CONFOUNDING CISCOES

Konrad Schmidt

St. Paul, MN

INTRODUCTION

My 25-year pursuit of ciscoes has been a fascinating—but very convoluted and exasperating—path. In 1989, I was a hobby photographer who had recently focused my camera on native fishes. The Deepwater Sculpin (*Myoxocephalus thompsonii*) was one species I never believed I would collect or photograph (Schmidt 1991), but I made several inquiries to fish biologists in the Minnesota Department of Natural Resources (MDNR) for recent records. I won the lottery when I got a call out of the blue from Duane Shodeen. He encouraged me to contact Dave Etnier who was a college buddy of his and was now a professor at the University Tennessee in Knoxville. Duane mentioned Dave's ongoing cisco research (Etnier and Skelton 2003) in Saganaga Lake on the Ontario-Minnesota border and that Deepwater Sculpins would occasionally show up in his gill nets. Following the scent like a bloodhound, I immediately rifled off a letter to Dave asking about possibly meeting him for a few days of gill netting. His answer was so much more than I ever expected—an invitation to his summer "Etnier Estate!"

In August the good professor met me with his boat at a Boundary Waters Canoe Area (BWCA) entry point off the Gunflint Trail and we headed for his family's summer home just across the border into Ontario. I very soon realized what a master story teller he was, covering topics from local history to, of course, all things fish. I marveled at Dave's boating skills traveling at full throttle on the narrow and very rocky Sea Gull River. He mentioned they often return from Grand Marais, MN, at night and lock on the North Star to guide them home. We passed the original cabin site of his wife's family and he chronicled how they had to move it log by log to the Canadian side of Saganaga Lake when the BWCA was designated a wilderness. We arrived on New Lewis Island and Dave gave me a few minutes to settle in before heading out again to check his gill nets.

Now it was orientation for me receiving a fascinating overview of his cisco research. He believed there were three distinct forms in Saganaga based on Walter Koelz's Great Lakes research (1929). One form matched meristics Koelz

Photos by the author unless otherwise indicated.

Cisco (*Coregonus artedi*): (from top) typical form (Amoeber Lake, Lake County, MN), tullibee form (Agnes Lake, St. Louis County, MN), dwarf form (Knife Lake, Lake County, MN), racer form (Brule Lake, Cook County, MN).

Figure 1. Nipigon Cisco, with Ray Katula and Dave Etnier (Saganaga Lake) (top), and Shortjaw Cisco (North Lake).

described from Lake Nipigon, Ontario, aptly named the Nipigon Cisco (*C. nipigon*) (Figure 1). This form was the easiest for me to identify because of the very dark fins, but Dave said it also had the highest gill raker count of the three forms. He later x-rayed specimens and found they also averaged an additional vertebra compared to the other two forms. The smallest form had very pale almost clear fins and the lowest gill raker counts. Dave believed these matched the Shortjaw Cisco (*C. zenithicus*) (Figure 1) from lakes Huron, Michigan, and Superior. The third form had intermediate fin pigment and gill raker counts. Dave felt this form was the Cisco (*C. artedi*) which had been assumed to be the one of two *Coregonus* species present in Minnesota's inland lakes. The other is Lake Whitefish (*C. clupeaformis*) which grows much larger than the three forms and is also morphologically distinct.

I was extremely intrigued with Dave's preliminary findings, but wondered if Nipigon and Shortjaw ciscoes may occur in other large inland lakes. In 1995, I was the MDNR's only non-game fish biologist and I thought I had struck gold when I was asked to participate in a panel of experts reviewing Superior National Forest's (SNF) sensitive species. One species the forest biologists were considering was the Shortjaw Cisco. I emphasized distribution data were severely lacking and surveys of large, deep lakes were needed throughout Superior National Forest and Voyageurs National Park (VNP) to the west. I offered to volunteer my time to collect specimens, but I first wanted to check with Dave if he would agree to examine the collections. The biologists were ecstatic at the possibility and offered to fly me into BWCA lakes with canoes and forest staff to assist with the surveys. Dave was, as expected, more than happy to look at the specimens, but when I called the forest biologists to discuss scheduling they reluctantly told me they had made promises they could not keep. The BWCA wilderness staff not only shot down flying in, but also denied any use of survey gear banned to the general public. Gill nets were out and I was dead in the water.

