Lake in St. Paul in Ramsey County (Mississippi River drainage).[4]

In their 1982 *Fishes of the Minnesota Region*, Phillips et al. (1982:213) describe an extremely limited distribution of "Longear Sunfish" (i.e., Northern Sunfish) in Minnesota, with the only confirmed records being the 1945 record from Little Rock Lake (now discounted[5]) and the 1974 record from Hustler Lake. They consider both of these populations as separated from the main range of the species and offer at least the possibility of introductions to explain these isolated occurrences. Although the 1975 Minnesota DNR records for Northern Sunfish in Kidd Lake and Three Island Lake were not mentioned by Phillips et al., these records and several others were accepted for Minnesota by Bauer (1980) in his compilation of records of Longear Sunfish for the *Atlas of North American Freshwater Fishes* (Lee et al. 1980) (Figure 14).

The pace of new Minnesota records for Northern Sunfish picked up considerably after 1985 (Figure 15) with 206 records from 96 separate waterbodies recorded from 1986–2020. Forty-two of those waterbodies are in the Hudson Bay drainage (40 in the Rainy River drainage and 2 in the Red River of the North drainage[6]), and the remaining 54 are in the Mississippi River drainage (Figure 16). Research funded through Minnesota State Wildlife Grants focused on genetics and life history but included survey work that expanded the known range of the species (Porterfield and Ceas 2008, 2012). During our 2018 foray into the BWCAW, Kon and I collected Northern Sunfish from 8 of 13 lakes in the Kawishiwi River system (Rainy River drainage) (Olson 2019). The Fishes of Minnesota database contains 315 records for Northern Sunfish from approximately 165 individual waterbodies in Minnesota and Ontario (Figure 16). Over 94% of the individual waterbodies with records for Northern Sunfish are identified as lakes in the database, thus indicating that it is almost exclusively a species of lakes in Minnesota and Ontario. The existence of only one accepted pre-1974 Minnesota record for Northern Sunfish, along with potentially valid (but discounted) historical records, suggests that this species may have been historically more widespread in Minnesota streams and rivers.

That the distribution of the Northern Sunfish in Minnesota and Ontario remained poorly understood through a good portion of the 20th century is interesting. Possible explanations include that this small sunfish is not part of the recreational fishery and consequently not a focus of fishery managers. Also, the preference of Northern Sunfish for undisturbed habitats with clear water and growth of emergent and submersed aquatic macrophytes (Porterfield and Ceas 2008) would require sampling at lakes that are difficult to access,

[4] The story goes that Hirsch noticed the Northern Sunfish on a young person's fish stringer and paid a dollar for the fish. The specimen was preserved but later discarded (Konrad Schmidt, personal communication, Nov. 17, 2020).

[5] A probable location error suggests that the 1945 specimen was actually from Trout Lake in Itasca County, MN (Jay Hatch, personal communication, Nov. 16, 2020).

[6] Although Hatch (2015:20) indicates that the occurrence of Northern Sunfish in the Red River drainage represents introductions, Schmidt (2016a:32) disagrees and suggests that a crossover-connection between the Crow Wing River (Mississippi drainage) and Otter Tail River (Red River of the North drainage) watersheds explains this occurrence.

