CISCO (COREGONUS ARTEDI) IN INDIANA'S GLACIAL LAKES

FINAL REPORT

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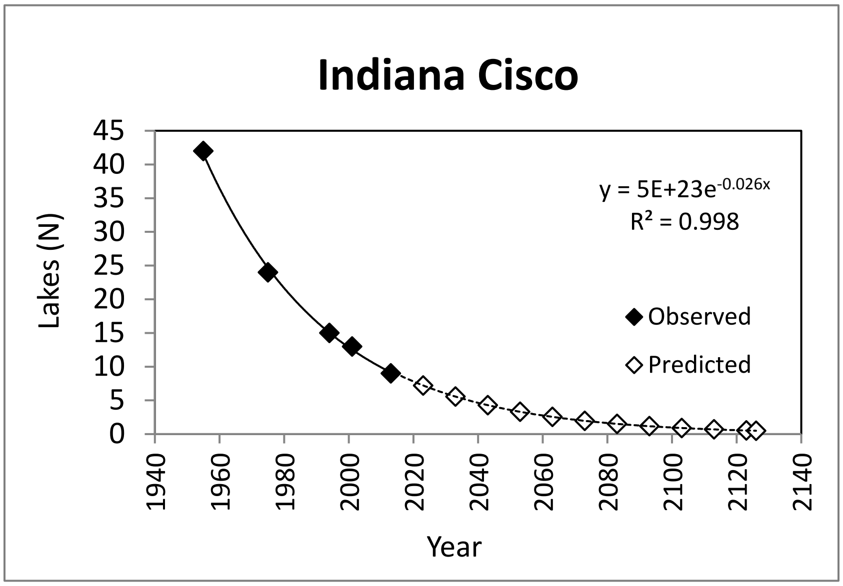
"As species disappear, they lose relevance to a society and a constituency to champion their revival."

- J. Waldman



"Under the current circumstances the Nongame Fish Technical Advisory Committee should review the Cisco's "special concern" status. Endangered species in Indiana are classified as 'any species or subspecies of wildlife whose prospects of survival and recruitment within Indiana are in jeopardy...' (IC 14-22-34-1). Historically, the Nongame Program would bring any species that had suffered a decline similar to Cisco before the appropriate committee for status review. Furthermore, classifying the Cisco as endangered would provide more stringent reviews of environmental permits for the lakes still supporting Cisco."

- Katie Smith, Non-game Supervisor, IDFW
March 20, 2000, Internal Memorandum

FOREWORD

Icy-cold winds of late November blow hard across the surface of Crooked Lake. Below, among quiet water along the western shore, silver-colored male and female Ciscoes, 12 to 16 inches long, move into traditional spawning grounds. Here their eggs are fertilized, drop to the bottom, and await hatching in the coming spring. The tiny fry emerge, search for food and start to grow, once again beginning the cycle of renewal. Their fate, however, is not guaranteed.

Threatened by declines in water quality, competition, and predation, Cisco populations have disappeared from dozens of lakes across northern Indiana. Their unique requirements of clear, cold, and oxygen-rich water make them vulnerable to habitat changes – changes brought on by land erosion, nutrient enrichment, damaging shoreline alterations, excessive lake use, and a warming climate.

From the 1950s to the 1970s, the number of Cisco lakes in Indiana declined from 42 to 26. By the 1990s the number dropped to 13. I've witnessed this decline firsthand, from days as a youngster swimming in Crooked Lake through four decades as a fisheries biologist. How many Cisco populations remain today is now in question. As an indicator of habitat quality, like a canary in a coal mine, their survival is a measure of our willingness and ability to protect our lakes for all species and for ourselves.

In this report, fisheries research biologist Steve Donabauer outlines a renewed effort shared by the Division of Fish and Wildlife and researchers from Purdue University and the University of Notre Dame to examine the current status of Ciscoes in Indiana lakes, to better understand their life cycle, and – hopefully – to improve management.

Jed Pearson, fisheries biologist
Indiana Division of Fish and Wildlife
December 18, 2012

ACKNOWLEDGEMENTS

Fisheries management biologists T. Bacula and J. Pejza (District 1; D1), N. Ledet and L. Koza (District 2; D2), J. Pearson and T. Delauder (District 3; D3), and M. Porto and B. Ciara (North Fisheries Research; NFR) collected the majority of field data from 2012-16. T. Leverman (NFR) assisted in the compilation and analyses of these data. Numerous D1-3 and NFR aides offered additional field, laboratory, and data entry support. A. Honsey and T. Höök (Purdue University) and C. Turner and D. Lodge (University of Notre Dame) served as project collaborators.

MISSION

The mission of the North Fisheries Research Unit
[Division of Fish and Wildlife] is to enrich the
quality of life for all Hoosiers

using quantitative evidence to inform science-based
actions and policies

that ensures the integrity of sport fish populations,
preservation of biodiversity, and vitality of
natural aquatic habitats.

FUNDING

The Indiana Division of Fish and Wildlife is funded by fishing and hunting license revenue, as well as, through the Wildlife and Sport Fish Restoration programs. These programs collect excise taxes on shooting, archery, and fishing equipment and motor boat fuel. This user-pay, everyone-benefits system has resulted in millions of acres of habitat saved and near-miraculous population increases in many species of fish and wildlife over the last 75 years. For more information on Fish and Wildlife Management in Indiana visit: wildlife.IN.gov.

EXECUTIVE SUMMARY

- Cisco (*Coregonus artedi*) inhabit Indiana's northern glacial lakes, which represents the southernmost extent of their native range.
- The Indiana Comprehensive Wildlife Strategy developed in 2005 classified Cisco as the *representative species* of the cold-water habitat guild for glacial lakes, in part, because Cisco are listed as a *Species of Special Concern* (www.endangeredwildlife.in.gov).
- Previous Cisco assessments include: Frey (1955), Gulish (1975), Koza (1994), and Pearson (2001).
- Pearson (2001) wrote that of the 49 lakes known to originally contain Cisco, 7 lakes had Cisco catch rates ≥ 1/lift (common), 6 lakes had < 1/lift but > 0/lift (rare), 4 lakes had 0/lift with sufficient Cisco habitat (probably extirpated), 30 lakes had 0/lift with insufficient Cisco habitat (extirpated) and 2 lakes had an "unknown" status.
- The primary objectives of this project are to re-evaluate the status of Cisco populations in Indiana based on: (a) temperature/dissolved oxygen water profiles, (b) catch rates (overnight gill net lifts), and population (c) size/age structures and (d) growth rates.
- The secondary objectives are to collaborate with university researchers (Honsey 2014) to: (e) analyze lake morphometric and land use characteristics of Cisco lakes (Honsey et al., 2016), (f) determine stock biology and genetic variation of Cisco (Honsey et al., *in-review*), (g) pilot test whether environmental DNA techniques are a viable tool to detect Cisco (Turner 2015), and (h) cooperate with other Great Lakes Region researchers to assess latitudinal effects on Cisco populations (Rypel et al., *in-review*).
- Ciscoes experienced oxy-thermal stress from 24-25 July 2012 on Little Crooked Lake (Whitley Co.); 104 Ciscoes were collected with dip nets and water profile data were collected.
- In September 2012, Cisco were collected from Crooked Lake (Noble/Whitley Co.; 0.8/lift), Eve Lake (LaGrange Co.; 5/lift), Failing Lake (Steuben Co.; 42 Cisco/lift), Lake Gage (Steuben Co.; 6/lift), Indiana Lake (Elkhart Co.; 34/lift), and South Twin Lake (LaGrange Co.; 24/lift).
- Only North Twin Lake (LaGrange Co.; 7/lift) produced Cisco among 16 other gill netted lakes (2012-16).
- Size (7.4-17.6 inches) and age (1-10 years) structures among Cisco varied widely among populations.
- Growth rates between males and females were similar; when at least 3 individuals within a population were measured within an age-class, mean length-at-capture deviated ≤ 7% between the sexes.
- Of the census of 49 historical Cisco lakes surveyed for cold-water habitat: 21 lakes had *quality* habitat; 5 lakes had *marginal* habitat; 5 lakes had *intermittent* habitat; and 18 lakes *lacked* habitat.
- The current status of Cisco populations in Indiana has changed to: 7 lakes classified as "common"; 1 lakes classified as "rare"; 9 lakes classified as "probably extirpated"; 32 lakes classified as "extirpated"; and 0 lakes classified as "unknown".
- It is recommended that Indiana Division of Fish and Wildlife share the data within this report to the appropriate Technical Advisory Committee so that they can determine whether formal reclassification of Cisco from a "*Species of Special Concern*" to an "*Endangered Species*" is warranted.

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INTRODUCTION

The Cisco *Coregonus artedi* is a cold-water species within the family Salmonidae that inhabit Canadian waters as far south as the upper mid-western United States (Page and Burr 1991). The glacial lakes of northern Indiana represent the southernmost extent of their native range (Simon and Tomelleri 2011). The abundance and distribution of Cisco in Indiana has been in decline since the turn of the twentieth century. In 1900, Cisco existed in 45 Indiana lakes (IDFW 1994). Subsequent population assessments of Cisco revealed a modest decline by the mid-1950's (42 lakes; Frey 1955), and a precipitous declines by the early 1970's (27 lakes; Gulish 1975) continuing into the early 1990's (12 lakes; Koza 1994). The last assessment (Pearson 2001) indicated that Cisco were still present in at least 13 Indiana lakes. This century-long trend in the decline of Cisco abundance and distribution has been attributed to accelerated eutrophication of lakes (IDFW 1983; IDFW 1994; IDFW 1997) caused by anthropogenic habitat modifications that include watershed nutrient loading, loss of near-shore riparian habitat (residential development), and limnologic nutrient recycling.

Over the last 40 years, the Indiana Division of Fish and Wildlife (IDFW) has taken several steps to conserve Cisco populations and their cold-water habitat: phase-out (1) commercial fishing and (2) predator stockings; (3) reintroduction; and (4) adoption of policies that restrict habitat modifications. First, commercial take of Cisco by gill nets was regulated through annual license sales from 1937 through 1976. James (1975) recommended that this practice be phased-out due to lack of angler interest. Although this paper focused on the commercial harvest of Cisco, the author noted "*until feasible lake reclamation techniques are developed that can retard or reverse present eutrophication trends, Cisco stocks will continue to decline*". Second, by the mid-1980's the IDFW phased-out predator stockings that were originally intended to utilize abundant Cisco populations as the primary forage base for stocked lake trout (IDFW 1994). Third, the IDFW made two unsuccessful attempts starting in the 1980's to establish a Cisco population in Gilbert Lake (Noble Co.; Pearson 1988) and in the 1990's to reintroduce Cisco into Green Lake (Steuben Co.; L. Koza, IDFW, personal communication). Lastly, the IDFW (1983) stated that the strategic objective of its Cisco management plan was to "*maintain existing Cisco fisheries by protecting Cisco habitat*". By the early 1990's, the IDFW (1992) issued a press release that stated "*the IDFW will severely restrict the permitting of shoreline alterations or chemical treatments of aquatic plants at Crooked (Whitley Co.), Lawrence (Marshall Co.) and South Twin (LaGrange Co.) lakes*", while DNR deputy director Doxtater added "*If we don't take a tougher stand now to maintain good water quality for these fish, we could lose Ciscoes altogether"*. Despite these efforts, the Northside Lawrence Lake Association's legal counsel (Connolly 1993) cited recreational purpose (IC 13-2-11) and vegetation treatment (IC 14-2-5) statutes to argue for their position to increase vegetation control at Lawrence Lake. Meanwhile, the IDFW produced a draft non-rule policy (Maudlin 1998; Eggen and James 2005) to "*establish guidelines for the assessment and determination of shoreline alterations and aquatic plant control on Cisco lakes*" and internally suggested a "*Cisco preservation project, possibly at Lawrence Lake*" (IDFW 1998). By 1998 however, the cold-water layer in Lawrence Lake was non-existent (Hudson 1998), and shortly thereafter Robertson (2000) stated "*We did not catch any Ciscoes and now feel fairly confident that this fish is no longer present in Lawrence Lake that once contained an abundance of these unique fish."*

Today, Cisco are listed as one of Indiana's *Species of Greatest Conservation Need* (www.endangeredwildlife.in.gov) and are classified as a S*pecies of Special Concern* (Whitaker and Amlaner 2012). These designations led technical experts, conservation partners, and concerned public stewards who participated in the 2005 Indiana Comprehensive Wildlife Strategy (CWS; now referred to as the State Wildlife Action Plan, or SWAP) to select Cisco as the *representative species* for cold-water glacial lake habitats and to use the species to *"paint a reasonable mental picture of an associated habitat type…and a desire to protect, enhance, or somehow improve that habitat"* (Gremillion-Smith 2005). The 2015 State Wildlife Action Plan (SWAP; IDFW 2015) used the lake catchments of known Cisco populations to define six Conservation Opportunity Area's in northern Indiana (Appendices A-F) aimed to focus the conservation community's efforts on cold-water habitat protection. This habitat is generally limited by late-summer (i.e., late-August through early-September) oxy-thermal lake stratification that includes water temperatures less than 68.0 °F with a dissolved oxygen concentration of at least 3 ppm (Frey 1955). Jacobson et al. (2008) proposed an "*oxythermal niche boundary*" for adult Cisco to include water temperatures thresholds of 75.0°F, 73.0°F, 71.5°F, and 67.0°F with corresponding minimum dissolved oxygen concentrations of 8 ppm, 5 ppm, 3 ppm, and 1 ppm, respectively. In order to sustain Indiana's remaining cold-water glacial lake habitats, the conservation community will need to implement the actions outlined in the 2015 SWAP that aim to curtail lake-eutrophication and emerging threats such as climate change (Huddleston and Moghari 2012).

Fisheries managers have documented over a century of declines in the distribution of Cisco in Indiana, identified the most significant threats to their populations, and have attempted to implement actions to prevent further losses of this species. The goal of the study described herein is to update the current status of Indiana's remnant Cisco populations that will provide policy-makers with the information they need to determine whether this species should be formally reclassified from a "*Species of Concern*" to an "*Endangered Species*". The primary objectives of this research are to assess: (a) temperature/dissolved oxygen water profiles to gauge the availability of cold-water habitat during the late-summer period; (b) Cisco catch rates (overnight gill net lifts); and Cisco population (c) size/age structures and (d) growth rates among all the lakes this species historical inhabited. The secondary objectives addressed in other manuscripts are to collaborate with university researchers (Honsey 2014) to: (e) analyze lake morphometric and land use characteristics of Cisco lakes (Honsey et al., 2016); (f) determine stock biology and genetic variation of Cisco (Honsey et al., *in-review*); (g) pilot test whether environmental DNA techniques are a viable tool to detect Cisco (Turner 2015); and (h) cooperate with other Great Lakes Region researchers to assess latitudinal effects on Cisco (Rypel et al., *in-review*).

METHODS

General Procedures

From 2012-16, all of the 47 historical Cisco lakes (plus George in Steuben Co. and Gilbert in Noble Co.) were sampled (water profile, gill nets, or both) at least once during the late-summer period (i.e., August through September). A Secchi disk reading (ft) was taken at most lakes to assess water clarity. In addition, temperature (°F) and dissolved oxygen (ppm) profiles were measured (Quanta Hydrolab or YSI; every two feet from the surface to the maximum lake depth) at each lake to determine if a quality (≥ 1.0 foot thickness) cold-water layer (water temperatures ≤ 68.0 °F and dissolved oxygen concentrations of ≥ 3 ppm; Frey 1955) was present. A standardized habitat calculator was developed (J. Pearson and M. Porto, IDFW, personal communication) to interpolate and auto-calculate quality and marginal (> 0.0 but < 1.0 foot thickness) habitat parameters derived from the temperature and dissolved oxygen profiles. If a quality cold-water layer was detected in a lake that previously classified Cisco as anything other than "extirpated" (Pearson 2001), experimental gill nets (250-ft x 6-ft, with 5 successive 50-ft panels including one panel of each: ¾ in, 1 in, 1-1/4 in, 1-1/2in, and 2 in square mesh) were deployed within the cold-water layer to target Cisco. At least 3 gill nets were deployed per lake, but the total number of gill nets was limited to no more than 12 overnight lifts to avoid excess by-catch mortality. The precise locations and depths of all gill net sets were recorded using a handheld global positioning system (Garmin GPSmap 76Cx) and a portable fish locator (Eagle Fish Mark 320 or Lowrance HDS-5). If the lake was devoid of a quality cold-water layer, gill nets were not deployed. Cisco were counted and measured for total length to the nearest tenth of an inch. Proportional size distribution (PSD) classes were defined using *Coregonus clupeaformis* as a surrogate for Cisco (Gabelhouse 1984): stock (7-12 in), quality (12-15 in), preferred (15-19 in), memorable (19-24 in) and trophy (≥ 24 in) size classes. Cisco (≤ 100/lake survey) were put on ice in the field, frozen at the nearest IDFW facility and then transported to Purdue University for subsequent analyses (Honsey 2014). Approximately 10 scales were collected from all Cisco that were subsequently heat pressed on acetate slides. The most readable scale impression of the series was projected with a microfiche reader and a high resolution image was captured with a digital camera. Three age analysts independently aged each digital sample and then conducted a concert read to resolve discrepancies. Length-at-capture data were used to calculate sex-specific growth rates for each population and these data were pooled to provide regional averages.