My cisco curiosity never waned, but another decade passed. In 2005, I began contacting MDNR Fisheries offices covering the BWCA. Never shy about asking, I made the request for specimens and ever so slowly ciscoes began trickling out of this top-secret Area 51. Dave soon confirmed both Nipigon and Shortjaw ciscoes from Basswood Lake and the added bonus of Deepwater Sculpins in Snowbank Lake. One of my many tasks with the MDNR was assisting the County Biological Surveys (CBS) Program with fish surveys. The CBS staff had mentioned surveys of BWCA counties were being scheduled and "negotiations" were underway with SNF. I was not optimistic, but in 2009 I found myself overseeing the cisco surveys in the BWCA. In this first year's effort, we found Nipigon and Shortjaw ciscoes in two new lakes.

During the fall, I eagerly began planning the 2010 lake survey schedule, but it simply was not meant to be. The position I held for 20 years was eliminated. The loss of the best job in the world was one thing, but I just could not walk away from the cisco effort. I sensed there was so much more to discover. I made the decision to continue funding the surveys out-of-pocket, but first I needed research permits from the MDNR and SNF. Clearing that hurdle, I added Voyageurs National Park and started on Canadian permits since I didn't want to be restricted only to Minnesota waters of boundary lakes or possibly "crossing the line" with a misplaced gill net. Here, I ran into a major snag because the Shortjaw Cisco was listed an endangered species, and yes, I would be killing them with premeditation and forethought. After many emails and phone calls I received a collecting permit with so many stipulations it was barely useable, but I was good to go.

Whenever possible, I made requests of staffs from MDNR and SNF to collect specimens for me and I was able to join survey crews with the Ontario Ministry Natural Resources (OMNR) on Lake of Woods and assigned staff for the VNP lakes. There would have been no collections from lakes with-

Figure 2. Selfie with canoe (top) and First Mate Saber of the SS Minnow Ice Breaker on North Lake.

out their assistance even though at the end of one field season I drove over 700 miles in one day rounding up specimens from three MDNR Fisheries offices and the OMNR in Kenora, Ontario. Despite having a wheel barrow of permits, going through customs with three coolers of frozen ciscoes was a real treat. They scrutinized every permit and alleged I had exceeded my daily limit. I calmly kept telling them these were for research and not for human consumption. Finally, I "dared" them to radio the local conservation officer if they believed there was a violation. I'm guessing by not showing a shred of guilt, they finally allowed me to clear customs.

My son, Bryan, initially greatly anticipated helping me, but I quickly and unfortunately burned him out on wilderness camping. Dave again graciously offered lodging and assistance for a Northern Light Lake's collection in Ontario. However, he did cut the last day short to make it back in time for the afternoon volleyball match with his neighbors. A man must have his priorities and I have always also greatly enjoyed a casual game of volleyball. In the end, I made most of the collections solo. I did bring my golden retriever, Saber, who was a wonderful companion, but at a price. He never carried his food over portages and would sneak into the tent at night sopping wet from swimming after noisy Beavers slapping their tails. Despite throwing my back out three times, chronic tennis elbow from paddling, and countless, agonizing welts from swarms of mosquitoes, flies, and no-see-ums; I was rewarded with many fond memories of gorgeous sunsets, sunrises, rainbows, and wildlife. However, I also have had a harrowing experience or two.

ICE, WIND, AND FIRE

In May 2011, I was feeling rather smug surfing the web following ice-out reports for some northern Minnesota lakes. When the lakes west and north of BWCA were ice-free, I thought it was safe to launch the first survey of the season. Logical thinking, but all so WRONG! I arrived at Gunflint Lake which was open and headed east seven miles. I was towing a canoe for portaging into my destination on South Lake (Figure 2). As I emerged from a narrows entering North Lake, I felt an icy cold blast. My spirits sank after finding two-thirds of the lake still covered in ice and separating me from my portage by more than a mile.

When I reached the edge, I could tell the ice was only about six inches thick, black, and honeycombed, which is a sure sign of rotten and very weak ice. I thought I just might make it. I hit the edge and the bow fractured the ice leaving a path of large ice cubes. My outboard stalled when a large chunk jammed in the prop and did so many more times, but I could always start moving again. However, when I looked back to check on my canoe I wondered why it would not follow in my path. It stubbornly insisted to instead ride up on

Figure 3. Pagami Creek fire east of Ely, MN. 12 September 2011.

the ice sheet and slide rather than float. I was still moving forward so I just let it be. The sound of ice breaking against the hull was deafening and Saber trembled with his head down and tail tucked until we emerged on the other side. I began portaging into South Lake; however, when I arrived at a protected inlet my hopes were again dashed. The ice was thicker and stronger here, but the overcast skies had turned to blue and I could feel the sun's warmth. I headed back to North Lake on the portage trail for the last load of gear and found most of the ice had melted. There were some large rafts of ice cubes near this end of the portage that sounded like wind chimes every time a light breeze blew. This created an acoustic and welcomed respite before heading back.