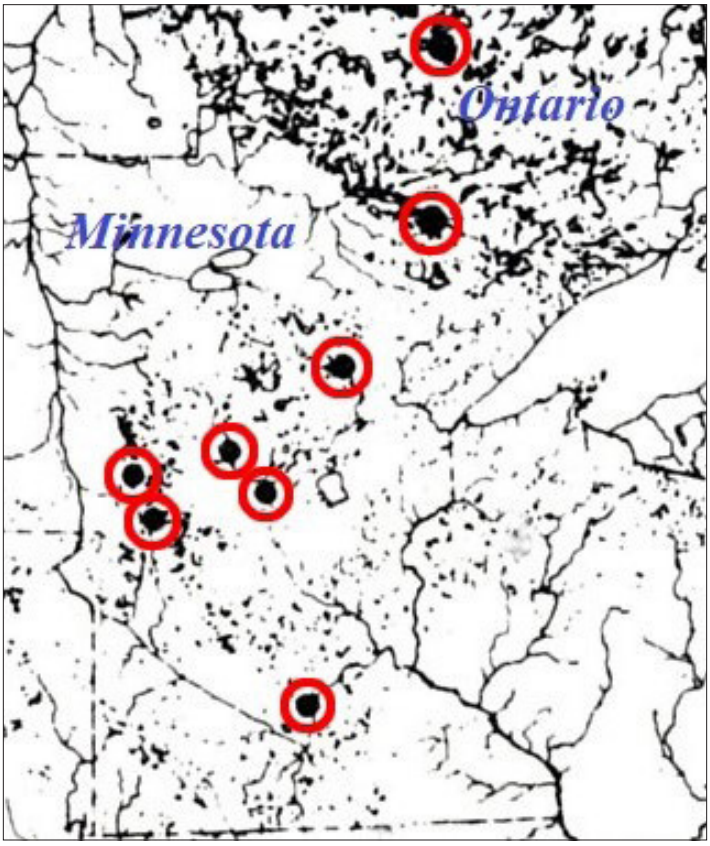

Figure 14. Modified excerpt of map of North American distribution of Longear Sunfish, compiled in 1978 by Bauer (1980), showing a total of 8 records in Minnesota and the adjoining area of Ontario.

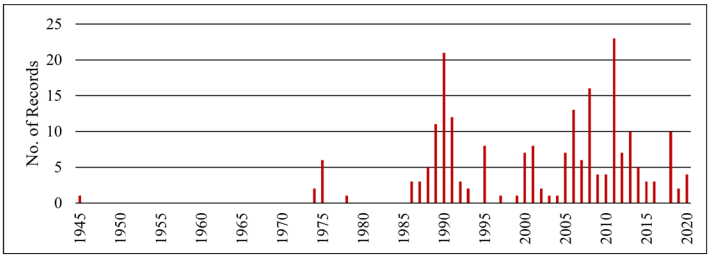

Figure 15. Records of Northern Sunfish in Minnesota by year, 1945–2020. Some waterbodies have more than one record per year. (Source: Fishes of Minnesota database)

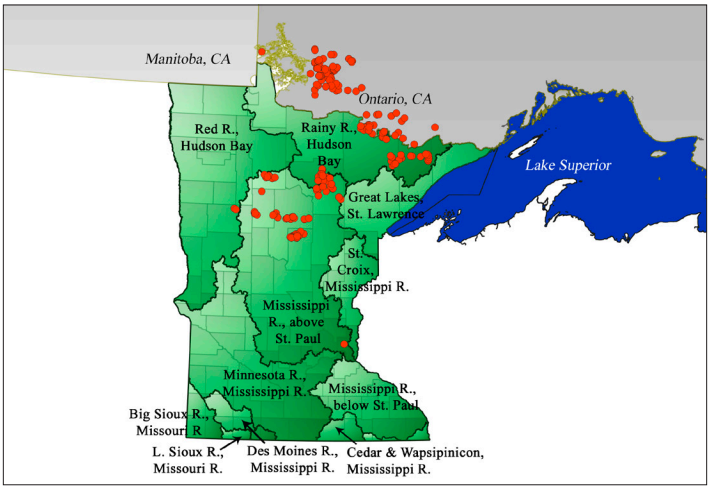

Figure 16. All 315 known records for Northern Sunfish in Minnesota and Ontario between 1945 and 2020. These 315 records represent records for Northern Sunfish from approximately 165 separate waterbodies. Records from Fishes of Minnesota database. HUC 4 (subregion) names (e.g., Rainy River) are followed by major drainage (HUC 2 region) names (e.g., Hudson Bay).

such as BWCAW lakes that can only be reached by canoeing and portaging. Given the presence of Northern Sunfish in hard-to-sample lakes, additional distributional work likely remains to be done.

Our August 2020 records for Northern Sunfish in Pocket and Finger lakes in the BWCAW are the first known for those lakes, although the species has been taken previously in two other lakes we visited: Hustler Lake (1974) and Ruby Lake (2011). We sampled Hustler Lake with the micro-fyke nets and the minnow traps set on the evening of August 20 and retrieved on the morning of August 21. Despite the capture of a considerable number of fish in these nets, including several *Lepomis* species, no Northern Sunfish were taken. We did not microfish in Hustler Lake. We sampled Ruby Lake by microfishing and kick-netting, but again found no Northern Sunfish. Submergent vegetation in Ruby Lake, however, was scarce, and appeared much less favorable for Northern Sunfish than that in Hustler, Pocket, and Finger lakes.