<u>2012 Surveys</u>

Six of the seven lakes surveyed in 2012 had quality cold-water layers. Although Gordy Lake (Noble Co.) had a marginal cold-water layer, gill nets were still deployed in the late-summer period given that: (1) this lake was most recently classified (Pearson 2001) as having a "rare" (≤1 Cisco/lift, but greater than 0 Cisco/lift) population status; and (2) resources were readily available to conduct the survey. Each of the other six lakes were surveyed with experimental gill nets during the late-summer period. Historically, five of these six lakes (Failing and Gage [Steuben Co.] lakes, Eve and South Twin lakes [LaGrange Co] and Crooked Lake [Noble/Whitley Co.]) have had among the highest Cisco catch rates, and thus, were classified as having a "common" population status (Pearson 2001). The last lake sampled in 2012 was Indiana Lake (Elkhart Co.), which was most recently classified as having an "unknown" Cisco population status (Pearson 2001). However, Cwalinski (2001) conducted an initial fish community survey at Indiana Lake and reported Cisco catch rates that met the "common" population criteria. Because few or no Cisco were collected during the late-summer period at Crooked and Gordy lakes, respectively, these lakes were also surveyed in November in an attempt to target spawning Cisco from 26-29 November 2012. Experimental gill nets were set on Gordy Lake in November at the same nine locations used during September sampling. In anticipation of catching adequate numbers of Cisco on Crooked Lake, two experimental gill nets were set on the afternoon of 26 November 2012 near the public access site in the shallow, northwest basin of the lake. These nets were checked hourly for 4 hours, while one net was left as an overnight set due to low catch rates during the afternoon. In addition to targeted gill netting, Little Crooked Lake (Whitley Co.) was also sampled for Cisco using dip nets during an observed mid-summer oxy-thermal hypoxic event (Donabauer 2015).

2013 Surveys

A standard fish community survey that included one gill net set in the cold-water layer was conducted on North Twin Lake on 26 June 2013 (Koza 2013). Late-summer water profiles were conducted on 16 of the historical Cisco lakes in 2013. Dallas (LaGrange Co.) and Snow (Steuben Co.) lakes did not have any quality or marginal cold-water habitat; therefore no gill nets were deployed. Little Lime and Meserve lakes (Steuben Co.) had marginal cold-water habitat, and because they were previously (Pearson 2001) listed as having a "rare" population status, gill nets were deployed in the late-summer period. Similarly, Lawrence Lake (Marshall Co.) had marginal cold-water habitat, thus gill nets were deployed since it had been previously (Pearson 2001) listed as "probably extirpated". Although, Myers Lake (Marshall Co.) had been previously (Pearson 2001) listed as "extirpated", it also had a marginal cold-water habitat layer; since resources were readily available, gill nets were deployed. Gill nets were also set on lakes that had a quality cold-water habitat layer and were previously listed (Pearson 2001) as "probably extirpated" (Clear [East, West and North Basins; Steuben Co.]; Dillard's Pit [Kosciusko Co.]; and Knapp [Noble Co.] lakes) and "rare" (Green Lake [Steuben Co.]). Although Big Cedar (Whitley Co.) and Martin, Olin and Oliver (LaGrange Co.) were previously classified as "extirpated" (Pearson 2001), gill nets were deployed because they all had quality cold-water habitat layers during the late-summer period and resources were readily available to conduct the surveys. Because Lake George (Steuben Co./Branch Co., MI) is in the Fawn River drainage (that historically supported Cisco) and it had a quality cold-water habitat layer on 16 August 2013 (marginal cold-water habitat layer on 16 September 2013), gill nets were deployed despite Ciscoes being historically undocumented by either the Indiana DFW (Pearson 2001) or Michigan DNR (S. Hanshue, personal communication).

2014 Surveys

Late-summer water profiles were collected among 24 historical Cisco lakes in 2014. Gill nets were only set in McClish Lake (LaGrange/Steuben Co.) because it had a quality cold-water layer and the previous assessment (Pearson 2001) classified them as “common”. Although four other lakes (Big Otter [Steuben Co.], Gilbert [Noble Co.], Hackenburg [LaGrange Co.] and Lake of the Woods [LaGrange/Steuben Co.]) had a quality cold-water layer, gill nets were not set in these lakes to target Cisco because the previous classifications (Gulish 1975, Koza 1994, Pearson 2001, and Koza 1994, respectively) listed them as “extirpated”. Lake James (Steuben Co.) and Waubee Lake (Kosciusko Co.) had a marginal cold-water layer, but again, gill nets were not deployed because both lakes were previously listed (Pearson 2001 and Gulish 1975, respectively) as “extirpated”. Moreover, 2 gill nets had been set in Waubee each June from 2010-14 for general surveys and none produced Cisco (J. Pearson, IDFW, personal communication). The two south basins of the Seven Sisters Lakes were the only other lakes in 2014 to have had a quality cold-water layer; however, the water profiles were deemed unreliable indicators of the late-summer period because the cold-water layers extended up to the surface on the 16 September 2014. Therefore, gill nets were not set in either of the two south basins of the Seven Sister chain despite the previous assessments (Koza 1994 and Pearson 2001) listing the species as “probably extirpated”. Gill nets were not set in any of the 16 other lakes surveyed because quality cold-water layers during late-summer assessments were not observed among: James, Oswego, Sechrist and Tippecanoe (Kosciusko Co.); Atwood, Big Long, Fish, Messick, Royer and Witmer (LaGrange Co.); Hindman and Village (Noble Co.); Gooseneck, Jimmerson and Marsh (Steuben Co.); and Round (Whitley Co.) lakes. Among these 16 lakes, Pearson (2001) classified Cisco in Gooseneck as “rare” while the other 15 lakes were classified as “extirpated” by Pearson (2001; Hindman, Jimmerson, Messick and Royer), Koza (1994; Atwood Lake) and Gulish (1975; the remaining 10 lakes). Because resources were readily available, additional late-summer water profile data were collected on Failing and Snow (Steuben Co.) lakes and Lawrence and Myers (Marshall Co.) lakes.

2015 Surveys

Just two of the remaining 49 historical Cisco lakes were sampled in 2015: Shock (Kosciusko Co.) and Shriner (Whitley Co.) lakes. Neither quality nor marginal cold-water layers were observed at Shock Lake; therefore gill nets were not deployed. A quality cold-water layer was observed at Shriner Lake, however, gill nets were not deployed because the previous assessments listed them as “extirpated” (Gulish 1975, Koza 1994, and Pearson 2001). Because resources were readily available, additional late-summer water profile data were collected on Waubee (Kosciusko Co.), North Twin and South Twin (LaGrange Co.), Lawrence and Myers (Marshall Co.), Crooked (Noble/Whitley Co.), Gage, George, Green and Jimmerson (Steuben Co.) and Big Cedar (Whitley Co.) lakes.

2016 Surveys

Late-summer profiles were completed at 6 northern Indiana glacial lakes during the last two weeks of August 2016. Quality cold-water layers were present at McClish (Steuben/LaGrange Co.), North Twin (LaGrange Co.), and Seven Sisters (Steuben Co.) lakes. Marginal cold-water layers were present at Meserve (Steuben Co.) and Failing (Steuben Co.) lakes. The only lake that lacked a cold-water layer was Hackenburg Lake (LaGrange Co.). Resources were available, therefore gill nets were set at McClish and Meserve lakes between 30 August and 9 September 2016. McClish and Meserve lakes were selected for gill netting efforts because of the presence of cold-water habitat and their previous classification (Pearson 2001) as “common” and “rare”, respectively.

Population Status (Classification) Defined

The classification system to describe the status of a Cisco population in any given lake was modeled after Koza (1994). Cisco catch rates were defined as the number of Cisco collected per overnight gill net lift, where the entire net had been set within the cold-water layer. Catch rates of Cisco ≥ 1 per gill net lift were classified as “common”, whereas catch rates of Cisco < 1 per gill net lift but > 0 per gill net lift were classified as “rare”. If a quality cold-water layer was observed but no Cisco were collected with gill nets, then the population was classified as “probably extirpated”. Lastly, if a quality cold-water layer was not present, the population status was defined as “extirpated”. However, a single-tier system of demotion from a lake’s prior designation (Pearson 2001) to its current designation was followed (J. Pearson, IDFW, personal communication) to define the current status of Cisco populations. For example, if a Cisco population was to have been listed in 2001 as "common" and yet a cold-water habitat layer was not observed during recent surveys (2012-16), the lake would be classified as "rare" rather than "extirpated". This method of reclassification conservatively acknowledges the limitations of information based a single water profile or annual gill net survey and behooves the IDFW and its collaborators to collect more information.

RESULTS

<u>Water Profiles</u>

One hundred and three late-summer water profiles were collected from 2012-16 among the 49 historical Cisco lakes (Table 1). Twenty lakes had *quality* cold-water habitat: Indiana (Elkhart Co./Cass MI); Dillard's Pit (Kosciusko Co.); Eve, Martin, Olin, Oliver, South Twin (LaGrange Co.); Lake of the Woods, McClish (LaGrange/Steuben Co.); Gilbert, Knapp (Noble Co.); Crooked (Noble/Whitley Co.); Big Otter, Clear, Failing, Gage, Green, Seven Sisters (Steuben Co.); and Big Cedar and Shriner (Whitley Co.). Five lakes had *marginal* cold-water habitat: Lawrence (Marshall Co.); Gordy (Noble Co.); and James, Little Lime, Meserve (Steuben Co.). Six lakes had *intermittent* cold-water habitat: Waubee (Kosciusko Co.); North Twin (LaGrange Co.); Myers (Marshall Co.); George (Steuben Co./Branch MI); Hackenburg (LaGrange Co.); and Jimmerson (Steuben Co.). Eighteen lakes *lacked* cold-water habitat: James, Oswego, Sechrist, Shock, Tippecanoe (Kosciusko Co.); Atwood, Big Long, Dallas, Fish, Messick, Royer, Witmer (LaGrange Co.); Hindman, Village (Noble Co.); Gooseneck, Marsh, Snow (Steuben Co.); and Round (Whitley Co.). Among 49 lakes sampled for water clarity during the late-summer period, median Secchi depth was 9.0 feet (quartile range: Min = 3.0, Q2 = 7.0, Q3 = 14.0, Max = 23.0).

<u>Catch Rates, Size/Age Structure and Growth Rates</u>

During the study, 466 Cisco were collected among 7 of the 22 lakes surveyed with gill nets (Tables 2-5). Additionally, 101 Cisco were collected with dip nets during the July 2012 hypoxic event at Little Crooked Lake. The gill net catch rates (1-42 Cisco/lift), length (7.4-17.6 in; Figure 1) and age (1-10 years; Figures 2-3) frequency distributions of Cisco varied greatly among lakes. Cisco (0.8/lift) were collected in Crooked Lake in September 2012 and again during the afternoon (8 soak hrs) and the overnight set on 27 November 2012 (8 and 46 Cisco, respectively). Although Failing and South Twin lakes produced among the highest catch rates (42 and 24 Cisco/lift, respectively), all Cisco collected (Max = 11.7 and 11.6 in, respectively) were less than quality-size. In contrast, Lake Gage had among the lowest catch rates (6 Cisco/lift), however 98% were of preferred-size (range: 14.8-17.6 in). Cisco from Eve Lake (5 Cisco/lift) and Indiana Lake (34 Cisco/lift) had the broadest range of total lengths observed (8.0-16.0 and 7.5-15.8 in, respectively). Growth rates between males and females were generally similar. Given at least 3 individuals within a population were measured within an age-class, mean length-at-capture deviated ≤ 7% between the sexes (Figures 2-3).

Classification

The results of the 2012-16 water quality and gill net surveys provide the information to describe the current status of Cisco in Indiana (Table 6). Fifteen of the 49 lakes had *quality* cold-water habitat and were sampled with gill nets. Of these, just 6 lakes met the "common" criteria (i.e., ≥ 1 Cisco/lift) for Cisco: Indiana (Elkhart/Cass MI Co.); Eve, Lake Gage and South Twin (LaGrange Co.); Crooked (Noble/Whitley Co.); and Failing (Steuben Co.). Although Martin, Olin and Oliver (LaGrange Co.), and Big Cedar (Whitley Co.) had *quality* cold-water habitat, the gill net data provided evidence that Cisco are still "extirpated" in these waters. Similarly, the five remaining lakes had *quality* cold-water habitat, but the gill net surveys did not produce any Cisco. The status of Knapp Lake (Noble Co.) as "probably extirpated" (Pearson 2001) remained unchanged. However, the status for Dillard's Pit (Kosciusko Co.) and Clear (Steuben Co.) lakes were both demoted from "rare" (Pearson 2001) to "probably extirpated". Green Lake (Steuben Co.) was demoted from "common" (Pearson 2001) to "rare". McClish Lake (LaGrange/Steuben Co.) was demoted from "common" (Pearson 2001) to "rare" and the "probably extirpated" (L. Koza, IDFW, personal communication) after Cisco were not observed in either 2014 or 2016 gill net sets, respectively.

Four of the 49 lakes surveyed from 2012-16 had a *quality* cold-water habitat layer but were not sampled with gill nets. Although Lake of the Woods (LaGrange/Steuben Co.), Big Otter (Steuben Co.), Gilbert (Noble Co.), and Shriner (Whitley Co.) lakes met the *quality* cold-water habitat criteria, we decided against gill net deployment given that all of these lakes were previously classified (Gulish 1975; Koza 1994; Pearson 2001) as "extirpated". Although the two south basins of the Seven Sisters chain also had *quality* cold-water habitat in 2014, gill nets were not deployed because the water profile was collected outside of the late-summer period (16 September 2014) and resources to conduct the survey were limited. In 2016, three of the five Seven Sisters basins had *quality* cold-water habitat, thus the prior classification (Pearson 2001) “probably extirpated” has remained unchanged.

Five of the 49 historical Cisco lakes had a *marginal* cold-water habitat layer. Lake James (Steuben Co.) was the only one of these lakes to retain a consistent classification with its previous designation (Pearson 2001: “extirpated”). The other 4 lakes were surveyed with gill nets and their classification was demoted based on the lack of both gill netted Cisco and consistent *quality* cold-water habitat: Lawrence (Marshall Co.: “extirpated”); Gordy (Noble Co.: “probably extirpated”); and Little Lime and Meserve (Steuben Co.: “probably extirpated”) lakes.

Nineteen of the 49 lakes were not surveyed with gill nets because they lacked a consistent *quality* or a *marginal* late-summer cold-water habitat layer and were previously listed as “extirpated” (Pearson 2001). All 19 of these lakes remain classified as “extirpated”: James, Oswego, Sechrist, Shock, Tippecanoe and Waubee (Kosciusko Co.); Atwood, Big Long, Fish, Hackenburg, Messick, Royer and Witmer (LaGrange Co.); Hindman and Village (Noble Co.); Jimmerson, Marsh and Snow (Steuben Co.); and Round (Whitley Co.).

Two other lakes were devoid of *quality* or *marginal* cold-water habitat, therefore we did not survey them with gill nets and reclassified them based on the single-tier system of demotion: Dallas Lake (LaGrange Co.) was reclassified from “probably extirpated” to “extirpated” and Gooseneck Lake (Steuben Co.) from “rare” to “probably extirpated”. Furthermore, three lakes including North Twin (LaGrange Co.); Myers (Marshall Co.); and Lake George (Steuben Co.) lacked a *quality* or *marginal* cold-water layer in at least one of the years the lakes were surveyed, but we sampled them with gill nets given that resources were readily available. North Twin Lake (LaGrange Co.) was previously listed (Pearson 2001) as “extirpated”; however, Cisco were “common” during the June 2013 fish community survey (Koza 2013), which suggests that the source of this population may be immigrant Cisco from neighboring South Twin Lake. Myers Lake (Marshall Co.) did not produce any Cisco and were classified as “extirpated”, consistent with its previous designation (Pearson 2001). Lake George gill netting did not produce any Cisco, which was classified as “extirpated”.

DISCUSSION

<u>Classification</u>

The purpose of this investigation was to collect targeted gill net and cold-water habitat data in order to evaluate the current (2012-16) distribution and abundance of Cisco among Indiana’s northern glacial lakes and to compare these findings to earlier research (Frey 1955, Gulish 1975, Koza 1994, and Pearson 2001). Pearson (IDFW email, 1/22/01) recommended that Ciscoes remain a species of "*Special Concern*" since more than 10 populations remained (Pearson 2001): 7 populations were listed "common" while another 6 populations were listed as "rare". The data provided in this report indicate that a single population in Green Lake (Steuben Co.) is "rare" and another 6 Cisco populations remain "common" in Indiana, among them: Crooked/Little Crooked lakes (Noble/Whitley Co.); Eve, North/South Twin lakes (LaGrange Co.); Failing and Gage lakes (Steuben Co.), and Indiana Lake (Elkhart Co.).

Both Crooked/Little Crooked and North/South Twin lakes should be considered single populations, respectively. A dredging project that removed bottom sediment in order to deepen the navigation channel between Crooked and Little Crooked lakes occurred in 2012 (Bright 2012). Even though the navigation channel was shallow (0.5 ft) prior to the sediment removal project, it is possible that Cisco moved between these two lakes during the cold-water seasons (i.e., late fall-early spring). Now that the navigation channel is at least 3.0 ft deep, it is more likely that Cisco use these two lakes as one continuous system, and therefore, they should be considered one population. Although Cisco in North Twin Lake (LaGrange Co.) were "common" based on a recent June general survey (Koza 2013), it was the only occasion that they have been observed since the early 1970's when Gulish (1974) suggested that they are likely immigrants from neighboring South Twin Lake. The late-summer water profile collected at South Twin Lake (LaGrange Co.) in 2015 had a temperature (T) of 48.3°F at dissolved oxygen (DO) concentration of 3 ppm (TDO3). However, the TDO3 was 68.1 °F at North Twin Lake (LaGrange Co.), just slightly above the defined cold-water habitat threshold of 68.0 °F. Thus, Gulish's (1974) theory that a single population of Cisco inhabits North and South Twin lakes remains plausible. Among all the lakes with a "common" population status, the Cisco population at North Twin Lake appears to be the most threatened by the lack of available cold-water habitat.