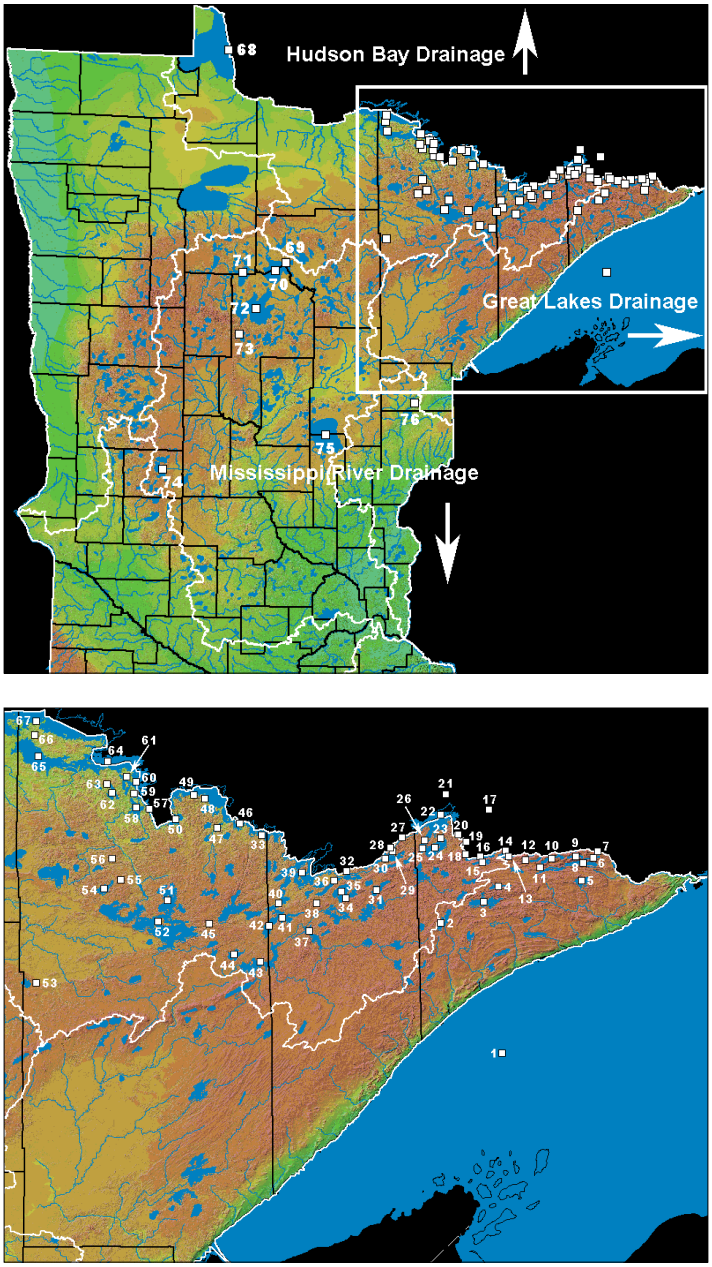

Figure 4. Cisco collection localities (see map numbers in Table 1 for corresponding lake names).

I loaded the canoe and was ready to launch, but first had to chip my way out of the inlet into South Lake. The sun helped and it was not too bad reaching the open water. Quite the journey I hope never to repeat, but I had finally made it!

In September 2011, I was on my last survey of the year heading for Shagawa Lake near Ely. Still several miles west of town I could not overlook a massive thunderhead filling the eastern sky, but this was no thunderstorm. A lightening strike had smoldered for weeks and was now a crowning fire fanned by 35 mph winds. In a very short time, it engulfed 93,000 acres in the BWCA (Figure 3).