SPECIES COLLECTED IN THE BWCAW, AUGUST 2020: SLIMY SCULPIN

The Slimy Sculpin is a smooth-skinned, benthic species that is gray/brown dorsally and distinctly mottled. It has large pectoral fins and a wide, flattened head. It is relatively common in the shallow waters of Lake Superior and in nearly all its tributary streams; large populations are also present in the spring-fed headwaters of coldwater streams of southeastern Minnesota (Eddy and Underhill 1974:394). In general, the Slimy Sculpin occupies upper segments of coldwater streams and deeper waters of lakes. Substrate and water temperatures are the important habitat variables, and primary food items include invertebrate bottom fauna, especially aquatic insect larvae (e.g., mayflies, caddisflies, dipteran larvae, stoneflies and dragonflies) (Scott and Crossman 1973). Of the approximately 300 waterbodies in Minnesota and Ontario with records for Slimy Sculpin in the Fishes of Minnesota database, about half are lakes. Nearly all (98%) of the Minnesota-Ontario stream waterbodies with records for Slimy Sculpin are in Minnesota, with over 90% of those stream records in the Mississippi and Great Lakes/St. Lawrence drainages (see Figure 17).

Kon conducted surveys for Deepwater Sculpin *Myoxocephalus thompsonii* and Slimy Sculpin in northeastern Minnesota lakes from 2009 to 2011 (Schmidt 2013). Based on Steinhilber and Neely's (2006) finding that wire minnow traps baited with glowsticks were more effective at sampling Deepwater Sculpin than the traditionally used small-mesh gill nets, Kon used minnow traps baited with glowsticks on his surveys. Although the glowstick/minnow trap gear has proved effective in capturing both Deepwater and Slimy sculpins from deep northern lakes, and despite his attempts in July 2010 and August 2011, Kon was unsuccessful in capturing any sculpins from Lac la Croix, an approximately 30,000-acre lake that accounts for about 28 miles of the border between St. Louis County, Minnesota and Ontario, Canada (Figure

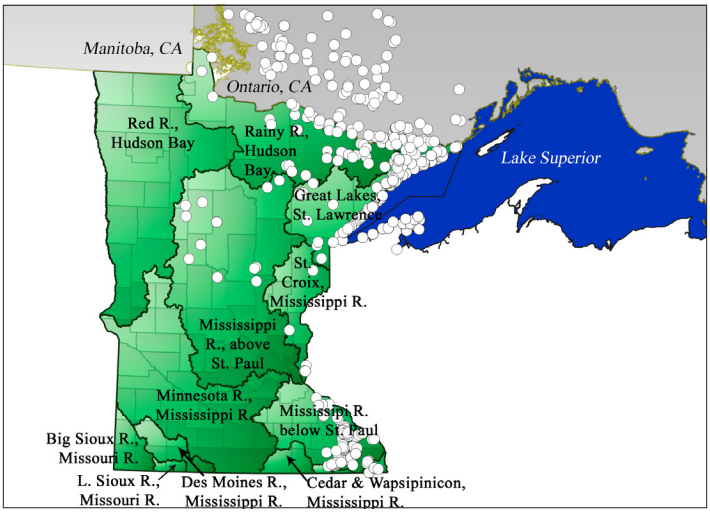

Figure 17. Distribution of Slimy Sculpin in all waterbody types in Minnesota and Ontario, 1922–2020: 1,170 total records from approximately 300 waterbodies. Records from Fishes of Minnesota database. HUC 4 (subregion) names (e.g., Rainy River) are followed by major drainage (HUC 2 region) names (e.g., Hudson Bay).

Figure 19. Kon "baiting" the collapsible double-funnel minnow traps with glowsticks prior to deployment of the traps in Snow Bay of Lac la Croix on the evening of August 23, 2020.

Figure 20. Lac la Croix's Snow Bay, where we deployed 10 double-funnel minow traps baited with glow sticks on the evening of August 23, 2020. Big water!