Indiana Lake (Elkhart Co./Cass MI) was identified as "common" in 2012, which had been undocumented (Pearson 2001) prior to the initial lake survey ("common"; Cwalinski 2001). Furthermore, Pearson (2001) classified Cisco in Green (Steuben Co.) and McClish (LaGrange/Steuben Co.) lakes as "common". We observed *quality* cold-water habitat in these lakes during our habitat surveys (2013/15 and 2014/16, respectively), yet we did not catch Cisco in our gill net sets. Therefore, the Green Lake population was demoted to a "rare" status and these data show that there is no long-term evidence that the IDFW's attempt in the 1990's to re-establish Cisco in this lake was successful. However, Green Lake could still be considered as a possible reintroduction site, given its consistent history of having *quality* cold-water habitat during the late-summer period. McClish Lake was demoted to "probably extirpated" (L. Koza, IDFW, personal communication). Although McClish Lake has *quality* cold-water habitat, its neighbor, Lake of the Woods, has been regularly stocked with Walleyes. We collected a Walleye in one of our gill nets at McClish Lake while netting for Cisco in 2014, which presumably, emigrated from Lake of the Woods. Thus, any discussion of rehabilitation of Cisco in McClish Lake would have to consider the implications of immigrant predator stockings.

Several other Cisco populations have been reclassified. Although Knapp (Noble Co.) and Seven Sisters (Steuben Co.) lakes remain "probably extirpated" given the availability of late-summer cold-water habitat, six other lakes were demoted from "rare" to "probably extirpated" because either: (1) Cisco were not collected: Clear (Steuben Co.) and Dillard's Pit (Kosciusko Co.), or (2) they lacked a sufficient (or consistent) cold-water layer: Gordy (Noble Co.); Gooseneck, Lime, Meserve (Steuben Co). Twenty-nine lakes remain classified as "extirpated", while Dallas Lake (LaGrange Co.) was demoted from "probably extirpated" to "extirpated" given its lack of available cold-water habitat. Although Lawrence Lake (Marshall Co.) had at least a marginal cold-water layer from 2013-15, it was demoted from "probably extirpated" to "extirpated" because 0 Cisco and 52 Northern Pike (20.5-38.5 in) were collected in 9 gill net lifts (T. Bacula, Indiana DFW, personal communication). Targeted Northern Pike sampling in March of 2016 further demonstrates the continued presence of the predator in Lawrence Lake with twenty-one Pike (21.9-38.8 in) collected in 8 trap net lifts (M. Linn, Indiana DFW). Lake George (Steuben Co./Branch MI) was previously unclassified (Pearson 2001), yet Cisco are classified as "extirpated" based on the evidence: (1) neither Michigan nor Indiana DNR had any historical record of Cisco in Lake George; (2) no Cisco were collected in 2013; and (3) cold-water habitat was lacking in 2015.

The population status of Cisco in Crooked Lake was previously defined as "common" (Pearson 2001), which was validated during the 2012 assessment. In addition, the frequency at which adult Cisco were dip netted during a 2012 mid-summer hypoxic event (Donabauer 2015) demonstrate that Cisco were also "common" in Little Crooked Lake. There are three considerations regarding the current management of Cisco at Crooked/Little Crooked lakes: (1)

the sport fishery; (2) undesirable predators; and (3) late summer oxythermal stress. First, this lake continues to support a recreational fishery for Cisco and anecdotal evidence suggests hook-and-line angling peaks in late-November through early-December. A creel survey would help to better understand the level of angling interest for Cisco. Second, a possible threat to Cisco in Crooked/Little Crooked lakes is the continued documentation of Northern Pike. The 2012 survey produced the seventh Pike collected in Crooked Lake since they were first observed in October 1996 (Pearson 2012), and the sixth Pike collected since September 2009. Pike had not been detected in Crooked Lake despite annual gill nets sets dating back to the 1970's. Pike are not native to Crooked Lake and could negatively impact on the Cisco population through excessive predation (J. Pearson, IDFW, 6/20/12 News Release). Lastly, it appears that a *lethal oxythermal niche boundary* poses a significant threat to Cisco in Crooked Lake during the late-summer period. For example, the cold-water layer was determined to be 3 ft on 19 August 2011, 6 ft on 9 August 2010, and 6 ft on 10 August 2009 (S. Donabauer, IDFW, unpublished data). Historically, Cisco die-offs have occurred at Crooked Lake (1981, 1986, and 2000; Pearson 1986, Pearson, 2000, Pearson 2001). Given the narrow cold-water layers observed in 2009, 2010, and especially in 2011, efforts should be made to monitor annual variation and the availability of cold-water habitat during this critical period. In addition, Pearson (1990) identified several tributaries to Crooked Lake that could contribute to poor water quality and these tributaries should be re-evaluated as potential drivers of nutrient loading.

While the Crooked/Little Crooked Lake Cisco should be considered a single population, the DFW currently has a better understanding of the habitat availability at Crooked Lake. We do not have information prior to the oxythermal event at Little Crooked Lake that occurred in 2012. Therefore, it is challenging to determine the exact temperature and dissolved oxygen threshold for this Cisco population. Oxythermal summer kills are not uncommon among Cisco populations and have been reported elsewhere in the literature (Jacobson et al. 2008; Pearson 1985; Colby and Brooke 1969). Jacobson et al. (2008) attempted to more precisely define this threshold by monitoring a number of Cisco summer kills in Minnesota. The authors found that the lethal threshold for Cisco was defined by an interaction between temperature and dissolved oxygen concentrations. This "*lethal oxythermal niche boundary*" suggests that adult Ciscoes require minimum dissolved oxygen concentrations of 3 and 1 ppm when they are exposed to temperatures thresholds of 71.5 °F, and 67.0 °F, respectively. The data we collected during the Cisco summer kill at Little Crooked Lake supports the theory that this interactive threshold is a more plausible boundary than the rigid *Cisco layer* established by Frey (1955). Furthermore, there is evidence that suggests young-of-year Cisco are more tolerant of higher temperatures and lower oxygen concentrations, and thus more likely to survive oxythermal stress (Edsall and Colby 1970). The fish we collected between 24-25 July 2012 corroborate this theory because no Cisco smaller than 9.4 in were collected and Cisco of this size have been found to average age-3 in neighboring Crooked Lake (Koza 1994).

Cisco Metrics for other Remnant Populations

The population status of Cisco in Eve Lake (LaGrange Co.), Failing Lake (Steuben Co.), Indiana Lake (Elkhart Co.), Lake Gage (Steuben Co.) and South Twin Lake (LaGrange Co.) were all previously defined as "common" (Pearson 2001), and were confirmed during the 2012 survey. Our catch rate of Cisco at Eve Lake (N = 49; 4.9/lift) was nearly unchanged from that reported by Koza (1994; 5.0/lift). A total of 126 Cisco were sampled from Failing Lake at a catch rate of 42/lift. This is a marked increase over the previous catch rate of 27/lift documented by Koza (1994) and the highest among the 2012 study lakes. Catch rates from the 2012 survey at Indiana Lake were higher (N = 101; 34/lift) than to those reported in the previous study (Cwalinski 2001) and were the second highest among all lakes sampled in 2012. At Lake Gage, our catch rate of Cisco was higher (N = 51; 5.7/lift) than that reported in the last survey (1.8/lift. N = 29; Pearson 2001). The higher catch rate (and possibly larger size structure) observed in 2012 at Lake Gage may be the result of our institutional awareness of how best to set effective nets for Cisco rather than a biological phenomenon between survey eras (L. Koza, IDFW, personal communication). However, the size and age distribution skewed towards larger older fish also suggests there may be inconsistent recruitment at Lake Gage. Our catch rate at South Twin Lake (N = 71; 24/lift) was the third highest among the 2012 lakes surveyed and notably higher than those reported in the most recent past survey (17/lift; Ledet 1987).

The length-frequency data indicated a bimodal distribution of size classes in Eve Lake, dominated by relatively large individuals (range: 8.0-16.0 in) that resulted in the second highest median size (14.8 in) of Cisco among all lakes sampled in 2012. The Failing Lake population had the second lowest median size (10.3 in) of Cisco among the 2012 study lakes. Likewise, Koza (1994) documented a population dominated by relatively small individuals in Failing Lake (7.0-

11.5 in). A wider range of lengths (7.5-15.8 in) were observed in the 2012 survey at Indiana Lake compared to Cisco collected in the previous survey (12.5-15.0 in) and the median length of Cisco in 2012 was higher (14.5 in) than the previous survey (13.7 in; Cwalinski 2001). The size range (14.8-17.6 in) and median length (16.4 in; highest among all lakes surveyed in 2012) of Cisco observed at Lake Gage in 2012 was higher than compared to the previous survey in 1990 (range: 12.2-16.4 in; median: 15.4 in; L. Koza, IDFW, personal communication). The South Twin Lake Cisco population is dominated by small individuals (range: 7.4-11.6 in) that had the smallest median size (9.2 in) of all the lakes sampled in 2012. Previous surveys also showed similar sizes of Cisco in South Twin Lake (8.0-11.4 in, Ledet 1987; 7.5-12.0 in, Ledet 1983).

Habitat Metrics for other Remnant Populations

Compared to prior assessments of lakes known to contain Cisco, the availability of cold-water habitat diminished in two lakes, increased in one lake, and data were collected too late in the season (i.e, late September) among the other two lakes to make comparisons. The cold-water layer at Eve Lake was determined to be 7 ft in early September 2012, which was lower than the 9 ft layer estimated by Koza (1994) in early September 1990. We documented the cold-water layer at Failing Lake to be 4 ft in early September 2012, while Koza (1994) found the layer to be 8 ft in late-August. The cold-water layer was approximately 14 ft in mid-September 2012 at Indiana Lake, compared to 12 ft in late-August 2001 (Cwalinski 2001). A 36 and 34 ft cold-water layer was verified in Lake Gage and South Twin, respectively, in the early fall (i.e., late-September). However, it is not known whether a *lethal oxythermal niche boundary* poses a threat to either of these lakes during the late-summer period and efforts should be made to collect water temperature and dissolved oxygen profiles between the third week in August through the second week in September.

Management Implications

The purpose of this study was to provide data that could be used to update the lake-specific classification of Cisco among Indiana's northern glacial lakes. To this end, our research has identified biologically important habitats that are in need of conservation. Gremillion-Smith (2000) stated the Cisco's "*special concern status*" be brought "*before the appropriate Technical Advisory Committee for status review*", which would be "*an important public relations step*" and if this species were to be reclassified as "*endangered*" it would "*provide more stringent reviews of* *environmental permits for lakes still supporting Cisco*". Most recently, Conservation Opportunity Areas (COA's) were delineated in the State Wildlife Action Plan (IDFW 2015) for the 6 land use catchments of lakes known to still be inhabited by Cisco in Indiana. The goal of COA's are to "*direct actions toward specific areas on Indiana's landscape*" and more specifically for glacial lakes "*to bridge the gap between terrestrial and aquatic conservation efforts that aim to sustain or enhance the water quality of streams and rivers that drain into them*" by acknowledging that "*lake eutrophication (i.e., nutrient loading) is a leading cause of lake degradation*." The top threat listed in the Indiana State Wildlife Action Plan (IDFW 2015) for Species of Greatest Conservation Need (e.g., Cisco) in aquatic systems (e.g., glacial lakes) within the Great Lake region was listed as "*natural habitat conversion*" followed by the top conservation actions "*enhance public, stakeholder, and landowner educational awareness*" and "*reduce sediment and nutrient loads*". If Ciscoes are to persist in Indiana, the conservation community will need to work synergistically to review their status as a Species of Greatest Conservation Need and allocate the resources (i.e., time, talent and treasure) necessary to prevent nutrient loading/recycling within the defined COA's.

RECOMMENDATION

Given that less than 10 populations are now classified as either "common" or "rare", we recommend that the North Fisheries Management Region share this report with the Aquatics Technical Advisory Committee so that they can determine whether formal reclassification of Cisco from a "Species of Special Concern" to an "Endangered Species" is warranted.

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APPROVAL

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Table 1.– Water profile data collected in glacial lakes (A-C) from 2012-16. D = depth (ft); T = temperature (°F); DO = dissolved oxygen (ppm); and CHL = Coldwater Habitat Layer (thickness; ft). Shaded values were derived from the water profile data using a habitat calculator (Pearson and Porto, IDFW).

Lake (County)	Atwood (LaGrange)		Bear (Noble)		Big Cedar (Whitley)		Big Cedar (Whitley)		Big Long (LaGrange)		Big Otter (Steuben)		Cass (LaGrange)	
Date	8/28/2014		8/30/2016		9/16/2013		8/18/2015		9/2/2014		9/3/2014		8/29/2016	
Unit	NFR		D3		D3		D3		NFR		D2		D2	
Clarity (ft)	9.5		7.0		18.0		14.5		10.0		N/A		8.5	
D @ 68°F	22.9		14.5		19.6		18.0		19.8		15.6		21.3	
D @ DO3	14.5		12.6		21.3		21.9		17.5		19.7		14.9	
T @ DO3	75.6		73.7		64.7		57.8		72.5		58.3		77.5	
CHL	0.0		0.0		1.7		3.9		0.0		4.0		0.0	
D	T	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T	DO
0	77.4	7.29	80.0	4.36	72.2	8.05	80.0	7.21	76.6	7.09	77.7	8.50	80.3	6.44
2	77.5	7.31	80.0	4.26			79.9	7.47	76.7	7.15	77.6	8.50	80.0	6.42
4			79.7	4.20			79.8	7.25	76.7	7.15	77.2	8.50	79.9	6.40
5	77.6	7.34	79.6	4.25	72.3	7.85	79.8	7.38						
6	77.6	7.32	79.6	4.31			79.8	7.37	76.8	7.15	77.2	8.50	79.6	6.45
8	77.6	7.32	78.7	4.03			79.8	7.36	76.8	7.15	77.1	8.40	79.1	6.11
10	77.5	7.11	77.7	3.95	72.4	7.66	79.7	7.30	76.8	7.13	77.0	8.20	78.7	5.22
12	77.1	6.20	75.0	3.62			79.7	7.24	76.8	7.09	76.7	8.00	78.3	5.04
14	75.9	3.86	70.7	1.63			77.0	7.16	76.4	6.22	72.7	10.50	77.8	4.04
15			65.7	1.07	72.3	7.68	75.5	7.71						
16	74.5	0.35	61.9	1.34			73.4	7.99	75.2	5.44	67.0	7.60	77.0	1.60
18	73.3	0.12	56.6	0.63	71.8	7.08	68.0	6.17	71.6	2.22	61.7	4.50	75.2	0.60
20	71.9	0.07	53.2	0.27	67.1	5.06	61.4	3.89	67.6	0.10	57.6	2.70	70.9	0.61
22					63.3	1.86	57.6	2.95			54.0	2.40	66.5	0.63
24					59.2	0.85	53.4	1.94			51.1	2.40		
25	65.2	0.05	48.7	0.20			52.6	1.22	59.8	0.04				
26					56.2	0.37	51.7	1.06			49.1	2.40		
28					53.9	0.36	49.8	0.50			47.2	2.50		
30	55.7	0.05	47.2	0.06	51.8	0.98	48.8	0.36	52.3	0.43	46.1	2.50		
32					50.7	0.93	46.8	1.12			45.0	2.40		
34					49.4	0.37	45.2	1.50			44.3	2.40		
35			46.4	0.00	48.8	0.25	44.8	1.44	50.6	0.21				
36							44.2	1.47			44.2	2.40		
38							43.4	1.50			44.1	2.40		
40			46.2	0.00	47.0	0.28	42.5	0.79	49.5	0.20				
42							42.1	0.33						
44														
45			46.1	0.00			41.3	0.22	48.7	0.13				
46														
48														
50			46.1	0.00					47.3	0.02				
52														
54														
55									46.5	0.02				
56														
58														
60									46.2	0.00				
62														
64														
65									46.1	0.00				
66														
68														
70									46.1	0.00				
72														
74														
75									46.1	0.00				
76														
78														
80									46.0	0.00				

Table 1.– Water profile data collected in glacial lakes (C-C) from 2012-16. D = depth (ft); T = temperature (°F); DO = dissolved oxygen (ppm); and CHL = Coldwater Habitat Layer (thickness; ft). Shaded values were derived from the water profile data using a habitat calculator (Pearson and Porto, IDFW).