The fire was heading away from Ely so I decided to set my nets, but I should have held an equal respect for the high winds. Shagawa was froth-whipped from two-foot whitecaps and I should have never launched my canoe. I set one net without incident, but the second was way too shallow. While trying to reset it, a rogue wave hit me from behind instantly swamping my canoe and spilling gill nets and gear into the water. Saber was rudely awakened from a sound sleep and paddled around the overturned canoe trying to get back in again. Then something caught his eye and he steamed full speed away. I looked where he was heading. Only 100 feet away an angler was casting a 12-inch Muskie lure from his boat. The retriever in him was on a mission to rescue that lure. I shouted at the angler, "Can I have a little help here!" I realized by his startled look he was totally unaware I was even there. He towed me back to shore and grabbed my gear that was floating, but I lost two gill nets I could not replace. The MDNR Fisheries office did send out a team the next week trolling with a body hook, but came up empty. The next day I pulled the two nets I had set, but despite calm weather, Shagawa was not finished with me yet. Each net had hundreds of Rusty Crayfish tangled in it. I bagged up the writhing mass and had Bryan clean the nets when I got home later that day. Waste not, want not—the chef cooked them up and he feasted for three days.

RESULTS AND DISCUSSION

In 2010 and 2011, I "dumped" 38 5-gallon buckets of ciscoes on Dave. Counting earlier collections, he has examined ciscoes from 76 lakes (Figure 4 and Table 1). Lake of the Woods is listed twice because of the striking differences in habitats between the US and Canada. US waters have a maximum depth of 39 feet while Canada has several deeper basins (maximum depth: 210 feet) that support Lake Trout (*Salvelinus namaycush*) and Slimy Sculpin (*Cottus cognatus*). Cisco specimens have been cataloged at the David A. Etnier Ichthyological Collection (UT) at the University of Tennessee in Knoxville. Tissues were also preserved in 95% ethyl alcohol and cataloged at UT. Nipigon Cisco occurred in nine lakes surveyed and possibly in Farm Lake (Lake County) and Lake

of the Woods (Canada), but may require collecting additional specimens for confirmation. Most of the occurrences center around Saganaga Lake where stream connections permit access to the following lakes: Gull, Northern Light, Red Rock, Saganagons, and Gneiss. On the latter, Nipigon Ciscoes can surmount Saganaga Falls draining Marabeouf Lake, but were absent in lakes above additional barriers further upstream (i.e., Granite, Gunflint, and North). Cisco populations reported in satellite lakes of Basswood with stream connections (i.e., Good and Newton lakes in Lake County) should likewise be examined for Nipigon. Shortjaw Ciscoes occurred in 14 lakes surveyed, but were found in only one satellite lake of Lac la Croix (i.e., Takucmich). Dave feels this species favors more oligotrophic conditions and is almost always associated with Lake Trout. I suspect Shortjaw Ciscoes may also occur in Gun Lake (St. Louis County) just west of Takucmich. Both species almost certainly occur in many more large and deep lakes in Canada.

Initially, the goal of these surveys was to define the distribution of Nipigon and Shortjaw ciscoes, which are special concern species. However, Dave soon realized there were several distinct forms of *C. artedi* in the collections. We were aware dwarf populations occurred in many lakes. However, research has shown some of these will grow to typical cisco size when stocked in other lakes. Dave labeled a very deep-bodied form, tullibee. The first time I encountered this form was on a lake with very dark tea-stained water, which greatly reduced visibility. My first thought before the fish broke the surface was White Bass (*Morone chrysops*), which I knew didn't occur in the drainage. Preliminary MDNR fisheries research suggests this form tends to occur in lakes with higher phosphorous concentrations (Pete Jacobson, personal communication). However, BWCA lakes would presume to be phosphorous-starved environments and I found the deepest-bodied specimens in very marginal, shallow lakes likely prone to reoccurring stressors such as summer kill.