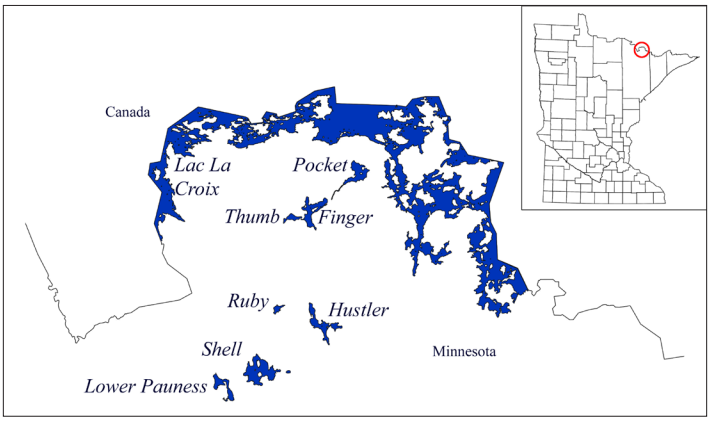

Figure 18. BWCAW lakes we sampled for fish in August 2020.

18). The only other record for Slimy Sculpin from Lac la Croix is a 2004 Minnesota DNR record in the eastern portion of the lake, where gill nets were used. Kon thus scheduled a stop at this lake on our last night in the BWCAW to see whether he could capture Slimy Sculpin or Deepwater Sculpin on his third attempt there.

On the evening of August 23, we deployed ten collapsible double-funnel minnow traps, each containing two green glowsticks, in Lac La Croix's Snow Bay (Figures 19 and 20). Traps were fished on the bottom in from 50 to 70 feet of water.

When retrieved the next morning, seven of the 10 traps contained Slimy Sculpin, with a total of 12 specimens captured (Figure 21). Along with capturing Northern Sunfish from Pocket and Finger lakes, finding Slimy Sculpin was a highlight of a somewhat difficult trip through the BWCAW.

All Slimy Sculpin specimens were preserved. Tissue samples were taken from several specimens; these samples will be deposited in the University of Tennessee's Etnier Ichthyological Collection (Figure 22). Four specimens from 46–63 mm standard length were entered into the fish collection of Iowa State University, Ames, Iowa (ISUA 4181). Our collection of Slimy Sculpin was only the fourth record for this species in the area of the BWCAW that we surveyed, with the previous three records from eastern Lac la Croix in 2004, Oyster Lake in 2009, and Loon Lake in 2010 (Figure 23).[7]

THE APPEAL OF GLOWSTICKS TO SCULPINS

As Kon mentioned in his article on his 2009–2011 sculpin surveys (Schmidt 2013), why glowstick-baited minnow traps are ef-

[7] We presume that the species we collected from Lac la Croix is Slimy Sculpin. *Cottus* species are well known for being difficult to identify, and considerable morphological variation exists within and between populations of the currently-recognized Slimy Sculpin species (Lyons 1990). In response to the need for taxonomic clarification in this genus, Young et al. (2013) used genetic-based species identification approaches on *Cottus* species of the upper Columbia River and Missouri River drainages in the northern Rocky Mountains of Idaho and Montana. Results of their work suggest the existence of undescribed species within the genus. Based on their work, efforts are underway to develop a new genomic approach for determining whether the sculpin species found in the deep clear lakes of northern Minnesota and Ontario (i.e., the sculpin species we collected) is possibly a different species from the Slimy Sculpin known from small coldwater streams in the upper Midwest (Dave Neely, personal communication, Oct. 14, 2020). The tissue samples taken by Kon from the sculpins we collected from Lac la Croix will be an important part of answering this question.

Figure 21. Specimens of Slimy Sculpin collected from Lac la Croix's Snow Bay on August 23–24, 2020.

Figure 22. Lac la Croix Slimy Sculpin specimen from which a tissue sample was taken for genetic analysis.

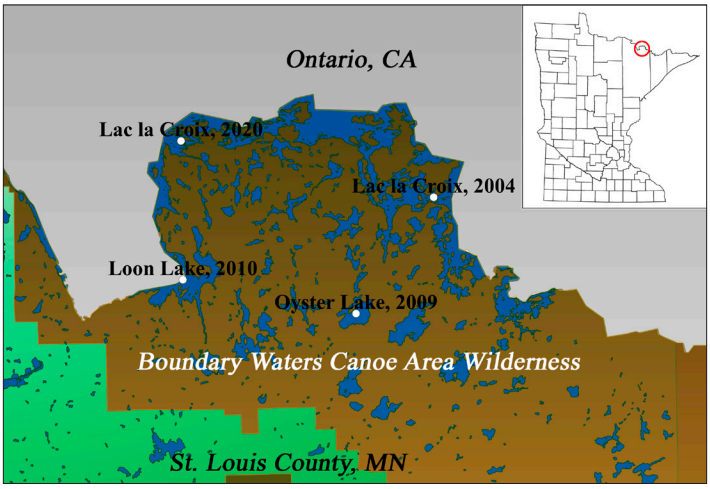

Figure 23. Slimy Sculpin records in the part of the BWCAW we surveyed. The 2020 Lac la Croix record is from this trip.