Lake (County)	Clear (East Basin; Steuben)		Clear (West Basin; Steuben)		Clear (North Basin; Steuben)		Clear (East Basin; Steuben)		Clear (West Basin; Steuben)		Clear (North Basin; Steuben)		Crooked (Noble/Whitley)	
Date	9/3/2013		9/3/2013		9/3/2013		9/1/2016		9/1/2016		9/1/2016		10/4/2012	
Unit	D2		D2		D2		NFR		NFR		NFR		NFR	
Clarity (ft)	7.5		7.5		N/A		13.5		14.0		16.0		7.0	
D @ 68°F	22.8		20.3		22.9		25.4		23.1		24.2		N/A	
D @ DO3	25.7		22.5		22.9		31.0		21.6		63.5		27.0	
T @ DO3	62.1		65.2		68.0		56.5		71.1		44.0		61.6	
CHL	2.9		1.2		0.0		5.6		0.0		7.1		27.0	
D	T	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T	DO
0	76.2	7.40	76.4	6.90	76.4	7.10	77.2	4.33	76.8	6.24	76.9	6.34	63.8	7.80
2	76.3	7.40	76.5	6.90	76.5	7.20	77.2	4.53	76.9	6.23	77.0	6.26	63.8	7.30
4	76.4	7.40	76.4	6.90	76.6	7.10	77.3	4.27	77.0	6.24	77.1	6.26	63.8	7.30
5							77.3	5.00	77.1	6.21	77.1	6.25	63.8	7.30
6	76.4	7.30	76.4	6.90	76.6	7.10	77.3	5.01	77.1	6.21	77.2	6.32	63.8	7.10
8	76.4	7.30	76.4	6.90	76.6	7.10	77.3	5.20	77.1	6.25	77.2	6.28	63.8	7.00
10	76.4	7.30	76.3	6.90	76.6	7.10	77.3	5.31	77.1	6.23	77.2	6.28	63.8	6.90
12	76.4	7.30	76.1	6.70	76.6	7.10	77.3	5.38	77.2	6.37	77.2	6.37	63.8	6.90
14	76.4	7.20	76.0	6.70	76.2	6.80	77.3	5.48	76.7	6.22	77.2	6.33	63.8	6.70
15							77.3	5.58	76.6	6.22	77.2	6.43	63.8	6.90
16	76.2	7.20	75.9	6.70	76.0	6.70	77.2	5.66	76.6	6.16	77.2	6.38	63.8	6.80
18	75.6	7.10	75.2	6.60	75.7	6.60	76.6	5.65	76.0	5.96	77.2	6.39	63.8	7.00
20	73.2	6.20	68.8	4.30	72.2	5.30	76.3	5.62	74.7	5.23	77.1	6.32	63.8	6.80
22	69.5	4.70	64.1	2.60	69.8	3.80	75.3	5.56	70.3	2.50	73.3	5.38	63.8	6.80
24	65.7	3.50	60.9	1.50	66.0	2.10	72.0	5.62	66.0	1.54	68.7	4.35	63.8	6.70
25							69.3	5.53	64.7	1.04	65.5	3.25	63.7	6.40
26	61.4	2.90	58.8	0.70	61.9	1.20	66.2	5.21	63.1	0.80	63.8	2.46	63.6	6.20
28	57.6	2.40	55.0	0.40	58.8	1.00	61.9	4.50	59.8	0.56	59.3	1.24	59.8	0.00
30	53.6	2.30	52.1	0.40	55.6	0.70	57.9	3.33	57.2	0.43	56.5	1.00	53.4	0.00
32	50.9	2.80	50.7	0.40	52.2	0.60	55.1	2.69	55.2	0.36	54.2	0.75	50.0	0.00
34	49.3	3.20	49.1	0.40	50.7	0.60	52.8	2.14	54.5	0.27	52.8	0.58	48.1	1.30
35							51.8	2.12	52.6	0.24	51.8	0.52	47.4	1.60
36	48.0	3.10	48.0	0.40	50.1	0.70	50.8	1.87	50.9	0.22	50.9	0.54	46.3	2.00
38	47.2	3.10	47.2	0.40	49.4	0.80	49.4	1.95	49.2	0.17	50.0	0.82	45.2	2.40
40	46.6	2.90	46.7	0.40	48.7	1.20	48.6	1.92	48.0	0.15	49.2	1.10	44.3	2.50
42	45.7	2.90	46.2	0.40	48.0	1.90	48.1	1.87	47.1	0.14	48.4	1.86	43.0	2.30
44	45.4	2.50	45.9	0.40	47.6	2.30	47.5	1.86	46.4	0.13	47.9	2.49	42.3	2.20
45							47.2	1.80	46.2	0.12	47.1	3.36	41.9	2.10
46	45.2	2.30	45.6	0.40	46.6	4.20	46.8	1.74	46.0	0.12	46.8	3.94	41.8	2.10
48	45.2	2.10	45.4	0.40	46.3	4.40	46.1	1.54	45.8	0.11	46.0	4.80	41.4	1.50
50	45.1	2.10	45.3	0.40	45.9	3.90	46.0	1.39	45.6	0.11	45.4	5.38	41.1	1.50
52	44.9	1.90	45.2	0.40	45.7	3.10	45.7	1.13			45.1	5.42	40.9	1.60
54	44.9	1.70	45.1	0.40	45.5	2.50	45.5	1.12			45.2	5.48	40.7	1.70
55							45.3	1.11	45.3	0.10	44.9	5.42	40.6	1.70
56	44.8	1.70	45.0	0.40	45.3	1.60	45.1	1.14			44.6	5.10	40.6	1.60
58	44.7	1.50	44.9	0.40	45.0	0.80	45.0	1.14			44.4	4.66	40.3	1.30
60	44.7	1.40	44.9	0.40	44.9	0.70	44.9	1.07	45.0	0.09	44.3	4.25	40.3	1.10
62	44.6	1.30	44.8	0.40	44.8	0.70	44.9	0.96			44.1	3.78	40.2	0.40
64	44.6	1.20	44.8	0.40	44.7	0.70	44.8	0.91			44.0	2.76	40.2	0.00
65							44.8	0.91	44.8	0.08	44.0	1.60	40.1	0.00
66	44.6	1.10	44.7	0.40	44.6	0.70	44.8	0.95			44.0	0.79	40.1	0.00
68	44.5	1.10	44.7	0.40	44.5	0.70	44.7	0.98			43.9	0.57	40.1	0.00
70	44.5	1.00	44.6	0.40	44.4	0.70	44.6	0.98	44.6	0.07	43.8	0.44	40.0	0.00
72	44.5	0.90	44.6	0.40	44.3	0.70	44.6	0.88			43.7	0.38	40.0	0.00
74	44.4	0.90	44.6	0.40	44.2	0.70	44.6	0.87			43.7	0.35	39.9	0.00
75							44.6	0.90	44.5	0.07	43.6	0.31	39.9	0.00
76	44.4	0.80	44.5	0.40	44.2	0.70	44.6	0.88			43.6	0.28		
78	44.4	0.80	44.5	0.40	44.1	0.70	44.6	0.77			43.6	0.24		
80	44.4	0.80			44.0	0.70	44.5	0.70			43.6	0.21	39.8	0.00

Table 1.– Water profile data collected in glacial lakes (C-D) from 2012-16. D = depth (ft); T = temperature (°F); DO = dissolved oxygen (ppm); and CHL = Coldwater Habitat Layer (thickness; ft). Shaded values were derived from the water profile data using a habitat calculator (Pearson and Porto, IDFW).

Lake (County)	Crooked (Noble/Whitley)		Crooked (Noble/Whitley)		Crooked (Basin 1; Steuben)		Crooked (Basin 2; Steuben)		Crooked (Basin 3; Steuben)		Dallas (LaGrange)		Diamond (Noble)	
Date	8/27/2015		8/30/2016		8/30/2016		8/30/2016		8/30/2016		9/13/2013		8/24/2016	
Unit	NFR		NFR		NFR		NFR		NFR		NFR		D3	
Clarity (ft)	12.5		18.0		9.5		12.0		7.0		3.5		12.5	
D @ 68°F	19.3		19.9		26.2		24.8		N/A		17.9		14.1	
D @ DO3	27.7		30.2		21.2		22.7		N/A		17.0		13.4	
T @ DO3	52.1		51.0		76.3		72.9		80.9		70.5		70.6	
CHL	5.7		6.5		0.0		0.0		0.0		0.0		0.0	
D	T	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T	DO
0	73.3	5.17	76.8	6.24	80.4	4.30	79.7	4.75	80.7	4.44	74.9	9.51	76.9	7.30
2	73.3	5.19	76.9	6.23	79.8	4.51	79.6	4.93	80.5	5.30	75.0	9.49	76.9	7.20
4	73.3	5.25	77.0	6.24	79.4	4.76	79.4	5.06	80.2	5.49	75.0	8.86	76.9	7.20
5			77.1	6.21	79.2	3.31	79.3	5.12	80.2	5.35			76.9	7.20
6	73.3	5.27	77.1	6.21	79.2	5.42	79.3	5.21	80.1	5.05	75.0	9.16	76.9	7.30
8	73.3	5.29	77.1	6.25	79.0	5.42	79.1	5.28	80.0	5.31	75.0	8.77	76.7	7.20
10	73.3	5.34	77.1	6.23	78.8	5.49	79.0	5.35			75.0	8.42	76.4	7.10
12	73.3	5.30	77.2	6.37	78.7	5.61	78.8	5.52			74.9	8.72	75.5	6.50
14	73.3	5.31	76.7	6.22	78.7	5.60	78.3	5.47			74.8	8.36	68.3	1.40
15			76.6	6.22	78.5	5.60	78.0	5.38					65.7	0.70
16	73.3	5.34	76.6	6.16	78.0	5.32	77.5	5.27			73.2	5.27		
18	73.3	5.37	76.0	5.96	77.4	4.87	76.9	5.13			67.6	0.52		
20	65.3	5.54	74.7	5.23	76.8	3.96	76.0	4.73			52.9	0.38	54.4	0.30
22	59.9	6.17	70.3	2.50	76.0	2.35	74.5	3.76						
24	56.1	5.15	66.0	1.54	73.8	0.50	69.7	1.46						
25			64.7	1.04	72.1	0.25	67.5	1.27			52.3	0.41	48.4	0.10
26	54.0	3.48	63.1	0.80	68.4	0.12	66.0	1.24						
28	51.7	2.90	59.8	0.56	64.7	0.06	63.0	0.96						
30	50.1	1.75	57.2	0.43	62.7	0.04	59.0	0.44			48.2	0.32	45.9	0.00
32	48.5	1.80	55.2	0.36	62.3	0.02	56.1	0.61						
34	47.2	1.23	54.5	0.27			54.3	0.44						
35			52.6	0.24			53.8	0.38			46.6	0.45	45.2	0.00
36	46.1	1.54	50.9	0.22			53.0	0.31						
38	45.5	1.64	49.2	0.17			51.6	0.28						
40	44.7	2.01	48.0	0.15			50.3	0.25			45.9	0.64	44.8	0.00
42	44.0	2.31	47.1	0.14			49.3	0.21						
44	43.5	2.44	46.4	0.13			48.7	0.19						
45			46.2	0.12			48.1	0.17			45.2	0.81		
46	43.1	2.68	46.0	0.12			47.9	0.16						
48	42.7	2.82	45.8	0.11			47.2	0.15						
50	42.5	3.00	45.6	0.11			46.9	0.13			44.8	0.52	44.3	0.00
52	42.2	3.08					46.6	0.12						
54	41.9	3.14					46.4	0.11						
55			45.3	0.10			46.3	0.09			44.1	0.31		
56	41.6	3.01					46.2	0.08						
58	41.4	2.88					46.1	0.08						
60	41.3	2.66	45.0	0.09			46.0	0.07			43.2	0.32	44.1	0.00
62	41.1	3.07					45.9	0.06						
64	40.9	3.21					45.8	0.05						
65			44.8	0.08			45.8	0.05			42.7	0.28		
66	40.7	3.27					45.8	0.05						
68	40.7	3.14					45.7	0.04						
70	40.6	2.71	44.6	0.07			45.6	0.03			42.4	0.32	44.0	0.00
72	40.6	2.34					45.6	0.03						
74	40.5	2.07					45.5	0.02						
75			44.5	0.07			45.5	0.00			42.2	0.31	44.0	0.00
76	40.5	1.61												
78	40.5	0.50												
80	40.5	0.34									42.1	0.24		

Table 1.– Water profile data collected in glacial lakes (D-F) from 2012-16. D = depth (ft); T = temperature (°F); DO = dissolved oxygen (ppm); and CHL = Coldwater Habitat Layer (thickness; ft). Shaded values were derived from the water profile data using a habitat calculator (Pearson and Porto, IDFW).

Lake (County)	Dillard's Pit (Kosciusko)		Eve (LaGrange)		Eve (LaGrange)		Failing (Steuben)		Failing (Steuben)		Failing (Steuben)		Fish (LaGrange)	
Date	9/3/2013		9/10/2012		8/30/2016		9/4/2012		9/4/2014		8/26/2016		9/4/2014	
Unit	D3		NFR		D1		D2		NFR		NFR		D2	
Clarity (ft)	10.0		12.5		10.0		16.0		19.0		23.0		N/A	
D @ 68°F	24.5		15.5		16.3		18.7		15.7		16.2		15.2	
D @ DO3	37.3		22.7		22.6		23.3		22.7		18.7		13.5	
T @ DO3	47.5		51.1		54.4		55.0		50.6		60.7		72.6	
CHL	5.5		5.0		5.9		4.5		4.7		2.5		0.0	
D	T	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T	DO
0	79.6	9.0	73.6	7.5	80.0	8.43	78.1	7.40	76.7	6.44	81.3	3.39	76.9	7.00
2	79.6	8.8	73.6	7.0	80.2	8.32	78.1	7.40	76.7	6.46	81.0	3.38	77.0	6.90
4	79.6	8.6	73.6	6.6	80.2	8.20	78.0	7.40	76.7	6.47	79.0	3.72	77.0	6.90
5	79.6	8.6	73.6	6.3							78.8	3.86		
6	79.6	8.5	73.6	6.4	80.0	8.10	77.8	7.60	76.7	6.47	78.7	3.89	77.1	6.90
8	79.6	8.4	73.6	6.5	79.7	7.61	77.6	7.60	76.7	6.41	78.6	3.88	77.0	6.90
10	79.6	8.4	73.4	6.2	78.9	8.08	77.5	7.60	76.7	6.40	78.3	4.03	77.0	6.90
12	79.6	8.3	73.1	6.3	77.7	7.63	77.4	7.60	76.2	5.50	77.5	3.40	75.9	5.90
14	79.6	8.3	71.9	6.3	74.5	8.99	75.6	8.60	73.4	7.94	73.7	3.28	71.5	2.00
15	79.6	8.3	69.4	7.7							70.8	3.30		
16	79.6	8.4	66.7	8.8	68.9	8.43	70.2	11.80	66.9	10.73	68.7	3.38	65.7	0.90
18	79.3	8.5	61.0	8.3	63.0	6.99	70.2	11.80	60.6	10.83	61.9	3.02	58.8	0.50
20	78.1	8.7	56.0	6.6	58.3	4.71	64.2	11.50	55.5	7.13	58.4	2.96	55.0	0.50
22	74.8	10.3	51.9	3.6	55.4	3.66	57.5	5.80	52.4	4.34	55.7	2.52	51.6	0.50
24	69.6	13.6	49.4	1.8	52.2	1.60	53.6	1.40	47.4	0.56	50.9	0.81	49.9	0.50
25	66.5	14.3	47.9	0.0							48.1	0.36		
26	63.8	14.3			49.9	1.25	49.0	0.50	43.8	0.38	46.4	0.23	48.3	0.50
28	59.0	12.7			48.6	1.13	44.6	0.50	41.4	0.15	44.5	0.12	46.6	0.50
30	55.0	11.6	44.0	0.0	47.3	1.14	42.9	0.50	40.5	0.11	43.4	0.09	45.4	0.50
32	51.8	10.5			46.2	1.13	41.9	0.50			42.6	0.05	44.9	0.50
34	49.8	8.7			45.6	1.13	41.5	0.50					44.3	0.50
35	48.8	7.9	42.6	0.0					39.7	0.09				
36	48.2	6.4			45.2	1.11	41.2	0.50					43.8	0.50
38	47.1	1.1			45.0	1.08	41.1	0.50					43.2	0.50
40	46.3	0.6	42.1	0.0	44.8	1.06	41.1	0.50	39.6	0.04			42.9	0.50
42					44.6	1.04	41.1	0.50					42.6	0.50
44	45.6	0.4	41.9	0.0	44.5	1.02	41.1	0.50					42.1	0.50
45					44.5	1.02			39.5	0.02				
46							41.1	0.50					41.6	0.50
48							41.1	0.50					41.4	0.50
50													41.2	0.50
52													41.1	0.50
54													41.1	0.50
55														
56													40.9	0.50
58													40.8	0.50
60													40.8	0.50
62													40.7	0.50
64													40.7	0.50
65														
66													40.7	0.50
68													40.6	0.50
70													40.6	0.50
72													40.6	0.50
74													40.6	0.50
75														
76													40.6	0.50
78													40.6	0.50
80														

Table 1.– Water profile data collected in glacial lakes (G-G) from 2012-16. D = depth (ft); T = temperature (°F); DO = dissolved oxygen (ppm); and CHL = Coldwater Habitat Layer (thickness; ft). Shaded values were derived from the water profile data using a habitat calculator (Pearson and Porto, IDFW).