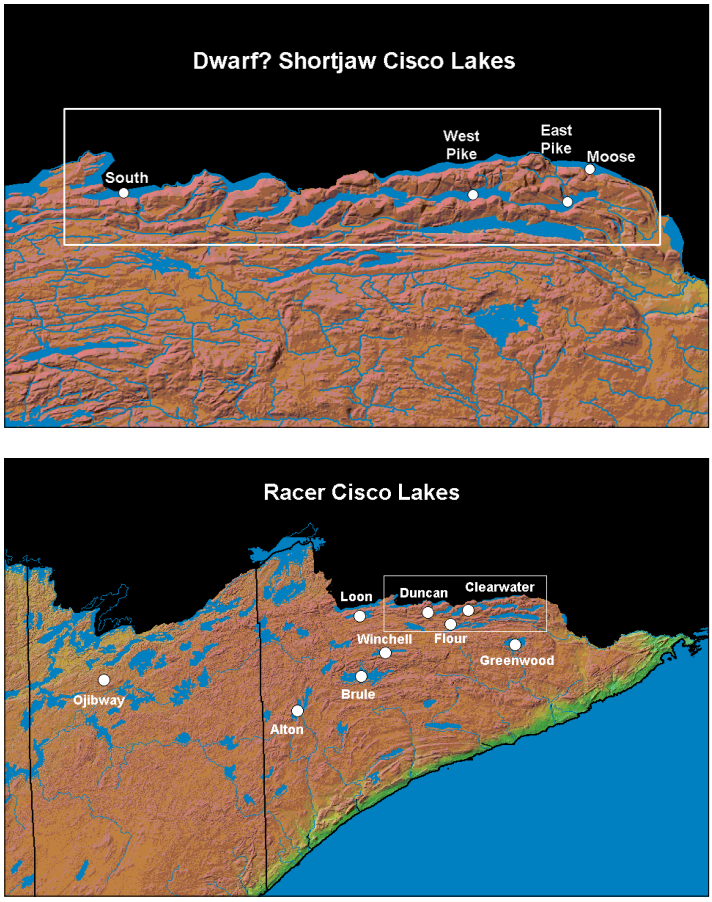

Figure 5. Top: Dwarf Shortjaw Cisco Lakes. Bottom: Racer Cisco Lakes.

Dave found another dwarf form in my collections with a low gill raker count hinting of Shortjaw Cisco. This form only occurs in four lakes of the Great Lakes drainage in Cook County (Figure 5). He cannot make a definitive identification because of the small collections and condition of the specimens. I do recall how "mushy" these specimens were from just overnight sets and would disintegrate trying to remove them from the nets. Dave has requested "more material," which translated into I had to consider a return trip to these lakes.

The cisco form that really piqued our interest had a terete body, very high lateral-line scale count, was always the sole cisco in the nine inland lakes where they occurred, and ironically, in close proximity to the Dwarf Shortjaw Cisco lakes (see insets in above maps). For a very brief period Dave believed this form was an undescribed species and was pondering a name to honor his graduate professor James Underhill (Curator Emeritus of the James Ford Bell Museum of Natural History fish collection). However, Dave had started a Cisco News email group and sent summaries periodically as he processed the many buckets of ciscoes. Tyler Winter was one of the most interested and frequent responders on the group. He re-read Walter Koelz's 1929 tome (no small feat) and thought he found a meristic match: *C. artedi artedi* which Koelz had reported in all the Great Lakes. Steve Geving (MDNR Fisheries) chimed in on the discussion and thought this form is what some Lake Superior commercial fishermen were calling racers. He introduced me to Stephen Dahl who fished the lake near Knife Island. He was very glad to help collect specimens and I was in awe of his extensive knowledge of ciscoes. At the end of the season he called me apologizing he had "only" caught six fish he felt were racers. I confessed to him that on some of my cisco lakes I had either been skunked or come back with just a single specimen. Dave examined the collection and confirmed they matched the form found in the inland lakes. I contacted the MDNR offices where the racer lakes occurred (Figure 5) and asked them to do some digging through their hard files. For most