fective for sculpins in deep lakes remains unknown. As he has noted (Schmidt 2018), a clue is that sculpins preserved in formalin have been observed to regurgitate "very profuse clouds of fresh phantom midge larvae *Chaoborus* sp." It follows then that one hypothesis to explain the attraction of sculpins to glowsticks is that the glowsticks attract food items (e.g., phantom midge larvae). I will offer a slightly different hypothesis. *Chaoborus* larvae are well known for diel migrations in lakes, with vertical movements toward the lake surface at night where they can feed on plankton while being less susceptible to predation from fishes. At sunrise, the *Chaoborus* larvae return to the dark profundal areas of lakes, again, to avoid predation. My hypothesis is that the glowsticks simply make the *Chaoborus* easier for the sculpins to see and consume in the dark lake bottom. Admittedly, it seems probable that the light-avoiding *Chaoborus* larvae would also avoid the light from a glowstick. The wavelength of light from a green glowstick, however, is about 525 nanometers (Kuntzelman et al. 2012). This wavelength is typical of the shorter wavelengths of sunlight potentially reaching profundal areas of deep, clear lakes. The longer wavelengths of sunlight (e.g., 600 to 700 nm) absorbed during daytime at lake surfaces are likely those avoided by *Chaoborus* larvae. Thus, the green light from a glowstick may not result in avoidance by *Chaoborus* larvae but may provide sufficient illumination for sculpins to see and feed on them. Kon's mention of fresh larvae being regurgitated suggests that the sculpins may be feeding on the *Chaoborus* larvae during daylight hours instead of at night when the larvae are near the surface. Thus, the regurgitated larvae may have been consumed by the sculpins shortly before the daytime retrieval of the trap from the lake.

HYBRID SUNFISH

We captured what appear to be several *Lepomis* hybrids (Figures 24–26) at three lakes with all gear types: micro-fyke nets, minnow trap nets, and microfishing.

The parentage of these hybrids is undetermined but likely involves Bluegill *L. macrochirus* and Pumpkinseed *L. gibbosus*.

CENTRAL NEWT AND MEDICINAL LEECH

We also encountered Central Newts *Notophthalmus viridescens* in three lakes (Shell, Hustler, and Ruby), and we collected the North American medicinal leech *Macrobdella decora* at Shell Lake (Figure 27). Central Newts were captured in the micro-fyke nets, the minnow trap net, and with kick-netting. The leeches were captured only by the minnow trap net. The saliva of medicinal leeches, such as *M. decora* and the European medicinal leech *Hirudo medicinalis*, has anticoagulant properties, which serve to keep blood flowing from a host. Leech saliva also has anti-inflammatory and anesthetic properties. Medicinal leeches have a long history of use in medicine (primarily for bloodletting) that ranges from the ancient Mideast to medieval and early modern Europe. Although their use in medicine declined in the late 1800s, medicinal leeches have been used internationally since the 1970s in microsurgery to stimulate blood circulation in skin graft procedures, finger reattachments, and reconstructive surgeries of the ear, nose, lip, and eyelid. Leech therapy was classified as a medical device by the US Food and Drug Administration in 2004 (Wikipedia 2020).


Figure 24. Two hybrid sunfish captured from Shell Lake.


Figure 25. Two hybrid sunfish captured from Hustler Lake.

Figure 26. Hybrid sunfish captured from Pocket Lake.