Lake (County)	Gage (Steuben)		Gage (Steuben)		George (Steuben/Branch MI)		George (Steuben/Branch MI)		George (Steuben/Branch MI)		Gilbert (Noble)		Gooseneck (Steuben)	
Date	9/24/2012		8/26/2015		8/16/2013		9/16/2013		8/28/2015		9/2/2014		9/4/2014	
Unit	D2		NFR		D2		D2		NFR		D3		NFR	
Clarity (ft)	11.0		8.0		25.5		18.0		17.5		20.0		14.0	
D @ 68°F	0.0		25.1		19.5		24.1		23.1		17.5		17.7	
D @ DO3	33.7		38.3		40.4		25.0		22.8		21.2		17.4	
T @ DO3	55.2		49.9		47.1		63.8		68.4		59.7		68.6	
CHL	33.7		5.1		5.6		0.9		0.0		3.8		0.0	
D	T	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T	DO
0	64.7	8.3	72.7	5.32	73.9	7.7	70.0	6.5	71.5	4.38	77.6	7.91	77.9	7.26
2	64.8	8.3	72.7	5.47	74.0	7.7	70.0	6.5	71.4	4.46	77.6	7.12	77.5	7.33
4	64.8	8.3	72.7	5.66	74.0	7.7	70.0	6.5	71.2	4.64	77.6	7.21	77.1	7.39
5											77.6	7.15		
6	64.8	8.3	72.7	5.86	74.0	7.8	70.1	6.5	71.1	4.82	77.6	7.14	76.9	7.47
8	64.8	8.3	72.7	5.96	73.9	7.8	70.1	6.5	71.1	5.05	77.6	7.14	76.8	7.50
10	64.8	8.3	72.7	5.99	73.9	7.8	70.0	6.5	71.0	5.14	77.5	7.14	76.6	7.45
12	64.7	8.3	72.7	6.03	73.9	7.8	70.0	6.5	71.0	5.31	77.4	7.04	76.3	7.26
14	64.7	8.3	72.7	6.22	73.7	7.7	69.8	6.4	71.0	5.42	75.4	6.90	75.9	6.30
15											73.4	6.69		
16	64.6	8.3	72.7	6.19	73.2	7.4	69.8	6.3	70.9	5.52	71.6	6.55	71.7	4.14
18	64.6	8.2	72.7	6.38	71.9	6.9	69.8	6.3	70.9	5.60	66.7	5.54	67.4	2.56
20	64.6	8.2	72.7	6.51	66.8	6.3	69.5	6.2	70.2	5.10	62.0	3.75	62.5	1.17
22	64.6	8.4	72.7	6.37	60.8	3.8	69.4	6.1	69.5	4.14	60.1	3.11		
24	64.5	8.3	72.5	6.46	56.5	3.9	68.6	4.7	66.7	1.15	58.2	2.62		
25											55.8	1.27	54.0	0.64
26	64.5	8.3	64.5	8.18	53.9	4.3	59.2	1.4	58.6	0.19	54.9	0.97		
28	64.5	8.3	58.8	8.33	52.1	4.4	56.3	1.6	56.2	0.25	53.5	0.40		
30	62.0	6.3	55.3	7.71	50.1	4.6	53.7	1.9	54.0	0.58	51.2	0.14	48.0	0.07
32	59.4	4.3	53.1	6.53	49.1	4.5	51.5	2.2	51.9	1.32	49.9	0.10		
34	54.5	2.8	51.8	5.37	48.5	4.0	50.7	2.0	50.5	1.25				
35													46.8	0.00
36	54.5	2.9	50.9	4.51	48.1	4.0	49.7	2.0	49.1	1.36				
38	51.9	1.0	50.0	3.11	47.6	3.8	48.4	1.4	48.1	1.28				
40	50.3	0.9	49.6	2.40	47.1	3.2	47.7	1.0	47.8	1.40				
42	49.0	0.9	49.3	1.85	46.9	2.3	47.4	0.8	46.8	0.89				
44	48.2	0.9	48.9	1.27	46.7	2.0	47.1	0.6	46.2	0.71				
45														
46	47.6	0.9	48.6	0.60	46.6	1.9	46.8	0.5	45.8	0.42				
48	47.2	0.9	48.5	0.55	46.5	1.7	46.7	0.5	45.6	0.18				
50	47.0	0.9	48.3	0.13	46.4	1.5	46.6	0.5	45.5	0.08				
52	47.0	0.9	48.1	0.08	46.3	1.3			45.3	0.02				
54	46.6	0.9	47.9	0.05	46.2	1.1								
55			47.9	0.04					45.1	0.00				
56	46.0	0.9			46.1	0.9								
58	45.9	0.9			46.1	0.8								
60	45.6	0.9	47.6	0.03	46.1	0.7			44.9	0.00				
62	45.5	0.9			46.0	0.7								
64	45.4	0.9			46.0	0.7								
65			47.4	0.02					44.7	0.00				
66	45.3	0.9			46.0	0.7								
68	45.2	0.9			45.9	0.7								
70	45.2	0.9	47.3	0.00	45.9	0.7			44.6	0.00				
72					45.8	0.7								
74					45.8	0.7								
75									44.5	0.00				
76					45.7	0.7								
78					45.7	0.7								
80					45.7	0.7			44.4	0.00				

Table 1.– Water profile data collected in glacial lakes (M-M) from 2012-16. D = depth (ft); T = temperature (°F); DO = dissolved oxygen (ppm); and CHL = Coldwater Habitat Layer (thickness; ft). Shaded values were derived from the water profile data using a habitat calculator (Pearson and Porto, IDFW).

Lake (County)	Gordy (Noble)		Green (Steuben)		Green (Steuben)		Green (Steuben)		Hackenburg (LaGrange)		Hackenburg (LaGrange)		Hindman (Noble)	
Date	9/4/2012		9/16/2013		8/28/2015		8/10/2016		8/28/2014		8/25/2016		9/2/2014	
Unit	D3		NFR		NFR		NFR		NFR		NFR		D3	
Clarity (ft)	5.5		10.5		17.0		20.0		7.0		6.5		7.0	
D @ 68°F	13.5		17.4		18.6		22.2		12.9		16.1		9.7	
D @ DO3	14.3		23.1		25.0		27.5		14.7		12.1		6.5	
T @ DO3	66.0		57.0		55.9		57.6		64.9		73.4		72.5	
CHL	0.8		5.7		6.5		5.3		1.8		0.0		0.0	
D	T	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T	DO
0	79.4	8.5	69.4	10.93	71.3	3.17	82.1	5.32	77.6	6.82	78.8	4.36	76.1	7.62
2	79.4	8.5	69.5	9.57	71.3	3.24	81.7	4.05	77.6	6.78	78.8	4.80	76.1	7.62
4	79.0	8.6	69.5	9.34	71.3	3.28	81.4	3.45	77.5	6.79	78.6	5.22	75.9	7.42
5	78.7	8.8					81.3	3.19			77.5	5.26	75.1	6.92
6	78.5	8.9	69.5	8.72	71.3	3.54	81.3	3.05	77.4	6.73	77.2	5.34	73.0	4.35
8	77.9	8.8	69.5	8.44	71.3	3.76	81.2	3.20	76.0	6.87	76.4	5.21	71.1	0.59
10	76.2	9.2	69.4	8.27	71.3	4.05	81.1	3.61	72.9	9.03	75.2	4.75	67.5	0.36
12	71.9	8.4	69.4	8.51	71.3	4.34	81.0	3.98	69.7	7.75	73.5	3.10	62.2	0.18
14	66.6	3.5	69.4	8.70	71.2	4.52	80.9	4.27	65.9	4.54	71.4	1.01	56.6	0.14
15	64.7	1.9					80.5	4.58	64.4	2.25	69.8	0.56	54.6	0.10
16	62.0	0.0	69.1	8.60	70.8	4.67	79.8	5.30	63.3	0.95	68.2	0.46	53.2	0.10
18	55.0	0.0	67.5	8.78	69.4	5.82	79.2	6.90	60.4	0.12	62.8	0.22	51.6	0.10
20	49.1	0.0	61.9	6.79	64.4	6.45	75.3	8.47	55.3	0.06	56.5	0.15		
22			58.6	4.49	59.6	6.33	68.4	9.59			50.5	0.10		
24			55.6	1.75	57.0	4.50	64.1	9.09			48.1	0.07		
25	45.0	0.0					60.0	6.59	46.5	0.03	47.0	0.02		
26			53.9	1.02	54.8	1.63	58.6	4.27			46.2	0.01		
28			51.9	0.56	53.2	0.23	57.3	2.55			45.4	0.02		
30			50.5	0.59	52.2	0.19	55.8	1.37	44.3	0.00	45.0	0.00		
32			49.5	0.47	51.3	0.07	54.5	0.86			44.5	0.00		
34					50.7	0.05	52.5	0.03			44.2	0.00		
35									43.4	0.00	44.1	0.00		
36											44.0	0.00		
38														
40														
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Table 1.– Water profile data collected in glacial lakes (H-J) from 2012-16. D = depth (ft); T = temperature (°F); DO = dissolved oxygen (ppm); and CHL = Coldwater Habitat Layer (thickness; ft). Shaded values were derived from the water profile data using a habitat calculator (Pearson and Porto, IDFW).

Lake (County)	Hoffman (Kosciusko)		Hog (LaPorte)		Hunter (Elkhart)		Indiana (Elkhart/Cass MI)		James (Steuben)		James (Kosciusko)		Jimmerson (Steuben)	
Date	8/4/2016		9/1/2016		8/29/2016		9/12/2012		9/3/2014		9/4/2014		9/3/2014	
Unit	D3		D1		D1		D2		D2		D3		D2	
Clarity (ft)	5.0		4.0		9.5		15.5		N/A		12.0		N/A	
D @ 68°F	18.0		11.4		22.2		25.8		23.7		20.2		22.7	
D @ DO3	12.0		N/A		17.2		39.9		23.9		17.5		20.4	
T @ DO3	76.7		N/A		76.8		47.6		67.5		72.9		72.2	
CHL	0.0		0.0		0.0		6.2		0.2		0.0		0.0	
D	T	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T	DO
0	83.8	10.60	76.1	2.20	79.7	7.06	74.5	8.5	78.2	6.60	76.6	7.31	78.2	6.10
2			76.1	2.10	79.6	7.11	74.6	9.0	78.2	6.60	76.6	7.24	78.0	6.10
4			76.1	2.10	79.5	7.12	74.6	9.0	77.6	6.60	76.6	7.30	77.8	6.10
5	83.2	10.20									76.6	7.27		
6			74.8	0.50	79.3	7.15	74.6	8.9	77.3	6.70	76.6	7.30	77.6	6.20
8	80.8	10.70	73.4	0.20	79.2	7.18	74.6	8.9	77.1	6.70	76.6	7.33	77.1	6.20
10	78.2	6.80	71.4	0.10	79.1	7.13	74.6	8.9	76.9	6.70	76.6	7.34	76.9	6.20
12	76.7	3.00	66.4	0.10	79.0	6.98	74.6	8.9	76.9	6.70	76.6	7.40	76.8	6.20
14	75.1	1.10	63.5	0.20	78.2	6.07	74.6	8.9	76.8	6.70	76.5	7.35	76.6	5.90
15	74.5	0.80									76.0	6.63		
16			57.9	0.20	77.6	5.56	74.6	8.9	76.8	6.60	74.6	5.24	76.4	5.60
18			53.8	0.20	76.2	1.19	74.6	8.9	76.7	6.50	72.3	2.28	76.2	5.40
20	63.5	0.30	50.9	0.20	72.5	0.36	74.4	9.0	75.1	5.40	68.4	0.41	72.8	3.20
22			48.7	0.20	68.6	0.34	73.7	9.3	72.1	4.50			69.3	2.10
24			47.3	0.20	63.1	0.30	72.7	10.2	67.2	2.90			65.4	0.70
25											59.4	0.33		
26			46.0	0.20	59.2	0.29	67.4	15.3	63.6	2.10			62.0	0.50
28			45.3	0.20	58.5	0.28	62.6	17.0	59.7	1.60			59.0	0.30
30			44.8	0.20			59.0	17.5	57.8	1.30	52.1	0.24	56.6	0.30
32			44.2	0.20			55.0	17.8	56.6	0.90			54.5	0.30
34			43.9	0.20			52.4	17.4	54.9	0.60			52.4	0.30
35														
36			43.5	0.20			50.5	15.0	53.1	0.60			51.0	0.30
38			43.2	0.20			48.3	5.7	51.8	0.70			50.1	0.30
40			42.8	0.20			47.6	2.8	50.6	1.20	48.0	0.21	49.1	0.30
42			42.6	0.20			47.0	1.0	49.3	1.50			48.1	0.30
44			42.4	0.20			46.0	0.9	48.3	1.40			47.4	0.30
45														
46			42.3	0.20			45.2	0.9	47.3	1.00			46.8	0.30
48			42.1	0.20			44.6	0.9	46.6	1.00			46.5	0.30
50			42.1	0.20			44.2	0.9	46.0	1.50	46.5	0.18	46.2	0.30
52							44.0	0.9	45.6	1.60			45.8	0.30
54							43.7	0.9	45.4	1.00			45.7	0.30
55														
56							43.6	0.8	45.4	0.90				
58							43.4	0.8	45.1	1.50				
60							43.3	0.8	44.3	1.60	46.0	0.13		
62							43.3	0.8	44.0	1.30				
64							43.3	0.8	43.7	1.30				
65														
66							43.3	0.8	43.3	1.70				
68							43.2	0.7	43.0	0.50				
70									42.9	0.40				
72									42.8	0.30				
74									42.6	0.30				
75														
76									42.5	0.30				
78									42.4	0.30				
80									42.3	0.30				
82									42.2	0.30				
84									42.2	0.30				
85														
86									42.2	0.30				

Table 1.– Water profile data collected in glacial lakes (J-L) from 2012-16. D = depth (ft); T = temperature (°F); DO = dissolved oxygen (ppm); and CHL = Coldwater Habitat Layer (thickness; ft). Shaded values were derived from the water profile data using a habitat calculator (Pearson and Porto, IDFW).

Lake (County)	Jimmerson (Steuben)		Jimmerson (Steuben)		Knapp (Noble)		Lake of the Woods (LaGrange/Steuben)		Lawrence (Marshall)		Lawrence (Marshall)		Lawrence (Marshall)	
Date	8/28/2015		8/23/2016		9/9/2013		9/2/2014		9/3/2013		8/22/2014		8/21/2015	
Unit	NFR		NFR		D3		NFR		D1		D1		D1	
Clarity (ft)	9.0		12.5		5.0		3.0		11.5		13.0		11.0	
D @ 68°F	21.3		21.4		12.2		17.3		16.6		17.7		16.5	
D @ DO3	21.9		27.6		13.2		18.8		16.7		18.6		18.5	
T @ DO3	67.4		54.9		64.9		64.3		67.8		66.3		62.9	
CHL	0.6		6.1		1.0		1.5		0.1		0.8		1.9	
D	T	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T	DO
0	71.5	3.26	77.1	6.20	74.4	10.34	76.8	8.47	76.5	4.30	78.8	7.58	77.2	8.41
2	71.5	3.51	77.2	6.26	74.4	10.15	76.9	8.59	76.5	4.30	78.4	7.93	77.2	8.10
4	71.3	3.63	77.1	6.40	74.4	10.13	76.9	8.59	76.5	4.20	77.9	7.94	77.2	7.98
5			77.2	6.46	74.4	10.13								
6	71.1	3.82	77.2	6.53	74.4	9.97	76.9	8.61	76.5	4.20	77.9	7.52	77.2	7.68
8	70.7	4.05	77.1	6.59	74.0	10.05	77.0	8.63	76.5	4.10	77.7	7.07	77.2	8.20
10	70.7	4.17	77.1	6.66	68.5	6.42	77.0	8.62	76.5	4.00	76.8	7.52	77.0	7.30
12	70.5	4.26	76.9	6.67	62.3	0.60	76.8	8.74	75.7	3.70	75.7	7.32	76.8	7.55
14	70.4	4.36	76.3	6.43	59.8	0.43	75.1	8.05	73.8	3.90	74.5	7.07	75.7	7.20
15			76.1	6.32	58.5	0.27								
16	70.1	4.57	75.7	6.50			71.2	6.38	69.3	3.30	71.4	6.70	70.0	6.93
18	70.1	4.71	75.5	6.12			66.1	3.67	64.8	2.40	67.5	3.90	64.0	3.38
20	69.3	4.61	73.0	5.45	50.1	0.47	61.4	0.98	59.0	1.10	63.0	0.63	59.7	1.74
22	67.3	2.95	65.9	4.60					56.5	0.60			55.4	1.23
24	61.6	1.76	60.7	4.67					53.2	0.40			51.8	1.20
25			60.6	4.65	46.7	0.37	52.1	0.08			52.2	0.21		
26	57.5	1.07	57.0	3.95					50.4	0.30			48.6	2.07
28	55.0	0.43	54.3	2.75					47.8	0.50			46.2	2.82
30	53.9	0.27	52.3	1.97	45.4	0.42	48.1	0.05	45.9	0.60	45.5	0.19	45.3	2.73
32	52.5	0.18	50.7	1.45					44.2	0.90			44.2	2.30
34	51.4	0.07	50.8	1.48					43.0	0.40			43.5	0.28
35			49.0	0.53			45.8	0.05			43.3	0.12	43.2	0.16
36	50.1	0.05	48.2	0.35					41.9	0.40				
38	49.5	0.04	47.6	0.28					41.4	0.30				
40	48.7	0.03	46.9	0.18			43.9	0.04	41.4	0.20	41.9	0.10	42.3	0.14
42			46.4	0.13					40.6	0.20				
44			46.0	0.10					40.5	0.20				
45	47.0	0.00	45.8	0.09			42.8	0.04			41.4	0.08	41.5	0.13
46			45.6	0.08					40.1	0.20				
48			45.5	0.06					39.9	0.20				
50	46.6	0.00	45.3	0.05			42.5	0.02	39.7	0.20	41.0	0.09	41.4	0.12
52			45.2	0.03					39.7	0.20				
54			45.8	0.02					39.6	0.20				
55	45.9	0.00					42.3	0.02			40.8	0.08	41.2	0.12
56									39.6	0.20				
58									39.6	0.20				
60							42.0	0.01					41.2	0.12
62														
64														
65							41.9	0.01						
66														
68														
70							41.8	0.00						
72														
74														
75							41.8	0.00						
76														
78														
80							41.7	0.00						

Table 1.– Water profile data collected in glacial lakes (L-M) from 2012-16. D = depth (ft); T = temperature (°F); DO = dissolved oxygen (ppm); and CHL = Coldwater Habitat Layer (thickness; ft). Shaded values were derived from the water profile data using a habitat calculator (Pearson and Porto, IDFW).