Table 1. Cisco collection localities and identification

Map	Lake	County/ Country	Latitude/ Longitude	Surface Acres	Littoral Acres	Maximum Depth (ft)	Nipigon (11 Lakes)	Shortjaw (14 Lakes)	Shortjaw Dwarf (4 Lakes)	Cisco (17 Lakes)	Dwarf (26 Lakes)	Tullibee (28 Lakes)	Racer (10 Lakes)
	GREAT LAKES DRAINAGE												
1	Superior	US/Canada	47.41215/-90.61354	N/A	N/A	1332		X		X			X
2	Alton	Cook	47.86986/-90.90750	969	320	72							X
3	Brule	Cook	47.94057/-90.68238	4617	1431	78							X
4	Winchell	Cook	47.99195/-90.60374	826	233	160							X
5	Greenwood	Cook	48.00160/-90.17304	2021	537	112							X
6	East Pike	Cook	48.07897/-90.10723	496	124	40			?				
7	Moose	Cook	48.09998/-90.08397	1005	146	113			?				
8	Pine	Cook	48.06246/-90.16422	2257	366	113					X		
9	West Pike	Cook	48.08592/-90.20118	715	224	120			?				
10	Clearwater	Cook	48.08215/-90.32589	1325	260	130							X
11	Flour	Cook	48.05229/-90.38732	330	115	75							X
12	Duncan	Cook	48.07821/-90.46128	481	148	130							X
13	South	Cook	48.09492/-90.54741	1190	167	140			?				
	HUDSON BAY DRAINAGE												
14	North	Cook	48.11487/-90.56221	2695	477	125		X			X		
15	Loon	Cook	48.07699/-90.68549	1096	137	202							X
16	Gunflint	Cook	48.09619/-90.69492	4009	674	200		X		X			
17	Northern Light	Canada	48.25762/-90.64123	N/A	N/A	N/A	X				X		
18	Magnetic	Cook	48.10643/-90.76966	431	95	90		X					
19	Granite	Cook	48.14989/-90.76416	235	N/A	45				X			
20	Gneiss	Cook	48.17573/-90.80665	239	79	70	X			X			
21	Saganagons	Canada	48.31639/-90.86389	N/A	N/A	N/A	X						
22	Saganaga	Cook	48.24417/-90.89227	N/A	N/A	280	X	X		X			
23	Gull	Cook	48.16423/-90.89750	183	109	40	X						
24	Sea Gull	Cook	48.13217/-90.92713	3957	927	145					X		
25	Alpine	Cook	48.13059/-90.99372	839	403	65					X		
26	Red Rock	Cook	48.15897/-90.97862	353	146	64	X						
27	Ottertrack	Lake	48.17055/-91.09600	1104	251	116				X			
28	Little Knife	Lake	48.13566/-91.15727	701	91	184					?		
29	Amoeber	Lake	48.12370/-91.14622	386	108	110				X			
30	Knife	Lake	48.09829/-91.18532	4920	1037	179					X		
31	Thomas	Lake	47.98951/-91.23774	1471	441	110				X			
32	Birch	Lake	48.05776/-91.39064	836	342	34						X	
33	Crooked	St. Louis	48.19813/-91.80082	10359	1898	165		X			X	X	
34	Parent	Lake	47.96400/-91.39633	326	91	50				X			
35	Snowbank	Lake	47.98819/-91.41868	4655	879	150				X			
36	Newfound	Lake	48.02594/-91.45272	604	119	45						X	
37	Gabbro	Lake	47.85372/-91.58839	896	457	50						?	
38	Ojibway	Lake	47.94867/-91.54728	367	134	115							X
39	Basswood	Lake	48.05648/-91.62105	22722	7034	111	X	X		?	?		
40	Fall	Lake	47.94981/-91.74229	2258	1178	32						X	
41	Farm	Lake	47.89936/-91.72534	1292	459	56	?				X	X	
42	White Iron	St. Louis	47.87262/-91.79365	3429	1603	47				?		X	
43	Birch	St. Louis	47.74989/-91.84386	5628	1060	25						X	
44	Bear Island	St. Louis	47.77479/-91.97727	2362	879	62					?		
45	Mud	St. Louis	47.88364/-92.10244	143	51	27						?	