FISH SPECIES CAPTURED AND LESSONS LEARNED

We collected a total of 14 fish taxa from eight BWCAW lakes from August 19–24, 2020, including 11 species and three hybrid/undetermined parental taxa (Table 1). The results of our survey suggest that microfishing is likely the most effective (and portage-friendly) means of sampling Northern Sunfish (at least adults) in remote lakes in the BWCAW. While the micro-fyke nets fished well and captured a number of sunfish species, they did not seem particularly effective for Northern Sunfish. In addition to being somewhat time-consuming to set and retrieve, it was not possible to completely dry the micro-fykes after retrieving them in the mornings. The increased wet weight of an already heavy micro-fyke net may not be optimal for repeated long portages in the BWCAW. The double-layer minnow trap was also effective in capturing a number of species, including smaller sunfish. Being relatively light and more easily dried, these nets would appear to be quite useful at BWCAW lakes, although their effectiveness for Northern Sunfish is questionable. Small mesh minnow seines, such as the 5 x 20-foot straight seine and the 5 x 30-foot bag seine used with good success by Porterfield and Ceas (2008), are also effective at capturing Northern Sunfish. Kon and I seined a number of YOY Northern Sunfish from lakes in the Kawishiwi River system in the BWCAW (Olson 2019). Finding suitable areas for seining in BWCAW lakes, however, can be difficult, with the presence of near-shore boul-



Figure 27. Central Newt (left and center) and medicinal leech (right) captured in Shell Lake.

Table 1. Summary of fish species captured in lakes of the Boundary Waters Canoe Area Wilderness in St. Louis County, MN, from August 19–24, 2020 (see Figure 18). Lakes are listed in the order that they were sampled.

Lake	Lower Pauness	Shell	Ruby	Hustler	Pocket	Finger	Thumb	Lac La Croix
Date Fish Collected	19-Aug-20	20-Aug-20	20-Aug-20	21-Aug-20	22-Aug-20	22-Aug-20	22-Aug-20	24-Aug-20
Lake Area (acres)*	171	493	68	276	241	272	9	29,597
Maximum depth (feet)*	36	15	70	74	27	60	55	168
Longitude, Latitude	-92.24328, 48.19458	-92.2118, 48.20327	-92.17326, 48.22945	-92.1581, 48.22987	-92.12771, 48.31528	-92.16532, 48.29468	-92.18307, 48.29078	-92.27332, 48.33667
SPECIES**								
CYPRINIDAE (CARPS AND MINNOWS)								
Notemigonus crysoleucas, Golden Shiner	X							
Pimephales notatus, Bluntnose Minnow		X				X		
ICTALURIDAE (NORTH AMERICAN CATFISHES)								
Noturus gyrinus, Tadpole Madtom	X					X		
ESOCIDAE (PIKES AND MUDMINNOWS)								
Umbra limi, Central Mudminnow		X						
COTTIDAE (SCULPINS)								
Cottus cognatus, Slimy Sculpin								X
CENTRARCHIDAE (SUNFISHES)								
Lepomis gibbosus, Pumpkinseed	X	X		X		X		
Lepomis macrochirus, Bluegill		X	X	X				
Lepomis peltastes, Northern Sunfish					X	X		
Lepomis hybrid, sunfish hybrid		X			X			
Lepomis sp., sunfish species		X				X	X	
Micropterus dolomieu, Smallmouth Bass			X	X				
PERCIDAE (PERCHES AND DARTERS)								
Etheostoma exile, Iowa Darter				X	X	X		
Perca flavescens, Yellow Perch	X	X		X	X			
Number of fish species/taxa collected per lake:	4	7	2	6	4	6	1	1

*From: Minnesota DNR "Lake Finder" (https://www.dnr.state.mn.us/lakefind/index.html) except for Ruby Lake: area estimated from Google Earth; maximum depth estimated from Voyageur Map 1: Boundary Waters Canoe Area Wilderness.

**Nomenclature and phylogenetic order follow Page et al. 2013.

ders and/or soft sediments both limiting the ability to effectively seine. Assuming that one can keep the live bait alive, microfishing seems a reasonable and very lightweight alternative to seining for purposes of documenting the presence of Northern Sunfish in remote BWCAW lakes. The double-funnel minnow traps baited with green glowsticks effectively sampled Slimy Sculpin. Being relatively light and collapsible, the double-funnel traps, along with a supply of glowsticks, seem a very good choice for sculpin sampling in BWCAW lakes.

Kon and I were both more or less challenged physically (me more; Kon less) by our August 2020 foray into the wilds of the northern Minnesota. While the lakes we sampled were not the "bridge too far" Kon once described (Schmidt 2018), it was not an easy trip. After six days of paddling and portaging, we exited the BWCAW on the evening of August 24th thinking "never again": no more BWCAW fish surveys. Within a couple weeks, however, the memories of difficulties on our trip had faded, and we were discussing plans for future BWCAW trips, though hopefully with fewer and shorter portages.

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