Lake (County)	Lime (Steuben)		Loomis (Porter)		Lukens (Wabash)		Marsh (Steuben)		Martin (LaGrange)		McClish (LaGrange/Steuben)		McClish (LaGrange/Steuben)	
Date	9/11/2013		8/31/2016		8/3/2016		9/4/2014		9/9/2013		9/2/2014		9/8/2014	
Unit	D2		D1		D3		NFR		NFR		NFR		NFR	
Clarity (ft)	6.0		5.6		10.0		8.5		9.0		13.0		18.0	
D @ 68°F	18.2		17.0		13.0		14.1		12.2		16.4		16.9	
D @ DO3	18.8		7.6		12.5		13.7		25.5		24.2		23.9	
T @ DO3	67.0		78.5		69.7		68.9		43.0		50.0		51.6	
CHL	0.6		0.0		0.0		0.0		4.5		4.9		5.0	
D	T	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T	DO
0	76.7	7.70	80.1	9.10	83.1	7.20	75.4	8.01	74.3	9.62	76.6	8.39	75.1	7.68
2	76.7	7.70	80.1	9.20	83.1	6.40	75.4	8.11	73.7	8.92	76.9	8.46	75.2	7.86
4	76.7	7.70	79.9	8.80	83.0	7.20	75.4	8.11	73.4	8.53	77.0	8.50	75.3	7.92
5					83.0	7.20								
6	76.7	7.70	79.9	9.00	82.8	6.60	75.4	8.13	73.4	8.73	77.0	8.53	75.4	8.00
8	74.9	7.90	78.1	1.40	82.3	6.20	75.4	8.11	73.3	8.73	77.0	8.55	75.4	8.01
10	74.4	8.00	76.5	0.60	78.6	4.90	75.3	7.88	72.6	8.07	77.0	8.60	75.4	8.02
12	74.0	7.90	75.7	0.20	71.6	3.20	72.5	6.53	68.5	10.00	76.9	9.02	75.4	8.06
14	73.4	7.60	74.5	0.10	64.1	2.40	68.3	2.44	63.3	10.13	73.5	11.99	75.4	8.06
15			73.0	0.10	61.7	2.40								
16	71.7	6.70			58.6	2.10	63.5	0.12	56.9	7.38	69.1	14.47	70.6	13.34
18	68.4	3.90			54.0	1.50	58.6	0.08	51.6	5.25	63.7	11.78	65.0	11.06
20	64.8	1.60	60.4	0.10	49.4	0.40	54.7	0.16	47.9	3.86	58.5	9.13	59.3	8.44
22	60.7	0.40							45.6	3.71	53.1	6.17	54.8	6.54
24	58.0	0.40							44.0	3.13	50.4	3.47	51.5	2.84
25			52.16	0.10	46.9	0.30	47.7	0.06			48.5	1.03		
26	54.5	0.40							42.7	2.96			47.5	0.36
28	52.8	0.40							41.7	2.16			45.3	0.20
30			47.5	0.10			45.3	0.05	41.2	1.36	43.7	0.18	43.9	0.13
32														
34														
35			46.2	0.10			43.8	0.04	40.3	0.55	41.7	0.13	41.7	0.04
36														
38														
40			45.1	0.10					39.8	0.31	40.8	0.11	40.7	0.03
42														
44														
45			44.6	0.10					39.5	0.29	40.3	0.08	40.3	0.02
46														
48														
50			44.6	0.10					39.6	0.27	40.0	0.06	40.0	0.00
52														
54														
55											39.9	0.01	39.9	0.00
56														
58														
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Table 1.– Water profile data collected in glacial lakes (M-M) from 2012-16. D = depth (ft); T = temperature (°F); DO = dissolved oxygen (ppm); and CHL = Coldwater Habitat Layer (thickness; ft). Shaded values were derived from the water profile data using a habitat calculator (Pearson and Porto, IDFW).

Lake (County)	McClish (LaGrange/Steuben)		Meserve (Steuben)		Meserve (Steuben)		Messick (LaGrange)		Myers (Marshall)		Myers (Marshall)		Myers (Marshall)	
Date	8/25/2016		9/16/2013		8/26/2016		8/28/2014		9/3/2013		8/22/2014		8/21/2015	
Unit	NFR		NFR		NFR		NFR		D1		D1		D1	
Clarity (ft)	8.5		6.5		9.0		7.0		9.0		9.5		8.0	
D @ 68°F	17.1		17.6		17.8		14.9		15.8		17.7		15.4	
D @ DO3	28.7		17.7		18.0		12.5		16.1		21.1		14.4	
T @ DO3	47.4		67.9		67.5		72.1		67.3		60.3		71.1	
CHL	4.8		0.1		0.2		0.0		0.4		3.4		0.0	
D	T	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T	DO
0	78.9	4.85	70.7	10.16	78.4	5.35	78.4	8.29	76.5	4.23	78.3	7.85	77.4	7.55
2	78.7	5.34	70.7	10.58	78.3	5.63	78.1	8.40	76.5	4.05	78.3	7.65	77.4	7.24
4	78.2	5.90	70.7	10.54	78.2	6.49	77.9	8.37	76.6	3.97	78.1	7.50	77.2	6.96
5	77.9	6.08			78.2	6.66								
6	77.8	6.24	70.7	10.43	78.1	6.64	77.8	8.38	76.6	3.85	77.7	7.44	77.0	6.75
8	77.8	6.38	70.7	10.23	77.9	6.52	77.4	8.25	76.5	3.78	77.2	7.43	76.8	6.78
10	77.6	6.66	70.7	10.20	77.5	6.72	75.0	6.13	76.5	3.70	75.9	7.80	76.8	6.82
12	77.5	6.69	70.6	10.21	77.0	6.66	72.7	3.64	75.6	3.81	75.4	7.42	76.5	6.51
14	76.4	6.97	70.4	9.99	75.9	7.63	70.2	1.07	71.6	4.72	74.7	7.20	76.3	6.30
15	74.9	8.19			74.6	9.51	67.7	0.29	69.6	4.30				
16	71.9	9.54	70.2	9.75	72.7	8.85			67.5	3.14	71.8	8.50	72.3	4.28
18	64.6	9.60	67.5	1.85	67.5	2.99			63.0	0.46	67.3	6.91	68.9	0.67
20	59.2	9.14	62.4	0.53	63.6	0.27	56.5	0.11	58.6	0.35	63.0	4.95	56.1	0.15
22	54.7	8.47			61.2	0.19			53.8	0.31	57.9	1.29		
24	52.2	6.09							51.1	0.29	55.0	0.18		
25	50.6	5.53					49.4	0.04			53.2	0.09	51.1	0.14
26	49.7	4.94							49.6	0.26				
28	47.8	4.07							48.0	0.24				
30	46.7	1.00					46.1	0.00	46.4	0.23	47.5	0.09	47.1	0.15
32	45.6	0.39							45.3	0.23				
34	44.9	0.26							44.6	0.23				
35	44.7	0.21					44.3	0.00			44.2	0.09	44.8	0.13
36	44.4	0.20							43.9	0.22				
38	43.9	0.19							43.2	0.21				
40	43.5	0.16					42.9	0.00	42.6	0.21	42.6	0.07	43.5	0.13
42	43.2	0.12							42.1	0.21				
44	42.8	0.13							41.5	0.22				
45	42.7	0.11					42.0	0.00			42.3	0.06	42.8	0.14
46	42.6	0.09							41.4	0.21				
48	42.3	0.06							41.2	0.20				
50	42.1	0.05							41.2	0.20				
52	41.9	0.06							41.0	0.20				
54	41.7	0.02							41.0	0.20				
55	41.6	0.00												
56														
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Table 1.– Water profile data collected in glacial lakes (N-P) from 2012-16. D = depth (ft); T = temperature (°F); DO = dissolved oxygen (ppm); and CHL = Coldwater Habitat Layer (thickness; ft). Shaded values were derived from the water profile data using a habitat calculator (Pearson and Porto, IDFW).

Lake (County)	North Twin (LaGrange)		North Twin (LaGrange)		North Twin (LaGrange)		Olin (LaGrange)		Oliver (LaGrange)		Oswego (Kosciusko)		Pike (Kosciusko)	
Date	6/24/2013		9/1/2015		8/23/2016		9/9/2013		9/9/2013		9/4/2014		8/11/2016	
Unit	D2		NFR		NFR		NFR		NFR		D3		NFR	
Clarity (ft)	11.0		8.5		11.5		4.0		7.0		15.5		3.5	
D @ 68°F	16.2		20.5		22.3		14.8		20.5		19.2		16.6	
D @ DO3	29.8		20.4		23.3		23.2		43.8		16.5		11.1	
T @ DO3	51.4		68.1		63.8		50.3		45.4		71.9		79.0	
CHL	6.4		0.0		1.0		5.2		5.2		0.0		0.0	
D	T	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T	DO
0	79.1	6.50	75.1	2.56	77.6	6.28	74.7	10.14	73.7	9.02	77.4	7.87	81.6	11.47
2	79.1	6.80	75.2	2.57	75.5	6.58	74.4	9.76	73.7	8.52	77.3	7.93	81.9	12.24
4	79.1	6.70	74.7	2.60	77.4	6.82	74.3	9.38	73.7	8.46	77.3	7.90	81.8	12.46
5					77.4	6.76					77.3	7.97	81.6	12.66
6	79.0	6.90	73.5	2.69	77.4	6.91	74.3	9.19	73.7	8.47	77.3	7.89	81.5	12.39
8	78.6	7.00	72.8	2.76	77.3	6.94	74.2	9.35	73.7	8.43	77.1	7.92	80.6	9.08
10	77.4	7.00	72.4	2.84	77.1	7.17	74.1	9.23	73.7	8.18	76.5	7.68	79.8	5.16
12	76.8	7.20	72.1	2.89	76.9	7.17	74.0	8.89	73.7	8.30	76.4	7.53	78.4	1.38
14	72.4	7.70	71.8	2.95	76.9	6.87	71.2	8.37	73.7	8.22	75.4	6.64	74.8	0.66
15					76.4	6.94					74.5	3.63	71.9	0.39
16	68.5	8.50	71.4	3.03	76.4	7.11	63.6	8.45	73.6	8.04	73.0	3.51	69.5	0.27
18	64.4	9.00	70.9	3.07	75.5	7.20	59.8	7.64	71.7	7.43	68.7	1.56	64.5	0.22
20	60.3	8.90	68.8	3.08	73.7	7.80	55.1	5.38	69.9	6.39	67.5	1.60	61.1	0.16
22	55.6	8.40	65.3	2.70	69.0	7.40	51.8	3.80	62.2	5.24			58.4	0.14
24	53.8	7.30	61.0	1.05	61.0	0.58	49.2	2.44	57.8	4.97			56.4	0.12
25					60.0	0.28					52.7	0.39	55.2	0.10
26	52.6	5.60	58.3	0.39	58.7	0.19	47.6	1.35	54.4	4.94			54.4	0.09
28	51.9	4.00	56.1	0.24	56.3	0.50	46.8	0.95	50.9	4.74			53.7	0.09
30	51.4	2.90	55.1	0.16	56.4	0.09	45.9	0.41	49.8	4.65	46.2	0.24	53.0	0.07
32	51.2	2.30	53.8	0.12	56.7	0.06			48.5	4.60			52.7	0.04
34	50.8	2.00	53.4	0.10	56.5	0.06			47.6	4.57	42.1	0.11	52.5	0.03
35							44.3	0.25						
36	50.5	0.60	52.4	0.05					46.7	4.45				
38	49.9	0.40	53.9	0.03					46.2	4.15				
40							44.3	0.19	45.9	3.99				
42									45.6	3.40				
44									45.4	2.95				
45							42.8	0.22						
46									45.2	2.95				
48									45.1	2.91				
50							42.4	0.29	44.9	2.85				
52									44.8	2.60				
54									44.6	2.13				
55							42.0	0.20						
56									44.5	1.93				
58									44.4	1.35				
60							41.6	0.26	44.3	0.61				
62														
64														
65							41.3	0.30	44.1	0.30				
66														
68														
70							41.0	0.23	43.9	0.21				
72														
74														
75							40.9	0.24	43.7	0.17				
76														
78														
80									43.6	0.27				

Table 1.– Water profile data collected in glacial lakes (N-P) from 2012-16. D = depth (ft); T = temperature (°F); DO = dissolved oxygen (ppm); and CHL = Coldwater Habitat Layer (thickness; ft). Shaded values were derived from the water profile data using a habitat calculator (Pearson and Porto, IDFW).

Lake (County)	Round (Steuben)		Round (Whitley)		Round (Whitley)		Royer (LaGrange)		Sechrist (Kosciusko)		Seven Sisters (Basin: 41.70584, -84.99324; Steuben)		Seven Sisters (Basin: 41.70676, -84.99126; Steuben)	
Date	8/30/2016		8/20/2014		8/10/2016		9/4/2014		9/4/2014		9/16/2014		9/16/2014	
Unit	D1		NFR		NFR		D2		D3		NFR		NFR	
Clarity (ft)	9.0		13.0		13.5		N/A		14.0		8.5		9.0	
D @ 68°F	20.1		18.3		18.5		13.0		20.8		N/A		N/A	
D @ DO3	14.8		17.2		17.0		10.1		17.1		18.3		11.4	
T @ DO3	77.0		69.9		71.8		75.4		71.6		60.0		64.2	
CHL	0.0		0.0		0.0		0.0		0.0		18.3		11.4	
D	T	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T	DO
0	79.6	7.16	78.0	7.98	82.6	6.69	76.9	5.40	77.3	7.01	66.6	7.15	65.8	3.57
2	79.8	7.19	77.3	8.03	82.2	6.90	77.0	5.30	77.3	6.93	66.6	7.19	65.3	3.58
4	79.6	7.22	76.7	8.08	81.9	7.05	77.0	5.30	77.3	6.93	66.4	7.22	64.7	3.43
5					81.8	7.11			77.3	6.95				
6	79.5	7.07	76.4	8.04	81.5	6.99	77.0	5.30	77.3	6.98	66.3	7.20	64.5	3.40
8	79.2	6.70	76.2	8.26	81.0	7.11	76.9	5.10	77.2	6.86	66.3	7.19	64.4	3.28
10	78.8	5.93	75.6	8.50	80.8	6.83	75.6	3.10	77.2	6.94	66.2	7.17	64.3	3.18
12	78.4	5.35	74.5	8.26	80.4	6.51	71.3	0.30	76.7	6.34	66.2	7.15	64.2	2.93
14	77.7	4.06	73.4	6.19	79.2	8.30	64.4	0.30	75.1	5.55	66.1	6.93	63.9	2.15
15					76.9	8.24			73.7	4.66				
16	75.9	1.25	71.8	5.01	74.3	5.55	57.9	0.40	72.6	3.92	65.8	6.87	59.4	0.07
18	73.1	0.40	68.7	1.65	69.2	0.33	53.9	0.40	70.8	2.23	60.9	3.48	55.0	0.01
20	68.1	0.39	64.3	0.44	64.7	0.44	49.7	0.40	68.6	1.04	54.5	0.20	51.7	0.02
22	64.7	0.39			59.5	0.22	47.7	0.40	67.1	0.64				
24	63.7	0.38			55.5	0.14	46.2	0.40	64.3	0.51				
25			54.9	0.41	54.7	0.11			59.0	0.53	45.4	0.11		
26					53.4	0.12	45.2	0.40						
28					51.7	0.17	44.5	0.40						
30			50.4	0.11	50.4	0.19	44.0	0.40	49.9	0.22	42.5	0.07		
32					49.5	0.08	43.5	0.40						
34					48.5	0.16	43.3	0.40						
35			46.3	0.08	48.2	0.13			45.8	0.12				
36					48.0	0.08	42.8	0.40						
38					47.6	0.07	42.5	0.40						
40			45.0	0.05	47.2	0.05	42.3	0.40	43.8	0.11				
42					46.8	0.04	42.2	0.40						
44					46.6	0.05	42.0	0.40						
45			44.5	0.03	46.4	0.06			43.3	0.08				
46					46.3	0.05	42.0	0.40						
48					46.2	0.04	42.0	0.40						
50			44.2	0.01	46.0	0.06	42.0	0.40	43.1	0.10				
52					45.9	0.05	41.9	0.40	43.0	0.06				
54					45.8	0.03	41.9	0.40						
55			44.0	0.01	45.7	0.02								
56					45.7	0.02	41.9	0.40						
58					45.6	0.03								
60			43.9	0.00	45.6	0.00								
62														
64														
65														
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Table 1.– Water profile data collected in glacial lakes (S-S) from 2012-16. D = depth (ft); T = temperature (°F); DO = dissolved oxygen (ppm); and CHL = Coldwater Habitat Layer (thickness; ft). Shaded values were derived from the water profile data using a habitat calculator (Pearson and Porto, IDFW).

Lake (County)	Seven Sisters (Basin: 41.705657, -84.993592; Steuben)		Seven Sisters (Basin: 41.706877, -84.991427; Steuben)		Seven Sisters (Basin: 41.708882, -84.989478; Steuben)		Seven Sisters (Basin: 41.709541, -84.987644; Steuben)		Seven Sisters (Basin: 41.71044, -84.9889216; Steuben)		Shock (Koscisuko)		Shriner (Whitley)	
Date	8/26/2016		8/26/2016		8/26/2016		8/26/2016		8/26/2016		8/21/2015		8/18/2015	
Unit	NFR		NFR		NFR		NFR		NFR		D3		D3	
Clarity (ft)	11.0		11.0		14.5		12.5		13.5		4.0		17.5	
D @ 68°F	14.6		14.2		13.8		14.3		14.5		9.6		17.5	
D @ DO3	9.5		15.3		21.2		5.0		7.6		7.6		19.4	
T @ DO3	76.5		64.3		51.9		77.1		76.2		73.4		62.5	
CHL	0.0		1.1		5.6		5.0		0.0		0.0		1.9	
D	T	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T	DO
0	79.9	3.86	80.1	3.48	79.9	3.92	79.6	3.61	80.4	3.70	75.1	7.09	79.5	8.36
2	78.5	4.00	78.3	3.92	78.5	4.18	78.3	3.59	78.4	3.83			79.5	8.44
4	78.1	4.10	77.6	3.95	77.9	4.43	77.6	3.39	77.4	3.28			79.5	8.95
5	77.8	4.23	77.3	3.43	77.7	4.58	77.1	2.98	76.8	3.33	75.1	7.04	79.6	8.53
6	77.2	4.32	76.9	3.18	77.3	4.18	76.8	2.88	76.6	3.35	75.1	7.07	79.5	8.51
8	77.2	3.42	76.4	2.70	76.4	3.35	75.9	2.41	76.1	2.90	73.0	1.93	79.5	8.54
10	76.2	2.86	76.0	2.36	75.4	3.35	75.1	1.65	75.3	2.13	66.9	1.61	79.5	8.51
12	74.5	2.19	74.4	0.76	72.6	2.70	72.8	1.27	73.8	0.86	60.4	0.34	78.7	8.87
14	70.2	0.86	68.8	4.26	67.6	3.02	68.7	1.51	69.8	0.82	54.9	0.45	77.3	8.49
15	66.7	0.63	65.2	3.85	65.7	3.27	66.2	0.95	66.3	0.68	53.1	0.45	76.8	8.23
16	65.1	0.60	61.8	0.79	62.4	4.01	62.9	0.27	63.0	0.23			72.6	8.05
18	61.2	0.76	56.1	0.20	57.5	5.28	57.1	0.17	58.6	0.16			66.4	6.57
20	55.0	0.37			54.0	5.41	53.7	0.27			42.0	0.25	60.8	1.44
22	51.1	0.22			50.6	1.46							56.9	0.37
24	48.6	0.10			48.0	0.42							52.8	0.33
25	47.8	0.08			46.8	0.27							51.3	0.28
26	46.8	0.06			45.8	0.21							50.3	0.21
28	45.8	0.06			44.7	0.13							49.0	0.17
30	45.1	0.06			44.1	0.10							47.6	0.17
32					43.5	0.09								
34					43.3	0.23								
35					42.8	0.12							46.0	0.11
36					42.6	0.07								
38					42.0	0.03								
40					42.0	0.02							45.2	0.10
42					42.0	0.03								
44					42.0	0.03								
45					41.9	0.01							44.8	0.08
46					41.9	0.01								
48														
50														
52														
54														
55														
56														
58														
60														
62														
64														
65														
66														
68														
70														
72														
74														
75														
76														
78														
80														

Table 1.– Water profile data collected in glacial lakes (S-T) from 2012-16. D = depth (ft); T = temperature (°F); DO = dissolved oxygen (ppm); and CHL = Coldwater Habitat Layer (thickness; ft). Shaded values were derived from the water profile data using a habitat calculator (Pearson and Porto, IDFW).