Table 1 (continued). Cisco collection localities and identification

Map	Lake	County/ Country	Latitude/ Longitude	Surface Acres	Littoral Acres	Maximum Depth (ft)	Nipigon (11 Lakes)	Shortjaw (14 Lakes)	Shortjaw Dwarf (4 Lakes)	Cisco (17 Lakes)	Dwarf (26 Lakes)	Tullibee (28 Lakes)	Racer (10 Lakes)
46	Iron	Lake	48.22885/-91.93731	1851	N/A	60					?	X	
47	Agnes	St. Louis	48.21615/-92.05375	984	453	30						X	
48	Lac la Croix	St. Louis	48.31725/-92.11674	34070	8500	168	X	X			?		
49	Takucmich	St. Louis	48.33080/-92.17513	327	98	150		X			X		
50	Loon	St. Louis	48.24736/-92.27270	2498	N/A	76		X			?	X	
51	Trout	St. Louis	47.96492/-92.31714	7425	1613	98		X					
52	Vermilion	St. Louis	47.89166/-92.36666	39272	15006	76						X	
53	Sturgeon	St. Louis	47.68106/-92.99714	1585	667	80						X	
54	Elbow	St. Louis	48.00827/-92.64665	1695	664	60					X		
55	Winchester	St. Louis	48.03791/-92.55893	320	54	60					X		
56	Kjostad	St. Louis	48.11072/-92.60343	437	286	50						X	
57	Little Vermilion	St. Louis	48.28370/-92.40886	1288	639	52						X	
58	Crane	St. Louis	48.28900/-92.47615	2921	618	80						X	
59	Mukooda	St. Louis	48.33627/-92.48862	774	151	78				X	?		
60	Sand Point	St. Louis	48.37789/-92.47385	8526	2847	184					X	X	
61	Little Trout	St. Louis	48.39681/-92.52258	272	79	95		X		X			
62	Johnson	St. Louis	48.33995/-92.60018	1674	557	88					?		
63	Spring	St. Louis	48.37128/-92.62878	219	39	60				X			
64	Namakan	St. Louis	48.44953/-92.62175	24066	5026	150	X	X			X	X	
65	Kabetogama	St. Louis	48.46702/-92.98611	24034	7440	80					X	X	
66	Locator	St. Louis	48.54007/-93.00585	140	44	52						X	
67	Rainy	St. Louis	48.58892/-92.99714	230301	18949	161					X	X	
68	Woods	Canada	49.05462/-94.75528	1074558	79253	210	?	X		?		X	
68	Woods	Lake of the Woods	49.05462/-94.75528	1074558	79253	39					X	X	
	MISSISSIPPI RIVER DRAINAGE												
69	Cut Foot Sioux	Itasca	47.50373/-94.08424	2853	1324	78				X			
70	Winnibigoshish	Cass	47.44159/-94.19801	56470	18904	70						X	
71	Cass	Beltrami	47.42269/-94.54776	15958	3119	120						X	
72	Leech	Cass	47.16226/-94.40534	102948	57994	150						X	
73	Ten Mile	Cass	46.97071/-94.57759	5047	1316	208					X		
74	Carlos	Douglas	45.96521/-95.35895	2598	910	163						X	
75	Mille Lacs	Mille Lacs	46.24245/-93.64622	128224	33129	42						X	
76	Hanging Horn	Carlton	46.47795/-92.69471	409	86	80					X		

of the racer lakes there were paper records from the 1920s to 1940s of culturing Lake Superior ciscoes (assumed to be *C. artedi*) and stocking them in lakes without ciscoes as a forage base for resident Lake Trout. During my surveys, MDNR Fisheries biologists from Grand Marais collected a single specimen of what Dave has coined a "golden" racer morph (Figure 6). I find it fascinating that almost a century since introductions began, racers remain an identifiable distinct form (or perhaps it merits elevation to a full species?).

Unfortunately, this is a question that cannot be answered here because opinions of diverging cisco camps may never reach consensus. DNA has been sequenced from tissues of *Coregonus* species including all three Dave had collected during his research. The results showed variation, but not specific species, which convinced one camp to dismiss the distinct meristic and morphological differences and insist all *Coregonus* are the same species. Dave counters for a second camp, "If two or more readily identifiable forms occur in the same lake, it is likely that multiple species are involved." Currently, DNA sequencing looks at very few genes and what works on one species may not on another. It did take many years of research to develop reliable diagnostic genetics to separate federally endangered Pallid Sturgeon (*Scaphirhynchus albus*) from the common and widespread Shovelnose Sturgeon (*S. platorynchus*). This remains unresolved in many other species including three species of Buf-

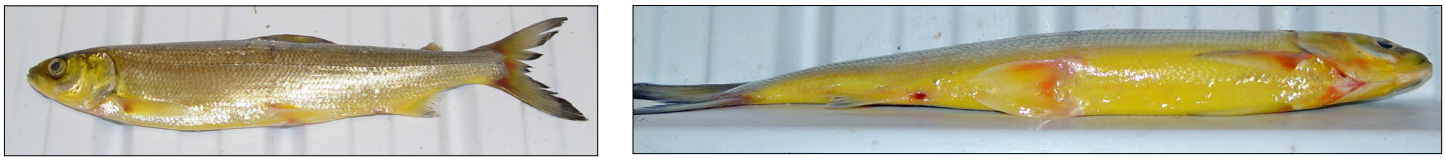

Figure 6. A very rare Golden Racer morph (Brule Lake, Cook County).

falo (*Ictiobus* spp.) found here in Minnesota. The MDNR was proposing to preserve tissues to confirm the identification of the state-threatened Black Buffalo (*Ictiobus niger*). However, managers soon realized this would be wasted effort because currently available sequencing techniques cannot distinguish species within the genus. A third camp concerned with the potential loss of rare species remains open minded to both camps. *Ciscoes may or may not be multiple species, but rather a single species that has adapted to fill open niches.* They advocate an ecosystem approach of management, which focuses on maintaining niches in lakes with sympatric, distinct morphological types and not individual species. Recent research of Cisco and Shortjaw Cisco populations supports this latter concept and recommends status assessments identify lake-specific designatable units where it applies through morphological, biological, ecological, and genetic evidence (Turgeon et al. 2015).

The impact of exotic Rainbow Smelt (*Osmerus mordax*) on cisco populations is not fully known. The species had been restricted to Lake Superior, but the exponential popularity of recreational fishing for smelt in North Shore streams eventually led to accidental introductions to inland lakes. The suspected vector was the transportation of ripe smelt and unintentional mixing of milt and roe which were rinsed out of containers into inland lakes. The species has since become established in at least 33 Minnesota lakes. In very large lakes, Cisco populations have survived, but competition with and predation from smelt may have eliminated the species in four lakes (Table 2). Ironically, the abundance of smelt in Lake Superior has crashed since the recovery of Lake Trout, and smelt runs very rarely occur, greatly reducing the risk of future introductions.

Table 2. Suspected Cisco Extirpations.

Lake	County	Surface Acres	Smelt First Report	Cisco Last Report	Last Survey
Rose	Cook	1315	1987	1992	2010
Trout	Cook	259	1984	1990	2011
Grindstone	Pine	533	1965	1992	2012
Burntside	St. Louis	7314	1970	1992	2011

I had hoped to do mop-up surveys in 2013, but on the first trip I threw my back out big time for the second time doing the cisco surveys and had not yet wet a net. I was three portages in from my entry point and ten very long portages if I continued. I was very disappointed, but hobbled and winced my way back to the car and home. I tried again in 2014, and yes, my back went out as I was picking ciscoes from my gill nets on the first lake. I was in a mile-long portage and had another mile-long one to reach the next lake I wanted to survey. I went for it! Some portages are wonderfully short and easy (Figure 7), but this was a gauntlet of slippery, muddy ruts and ankle-twisting boulders. Every step shot waves of intense pain through my back. I got my specimens, but was absolutely convinced this would be my final cisco survey.

ACKNOWLEDGEMENTS

First and foremost I can't express in words the vital role Dave Etnier fulfilled identifying the 38 buckets of ciscoes

Figure 7. A rare easy, but expensive, portage (left), and a better than average DIY portage. (Photo on right by Mark Stopyro)

Figure 8. 2010 and 2011 Cisco specimens.

(Figure 8). I initially felt bad about burying the good professor in a truckload of preserved fishes, but I soon learned "Ets" became a kid in candy store with each new bucket he opened. I would have never begun these surveys if Ets was not on my team! I'm also thankful to several others who collected specimens for me or invited me to tag along on scheduled surveys. My partners in this effort include the Ontario Ministry of Natural Resources, MDNR Fisheries, Dr. Tom Hrabik (University of Minnesota-Duluth), Superior National Forest, Voyageurs National Park, and commercial operators on Lake Superior. Finally, I must praise the volunteers who joined me on some of these insane endeavors: Bryan and Mary Stefansky, Mark Stopryo, and Greenwood Champ.

References

Etnier, D.A., and C.E. Skelton. 2003. Analysis of three cisco forms (*Coregonus*, Salmonidae) from Lake Saganaga and adjacent lakes near the Minnesota/Ontario border. Copeia 2003(4): 739–749.

Koelz, W. 1929. Coregonid fishes of the Great Lakes. Bulletin of the US Bureau of Fisheries 43: 297–643.

Schmidt, K.P. 1991. Lake Superior's inferior fishes. American Currents 17(4): 22-25. North American Native Fishes Association.

Turgeon, J., S.R. Reid, A. Bourret, T.C. Pratt, J.D. Reist, A.M. Muir, and K.L. Howland. 2015. Morphological and genetic variation in Cisco (*Coregonus artedi*) and Shortjaw Cisco (*C. zenithicus*): multiple origins of Shortjaw Cisco in inland lakes require a lake-specific conservation approach. Conserv.Genet. http://dx.doi.org/10.1007/s10592-015-0759-4