Lake (County)	Snow (Steuben)		Snow (Steuben)		South Twin (LaGrange)		South Twin (LaGrange)		Tamarack (West; Noble)		Tamarack (East; Noble)		Tippecanoe (Kosciusko)	
Date	8/16/2013		9/3/2014		9/24/2012		9/1/2015		8/29/2016		8/8/2016		9/4/2014	
Unit	NFR		D2		D2		NFR		D3		D3		D3	
Clarity (ft)	8.5		N/A		10.5		10.0		4.5		2.5		11.5	
D @ 68°F	18.2		22.0		N/A		19.5		12.6		11.2		23.2	
D @ DO3	16.9		18.5		34.2		31.2		9.1		8.7		20.9	
T @ DO3	70.2		73.3		48.7		48.3		74.3		75.5		73.5	
CHL	0.0		0.0		29.4		6.3		0.0		0.0		0.0	
D	T	DO	T	DO	T	DO	T	DO	T	DO	T	DO	T	DO
0	75.4	7.30	77.6	6.50	65.0	8.80	75.3	3.64	79.4	4.60	80.6	10.20	77.0	6.88
2	75.3	5.50	77.2	6.40	65.0	8.70	75.1	3.66	79.4	4.50	80.6	10.00	77.0	6.94
4	74.9	5.30	76.9	6.50	65.0	8.50	75.0	3.67	79.2	4.40	80.6	10.10	77.0	6.93
5									78.9	4.30	80.6	9.80	76.9	6.91
6	74.6	5.50	76.9	6.50	65.0	8.50	74.9	3.69	78.8	4.30	80.5	9.60	76.8	6.92
8	74.3	5.80	76.7	6.50	65.1	8.50	74.0	3.83	75.9	4.20	77.4	4.40	76.6	6.86
10	74.2	6.30	76.7	6.40	65.0	8.50	73.2	3.93	73.0	2.00	72.0	0.50	76.5	6.71
12	73.8	6.20	76.5	6.40	65.0	8.50	72.5	3.97	69.8	1.10	65.2	0.30	76.4	6.56
14	73.1	5.80	76.4	6.30	65.0	8.50	72.6	4.02	64.0	0.40	58.9	0.20	76.3	6.50
15									61.7	0.30	57.3	0.20	76.3	6.65
16	71.8	4.40	75.7	5.10	65.0	8.60	72.4	4.07	59.1	0.20			76.3	6.33
18	68.4	1.40	74.0	3.50	64.9	8.60	70.9	4.34	53.3	0.10			76.0	6.15
20	64.7	0.40	71.4	1.60	64.9	8.50	67.0	5.22	49.4	0.10	50.6	0.10	75.2	5.01
22	60.6	0.30	68.0	0.40	64.8	8.60	62.0	6.06					71.3	0.41
24	55.2	0.30	63.7	0.40	64.7	8.50	57.9	6.71			49.0	0.10	65.7	0.29
25									46.2	0.10			63.1	0.19
26	52.8	0.30	59.3	0.40	64.3	8.60	54.6	7.13						
28	51.0	0.30	56.5	0.40	59.5	9.50	51.5	6.57						
30	49.5	0.50	53.5	0.40	53.2	7.00	49.5	4.52	45.0	0.00			55.9	0.16
32	48.6	0.80	50.8	0.40	50.4	4.30	47.4	1.91						
34	47.9	0.90	49.5	0.40	48.9	3.20	45.8	0.22						
35									44.3	0.00				
36	47.3	1.00	48.1	0.40	47.5	1.40	45.2	0.13						
38	46.9	1.10	47.0	0.40	46.3	0.60	44.5	0.11						
40	46.6	1.10	46.4	0.40	45.1	0.50	43.9	0.10					50.1	0.13
42	46.4	0.80	45.7	0.40	44.1	0.50								
44	46.1	0.60	45.2	0.40	43.2	0.50								
45							42.6	0.05						
46	46.0	0.50	45.1	0.40	42.8	0.50								
48	46.0	0.40	44.8	0.40	42.6	0.50								
50	45.9	0.40	44.6	0.40	42.3	0.50	42.0	0.00					47.6	0.13
52	45.8	0.40	44.5	0.40	42.3	0.40								
54	45.7	0.40	44.4	0.40										
55														
56	45.6	0.40	44.2	0.40										
58	45.5	0.40	44	0.40										
60	45.4	0.40	43.7	0.40									45.2	0.1
62	45.3	0.40	43.4	0.40										
64	45.2	0.40	43.1	0.40										
65														
66	45.1	0.40	42.8	0.40										
68	45.0	0.40	42.5	0.40										
70	44.9	0.40	42.3	0.40									43.0	0.31
72	44.7	0.40	42.3	0.40										
74	44.5	0.40	42.2	0.40										
75														
76	44.3	0.40	42.1	0.40										
78	44.2	0.30	42.1	0.40										
80	44.1	0.30	42.0	0.40									41.4	0.15

Table 1.– Water profile data collected in glacial lakes (V-W) from 2012-16. D = depth (ft); T = temperature (°F); DO = dissolved oxygen (ppm); and CHL = Coldwater Habitat Layer (thickness; ft). Shaded values were derived from the water profile data using a habitat calculator (Pearson and Porto, IDFW).

Lake (County)	Village (Noble)		Wawasee (Kosciusko)		Waubee (Kosciusko)		Waubee (Kosciusko)		Witmer (LaGrange)	
Date	9/2/2014		8/22/2016		8/5/2014		8/21/2015		8/28/2014	
Unit	D3		NFR		D3		D3		NFR	
Clarity (ft)	4.0		10.5		N/A		7.0		3.0	
D @ 68°F	11.2		25.8		18.3		18.9		17.0	
D @ DO3	5.5		23.2		18.6		16.7		13.8	
T @ DO3	75.8		74.8		67.5		73.4		73.5	
CHL	0.0		0.0		0.3		0.0		0.0	
D	T	DO	T	DO	T	DO	T	DO	T	DO
0	76.7	8.97	77.9	4.35	77.2	11.04	76.4	7.13	77.3	8.18
2	76.7	9.01	77.9	4.51	77.2	11.16	76.4		77.4	8.20
4	76.7	8.89	77.5	4.67	77.3	11.23	76.4		77.4	8.20
5	76.3	5.62	77.3	4.75	77.3	11.08	76.4	7.17		
6	75.3	0.84	77.2	4.78	77.2	11.14	76.4	7.16	77.3	8.15
8	73.3	0.37	77.1	5.00	75.6	11.63	76.4	7.18	77.1	8.10
10	70.9	0.22	77.1	5.23	74.8	11.29	76.4	7.20	77.0	8.07
12			77.0	5.42	74.3	10.53	76.4	7.28	76.3	6.67
14			76.9	5.46	73.5	9.58	76.3	7.36	73.3	2.69
15	58.9	0.20	76.9	5.53	73.2	9.05	76.2	7.34		
16			76.8	5.68	72.5	8.44	74.6	4.20	70.1	0.13
18			76.8	5.80	68.7	3.73	71.1	0.79	66.0	0.06
20	50.4	0.04	76.5	5.90	64.6	1.32	64.0	0.52	61.7	0.04
22			75.7	5.48	61.3	1.31	61.4	0.37		
24			74.3	1.44	58.3	0.70	59.1	0.31		
25			71.6	1.47	56.3	0.40	58.0	0.28	52.1	0.04
26			67.3	0.21	55.3	0.30				
28			66.3	0.17	53.7	0.27				
30			63.0	0.12	53.1	0.23	53.4	0.24	49.2	0.03
32			61.5	0.10						
34			59.9	0.09						
35			59.0	0.09			51.0	0.17	47.3	0.03
36			58.5	0.08						
38			58.1	0.07						
40			57.7	0.06					46.4	0.02
42			57.2	0.06						
44			56.8	0.05						
45			56.7	0.05					45.6	0.01
46			56.6	0.04						
48			56.4	0.04	49.4	0.21				
50			56.1	0.04					44.9	0.00
52			55.8	0.03						
54			55.6	0.03						
55			55.6	0.02						
56			55.5	0.02						
58			55.4	0.02						
60			55.3	0.01						
62			55.2	0.01						
64			55.2	0.00						
65			55.1	0.01						
66			55.1	0.00						
68			55.1	0.00						
70			55.0	0.01						
72			55.0	0.01						
74			54.9	0.00						
75			54.8	0.00						
76										
78										
80										

Table 2.– Summary statistics of targeted (< 68 °F, > 3ppm DO) experimental gill net lifts (Start/End) for Cisco, 2012.

Gill Net (lift)	Cisco (N)	Crew	Lake	County	Lift Date	Depth (ft)	Start		End	
							Latitude	Longitude	Latitude	Longitude
1	1	D3	Crooked	Whitley	9/26/12	15-45	41.26599	-85.48083	41.26651	-85.48164
2	2	D3	Crooked	Whitley	9/26/12	25-30	41.26401	-85.48242	41.26326	-85.48221
3	0	D3	Crooked	Whitley	9/26/12	30-50	41.25868	-85.47902	41.25832	-85.47834
4	0	D3	Crooked	Whitley	9/26/12	15-30	41.26707	-85.48320	41.26643	-85.48365
5	2	D3	Crooked	Whitley	9/27/12	15-45	41.26599	-85.48083	41.26651	-85.48164
6	1	D3	Crooked	Whitley	9/27/12	33-33	41.26699	-85.48193	41.26731	-85.48277
7	0	D3	Crooked	Whitley	9/27/12	25-35	41.26495	-85.48326	41.26578	-85.48362
8	0	D3	Crooked	Whitley	9/27/12	32-40	41.25813	-85.47924	41.25793	-85.47826
9	1	D3	Crooked	Whitley	9/27/12	25-30	41.26401	-85.48242	41.26326	-85.48221
1	6	NFR	Eve	LaGrange	9/11/12	19-20	41.56186	-85.32026	41.56227	-85.31958
2	0	NFR	Eve	LaGrange	9/11/12	14-19	41.56168	-85.31891	41.56103	-85.31835
3	4	NFR	Eve	LaGrange	9/11/12	21-27	41.55934	-85.31989	41.55957	-85.32070
4	2	NFR	Eve	LaGrange	9/12/12	19-20	41.56186	-85.32026	41.56227	-85.31958
5	3	NFR	Eve	LaGrange	9/12/12	16-21	41.56166	-85.31000	41.56102	-85.31842
6	5	NFR	Eve	LaGrange	9/12/12	21-27	41.55934	-85.31989	41.55957	-85.32070
7	2	NFR	Eve	LaGrange	9/13/12	19-20	41.56186	-85.32026	41.56227	-85.31958
8	18	NFR	Eve	LaGrange	9/13/12	18-23	41.56163	-85.31912	41.56098	-85.31852
9	7	NFR	Eve	LaGrange	9/13/12	21-27	41.55934	-85.31989	41.55957	-85.32070
10	2	NFR	Eve	LaGrange	9/13/12	18-23	41.56033	-85.31789	41.56012	-85.31876
1	17	D2	Failing	Steuben	9/5/12	26-27	41.70406	-85.00040	41.70425	-85.00108
2	24	D2	Failing	Steuben	9/5/12	26-27	41.70594	-85.00064	41.70562	-85.00142
3	85	D2	Failing	Steuben	9/5/12	26-27	41.70579	-84.99834	41.70631	-84.99781

Table 2.– Summary statistics of targeted (< 68 °F, > 3ppm DO) experimental gill net lifts (Start/End) for Cisco, 2012.

Gill Net (lift)	Cisco (N)	Crew	Lake	County	Lift Date	Depth (ft)	Start		End	
							Latitude	Longitude	Latitude	Longitude
1	7	D2	Gage	Steuben	9/25/12	38-39	41.69982	-85.10617	41.69932	-85.10635
2	3	D2	Gage	Steuben	9/25/12	38-39	41.69961	-85.11606	41.69980	-85.11687
3	7	D2	Gage	Steuben	9/25/12	38-39	41.70435	-85.11085	41.70480	-85.11153
4	4	D2	Gage	Steuben	9/26/12	38-39	41.70488	-85.11160	41.70482	-85.11233
5	13	D2	Gage	Steuben	9/26/12	38-39	41.70339	-85.12170	41.70353	-85.12080
6	2	D2	Gage	Steuben	9/26/12	38-39	41.69815	-85.10677	41.69875	-85.10642
7	1	D2	Gage	Steuben	9/27/12	38-39	41.70465	-85.11279	41.70454	-85.11359
8	11	D2	Gage	Steuben	9/27/12	38-39	41.70513	-85.12070	41.70548	-85.11996
9	3	D2	Gage	Steuben	9/27/12	38-39	41.70084	-85.10645	41.70143	-85.10632
1	0	D3	Gordy	Noble	9/5/12	18-22	41.34967	-85.62865	41.34901	-85.62842
2	0	D3	Gordy	Noble	9/5/12	14-15	41.35063	-85.62817	41.35123	-85.62772
3	0	D3	Gordy	Noble	9/5/12	13-17	41.34894	-85.62584	41.34957	-85.62543
4	0	D3	Gordy	Noble	9/6/12	12-17	41.34814	-85.62690	41.34751	-85.62688
5	0	D3	Gordy	Noble	9/6/12	17-17	41.35180	-85.62741	41.35175	-85.62650
6	0	D3	Gordy	Noble	9/6/12	15-17	41.34837	-85.62560	41.34771	-85.62552
7	0	D3	Gordy	Noble	9/7/12	19-12	41.34757	-85.62587	41.34733	-85.62669
8	0	D3	Gordy	Noble	9/7/12	15-17	41.34845	-85.62733	41.34872	-85.62819
9	0	D3	Gordy	Noble	9/7/12	21-15	41.35040	-85.62570	41.35108	-85.62580
1	15	D2	Indiana	Elkhart	9/13/12	42-43	41.75856	-85.83131	41.75803	-85.83204
2	39	D2	Indiana	Elkhart	9/13/12	42-43	41.76299	-85.83456	41.76355	-85.83445
3	47	D2	Indiana	Elkhart	9/13/12	42-43	41.76404	-85.83200	41.76430	-85.83120
1	5	NFR	South Twin	LaGrange	9/25/12	37-39	41.72822	-85.46461	41.72783	-85.46544
2	11	NFR	South Twin	LaGrange	9/25/12	37-39	41.72255	-85.46564	41.72322	-85.46495
3	55	NFR	South Twin	LaGrange	9/25/12	37-39	41.72404	-85.47009	41.72355	-85.46963

Table 3.– Summary statistics of targeted (< 68 °F, > 3ppm DO) experimental gill net lifts (Start/End) for Cisco, 2013.

Gill Net (lift)	Cisco (N)	Crew	Lake	County	Lift Date	Depth (ft)	Start Latitude	Start Longitude	End Latitude	End Longitude
1	0	D3	Big Cedar	Whitley	9/17/13	-	41.25673	-85.45957	41.25609	-85.45924
2	0	D3	Big Cedar	Whitley	9/17/13	-	41.25584	-85.45519	41.25551	-85.45407
3	0	D3	Big Cedar	Whitley	9/17/13	-	41.25238	-85.45086	41.25181	-85.45118
4	0	D3	Big Cedar	Whitley	9/18/13	-	41.25135	-85.45115	41.25111	-85.45028
5	0	D3	Big Cedar	Whitley	9/18/13	-	41.25732	-85.45662	41.25678	-85.45616
6	0	D3	Big Cedar	Whitley	9/18/13	-	41.25531	-85.45645	41.25508	-85.45378
7	0	D3	Big Cedar	Whitley	9/19/13	-	41.25294	-85.44888	41.25255	-85.44763
8	0	D3	Big Cedar	Whitley	9/19/13	-	41.25002	-85.44806	41.24955	-85.44655
9	0	D3	Big Cedar	Whitley	9/19/13	-	41.24971	-85.44389	41.24909	-85.44385
1	0	D2	Clear (West)	Steuben	9/4/13	24-24	41.73701	-84.85576	41.73637	-84.85536
2	0	D2	Clear (West)	Steuben	9/4/13	24-24	41.73357	-84.85230	41.73307	-84.85186
3	0	D2	Clear (North)	Steuben	9/4/13	50-54	41.74009	-84.84567	41.73944	-84.84524
4	0	D2	Clear (North)	Steuben	9/5/13	50-54	41.74459	-84.84023	41.74388	-84.84022
5	0	D2	Clear (North)	Steuben	9/5/13	50-54	41.74048	-84.84060	41.73994	-84.84120
6	0	D2	Clear (East)	Steuben	9/5/13	40-42	41.73234	-84.84655	41.73175	-84.84607
7	0	D2	Clear (East)	Steuben	9/6/13	40-42	41.73526	-84.84054	41.73517	-84.83961
8	0	D2	Clear (East)	Steuben	9/6/13	40-42	41.73130	-84.83791	41.73128	-84.83699
9	0	D2	Clear (East)	Steuben	9/6/13	40-42	41.73621	-84.83412	41.73623	-84.83507
1	0	D3	Dillard's Pit	Kosciusko	9/4/13	-	41.42019	-85.79614	41.42057	-85.97569
2	0	D3	Dillard's Pit	Kosciusko	9/4/13	-	41.42128	-85.79742	41.42071	-85.79732
3	0	D3	Dillard's Pit	Kosciusko	9/4/13	-	41.42060	-85.79506	41.42023	-85.79552
4	0	D3	Dillard's Pit	Kosciusko	9/5/13	-	41.41948	-85.79594	41.41967	-85.79639
5	0	D3	Dillard's Pit	Kosciusko	9/5/13	-	41.42143	-85.79499	41.42142	-85.79565
6	0	D3	Dillard's Pit	Kosciusko	9/5/13	-	41.41911	-85.79581	41.41943	-85.79640
7	0	D3	Dillard's Pit	Kosciusko	9/6/13	-	41.42003	-85.79723	41.41955	-85.79699
8	0	D3	Dillard's Pit	Kosciusko	9/6/13	-	41.42144	-85.79727	41.42143	-85.79645
9	0	D3	Dillard's Pit	Kosciusko	9/6/13	-	41.42125	-85.79485	41.42083	-85.79467

Table 3.– Summary statistics of targeted (< 68 °F, > 3ppm DO) experimental gill net lifts (Start/End) for Cisco, 2013.

Gill Net (lift)	Cisco (N)	Crew	Lake	County	Lift Date	Depth (ft)	Start		End	
							Latitude	Longitude	Latitude	Longitude
1	0	D2	George	Steuben	9/17/13	27-27	41.75698	-85.00848	41.75731	-85.00933
2	0	D2	George	Steuben	9/17/13	27-27	41.76134	-85.00245	41.76070	-85.00213
3	0	D2	George	Steuben	9/17/13	27-27	41.75828	-85.00248	41.75759	-85.00248
4	0	D2	George	Steuben	9/17/13	27-27	41.75152	-85.00573	41.75162	-85.00479
5	0	D2	George	Steuben	9/17/13	27-27	41.75008	-85.01114	41.74989	-85.01025
6	0	D2	George	Steuben	9/17/13	27-27	41.75267	-85.01123	41.75203	-85.01161
1	0	NFR	Green	Steuben	9/17/13	24-27	41.72823	-84.99908	41.72810	-84.99815
2	0	NFR	Green	Steuben	9/17/13	26-26	41.72718	-84.99712	41.72675	-84.99787
3	0	NFR	Green	Steuben	9/17/13	25-26	41.72630	-84.99917	41.72682	-84.99988
4	0	NFR	Green	Steuben	9/18/13	23-26	41.72827	-84.99937	41.72776	-84.99979
5	0	NFR	Green	Steuben	9/18/13	26-26	41.72718	-84.99712	41.72675	-84.99787
6	0	NFR	Green	Steuben	9/18/13	25-26	41.72630	-84.99917	41.72682	-84.99988
7	0	NFR	Green	Steuben	9/19/13	23-26	41.72827	-84.99937	41.72776	-84.99979
8	0	NFR	Green	Steuben	9/19/13	26-26	41.72718	-84.99712	41.72675	-84.99787
9	0	NFR	Green	Steuben	9/19/13	25-26	41.72630	-84.99917	41.72682	-84.99988
1	0	D3	Knapp	Noble	9/10/13	-	41.34299	-85.60490	41.34238	-85.60434
2	0	D3	Knapp	Noble	9/10/13	-	41.34863	-85.61032	41.34201	-85.61115
3	0	D3	Knapp	Noble	9/10/13	-	41.34520	-85.61123	41.34476	-85.61195
4	0	D3	Knapp	Noble	9/11/13	-	41.34006	-85.60064	41.33959	-85.60116
5	0	D3	Knapp	Noble	9/11/13	-	41.34419	-85.61259	41.34358	-85.61210
6	0	D3	Knapp	Noble	9/11/13	-	41.34494	-85.60700	41.34542	-85.60819
7	0	D3	Knapp	Noble	9/12/13	-	41.34486	-85.60660	41.34440	-85.60599
8	0	D3	Knapp	Noble	9/12/13	-	41.33960	-85.60183	41.34008	-85.60276
9	0	D3	Knapp	Noble	9/12/13	-	41.34177	-85.60848	41.34128	-85.60868

Table 3.– Summary statistics of targeted (< 68 °F, > 3ppm DO) experimental gill net lifts (Start/End) for Cisco, 2013.

Gill Net (lift)	Cisco (N)	Crew	Lake	County	Lift Date	Depth (ft)	Start		End	
							Latitude	Longitude	Latitude	Longitude
1	0	D1	Lawrence	Marshall	9/3/13	22-22	41.29593	-86.33648	41.29635	-86.33709
2	0	D1	Lawrence	Marshall	9/3/13	22-22	41.29630	-86.33454	41.29685	-86.33453
3	0	D1	Lawrence	Marshall	9/3/13	22-21	41.29866	-86.33617	41.29895	-86.33521
4	0	D1	Lawrence	Marshall	9/4/13	21-20	41.29877	-86.33449	41.29854	-86.33352
5	0	D1	Lawrence	Marshall	9/4/13	22-21	41.29522	-86.33531	41.29553	-86.33625
6	0	D1	Lawrence	Marshall	9/4/13	21-23	41.29737	-86.33819	41.29672	-86.33778
7	0	D1	Lawrence	Marshall	9/5/13	21-22	41.29837	-86.33841	41.29836	-86.33730
8	0	D1	Lawrence	Marshall	9/5/13	21-23	41.29532	-86.33558	41.29549	-86.33466
9	0	D1	Lawrence	Marshall	9/5/13	22-23	41.29741	-86.33269	41.29718	-86.33368
1	0	D2	Little Lime	Steuben	9/12/13	21-21	41.75068	-85.18425	41.75041	-85.18426
2	0	D2	Little Lime	Steuben	9/12/13	21-21	41.75008	-85.18398	41.74987	-85.18378
3	0	D2	Little Lime	Steuben	9/12/13	21-21	41.74990	-85.18276	41.75010	-85.18249
4	0	D2	Little Lime	Steuben	9/12/13	21-21	41.75077	-85.18286	41.75089	-85.18322
1	0	NFR	Martin	LaGrange	9/10/13	29-29	41.56514	-85.38365	41.56471	-85.38298
2	0	NFR	Martin	LaGrange	9/10/13	24-23	41.56324	-85.38354	41.56395	-85.38308
3	0	NFR	Martin	LaGrange	9/10/13	22-22	41.56317	-85.38503	41.56379	-85.38564
4	0	NFR	Martin	LaGrange	9/11/13	29-29	41.56514	-85.38365	41.56471	-85.38298
5	0	NFR	Martin	LaGrange	9/11/13	24-23	41.56324	-85.38354	41.56395	-85.38308
6	0	NFR	Martin	LaGrange	9/11/13	22-22	41.56317	-85.38503	41.56379	-85.38564
7	0	NFR	Martin	LaGrange	9/12/13	24-25	41.56554	-85.38573	41.56567	-85.38496
8	0	NFR	Martin	LaGrange	9/12/13	25-19	41.56310	-85.38411	41.56318	-85.38500
9	0	NFR	Martin	LaGrange	9/12/13	17-19	41.56391	-85.38608	41.56420	-85.38681
1	0	NFR	Meserve	Steuben	9/17/13	22-19	41.57380	-84.99876	41.57355	-84.99793
2	0	NFR	Meserve	Steuben	9/17/13	19-23	41.57342	-84.99707	41.57354	-84.99620
3	0	NFR	Meserve	Steuben	9/18/13	22-19	41.57380	-84.99876	41.57355	-84.99793
4	0	NFR	Meserve	Steuben	9/18/13	19-23	41.57342	-84.99707	41.57354	-84.99620
5	0	NFR	Meserve	Steuben	9/19/13	19-20	41.57414	-84.99774	41.57401	-84.99685
6	0	NFR	Meserve	Steuben	9/19/13	20-20	41.57352	-84.99820	41.57322	-84.99738

Table 3.– Summary statistics of targeted (< 68 °F, > 3ppm DO) experimental gill net lifts (Start/End) for Cisco, 2013.

Gill Net (lift)	Cisco (N)	Crew	Lake	County	Lift Date	Depth (ft)	Start		End	
							Latitude	Longitude	Latitude	Longitude
1	0	D1	Myers	Marshall	9/3/13	23-20	41.30294	-86.35418	41.30272	-86.35318
2	0	D1	Myers	Marshall	9/3/13	20-20	41.30006	-86.34897	41.29993	-86.34791
3	0	D1	Myers	Marshall	9/3/13	20-20	41.30124	-86.34731	41.30122	-86.34632
4	0	D1	Myers	Marshall	9/4/13	20-20	41.30136	-86.34979	41.3013	-86.34883
5	0	D1	Myers	Marshall	9/4/13	20-23	41.30020	-86.34440	41.29962	-86.34354
6	0	D1	Myers	Marshall	9/4/13	21-21	41.30146	-86.35719	41.30126	-86.35650
7	0	D1	Myers	Marshall	9/5/13	20-21	41.30207	-86.35162	41.30242	-86.35248
8	0	D1	Myers	Marshall	9/5/13	20-21	41.30116	-86.35314	41.30126	-86.35406
9	0	D1	Myers	Marshall	9/5/13	19-19	41.30073	-86.34229	41.30077	-86.34322
1	7	D2	North Twin	LaGrange	6/26/13	27-30	41.73169	-85.45980	41.73104	-85.46008
1	0	NFR	Olin	LaGrange	9/10/13	26-27	41.56486	-85.39502	41.56499	-85.39592
2	0	NFR	Olin	LaGrange	9/10/13	23-24	41.56351	-85.39146	41.56301	-85.39197
3	0	NFR	Olin	LaGrange	9/10/13	22-22	41.55989	-85.39122	41.56046	-85.39181
4	0	NFR	Olin	LaGrange	9/11/13	26-27	41.56486	-85.39502	41.56499	-85.39592
5	0	NFR	Olin	LaGrange	9/11/13	23-23	41.56232	-85.39381	41.56298	-85.39402
6	0	NFR	Olin	LaGrange	9/11/13	26-27	41.56486	-85.39502	41.56499	-85.39592
7	0	NFR	Olin	LaGrange	9/12/13	27-27	41.56296	-85.39757	41.56359	-85.39777
8	0	NFR	Olin	LaGrange	9/12/13	25-27	41.56107	-85.39396	41.56160	-85.39347
9	0	NFR	Olin	LaGrange	9/12/13	17-25	41.56211	-85.38783	41.56223	-85.38873
1	0	NFR	Oliver	LaGrange	9/10/13	54-54	41.56986	-85.40208	41.56927	-85.40282
2	0	NFR	Oliver	LaGrange	9/10/13	45-45	41.57141	-85.39722	41.57202	-85.39713
3	0	NFR	Oliver	LaGrange	9/10/13	38-39	41.57436	-85.40476	41.57495	-85.40446
4	0	NFR	Oliver	LaGrange	9/11/13	54-54	41.56986	-85.40208	41.56927	-85.40282
5	0	NFR	Oliver	LaGrange	9/11/13	45-45	41.57141	-85.39722	41.57202	-85.39713
6	0	NFR	Oliver	LaGrange	9/11/13	38-39	41.57436	-85.40476	41.57495	-85.40446
7	0	NFR	Oliver	LaGrange	9/12/13	47-54	41.57489	-85.40430	41.57431	-85.40471
8	0	NFR	Oliver	LaGrange	9/12/13	57-61	41.57373	-85.40631	41.57320	-85.40592
9	0	NFR	Oliver	LaGrange	9/12/13	57-63	41.57061	-85.40848	41.57117	-85.40816
10	0	NFR	Oliver	LaGrange	9/13/13	41-43	41.57445	-85.41109	41.57375	-85.41119
11	0	NFR	Oliver	LaGrange	9/13/13	45-70	41.57482	-85.39816	41.57418	-85.39854
12	0	NFR	Oliver	LaGrange	9/13/13	33-50	41.56860	-85.40196	41.56818	-85.40124

Table 4.– Summary statistics of targeted (< 68 °F, > 3ppm DO) experimental gill net lifts (Start/End) for Cisco, 2014.

Gill Net (lift)	Cisco (N)	Crew	Lake	County	Lift Date	Depth (ft)	Start		End	
							Latitude	Longitude	Latitude	Longitude
1	0	NFR	McClish	Steuben	9/9/14	25-25	41.54061	-85.19166	41.54091	-85.19045
2	0	NFR	McClish	Steuben	9/9/14	25-25	41.53928	-85.19004	41.53898	-85.19093
3	0	NFR	McClish	Steuben	9/9/14	25-25	41.53994	-85.19470	41.54056	-85.19404
4	0	NFR	McClish	Steuben	9/10/14	24-23	41.54110	-85.19006	41.54103	-85.18911
5	0	NFR	McClish	Steuben	9/10/14	25-25	41.54029	-85.18895	41.53973	-85.18955
6	0	NFR	McClish	Steuben	9/10/14	25-25	41.53994	-85.19470	41.54056	-85.19404
7	0	NFR	McClish	Steuben	9/11/14	24-23	41.54110	-85.19006	41.54103	-85.18911
8	0	NFR	McClish	Steuben	9/11/14	25-25	41.54029	-85.18895	41.53973	-85.18955
9	0	NFR	McClish	Steuben	9/11/14	25-25	41.53945	-85.19501	41.53501	-85.19402

Table 5.– Summary statistics of targeted (< 68 °F, > 3ppm DO) experimental gill net lifts (Start/End) for Cisco, 2016.

Gill Net (lift)	Cisco (N)	Crew	Lake	County	Lift Date	Depth (ft)	Start		End	
							Latitude	Longitude	Latitude	Longitude
1	0	NFR	McClish	Steuben	8/31/16	28-36	41.54081	-85.18981	41.54021	-85.19027
2	0	NFR	McClish	Steuben	8/31/16	25-43	41.53976	-85.18959	41.53929	-85.19020
3	0	NFR	McClish	Steuben	8/31/16	30-38	41.53969	-85.19510	41.53916	-85.19446
4	0	NFR	McClish	Steuben	9/1/16	25-45	41.53998	-85.19432	41.53986	-85.19535
5	0	NFR	McClish	Steuben	9/1/16	20-52	41.54033	-85.19405	41.54057	-85.19313
6	0	NFR	McClish	Steuben	9/1/16	23-33	41.54051	-85.18926	41.54104	-85.18983
7	0	NFR	McClish	Steuben	9/2/16	10-52	41.53943	-85.18963	41.53938	-85.19075
8	0	NFR	McClish	Steuben	9/2/16	10-51	41.53879	-85.19122	41.53897	-85.19221
9	0	NFR	McClish	Steuben	9/2/16	25-55	41.54063	-85.19127	41.54005	-85.19196
1	0	NFR	Meserve	Steuben	9/8/16	16-21	41.57436	-84.99850	41.57405	-84.99757
2	0	NFR	Meserve	Steuben	9/8/16	16-22	41.57401	-84.99644	41.57351	-84.99722
3	0	NFR	Meserve	Steuben	9/8/16	18-22	41.57317	-84.99603	41.57346	-84.99691
4	0	NFR	Meserve	Steuben	9/8/16	17-21	41.57339	-84.99831	41.57325	-84.99716
5	0	NFR	Meserve	Steuben	9/9/16	16-22	41.57355	-84.99848	41.57387	-84.99781
6	0	NFR	Meserve	Steuben	9/9/16	16-22	41.57421	-84.99695	41.57421	-84.99695
7	0	NFR	Meserve	Steuben	9/9/16	14-20	41.57291	-84.99560	41.57327	-84.99640
8	0	NFR	Meserve	Steuben	9/9/16	18-21	41.57314	-84.99754	41.57342	-84.99670

Table 6.– Population status of Cisco in Indiana lakes since 1955 (*C = common, R = rare, P = probably extirpated, E = extirpated, U = unknown status*).

Lake	County	Acres	Frey 1955	Gulish 1975	Koza 1994	Pearson 2001	Donabauer 2016
Atwood	LaGrange	170	R	P	E	E	E
Big Cedar	Whitley	144	C	R	P	E	E
Big Long	LaGrange	366	R	E	E	E	E
Big Otter	Steuben	69	C	E	E	E	E
Clear	Steuben	800	C	R	R	R	P
Crooked	Noble/Whitley	206	C	C	C	C	C
Dallas	LaGrange	283	C	R	P	P	E
Dillard's Pit	Kosciusko	13	U	R	R	R	P
Eve	LaGrange	31	R	C	C	C	C
Failing	Steuben	23	C	C	C	C	C
Fish	LaGrange	100	C	E	E	E	E
Gage	Steuben	327	C	C	C	C	C
George	Steuben/Branch MI	509	U	U	U	U	E
Gilbert	Noble	28	U	U	E	E	E
Gooseneck	Steuben	25	R	R	R	R	P
Gordy	Noble	31	C	R	R	R	P
Green	Steuben	24	R	E	U	C	R
Hackenburg	LaGrange	42	R	R	P	E	E
Hindman	Noble	13	R	R	P	E	E
Indiana	Elkhart/Cass MI	122	U	U	U	U	C
James	Steuben	1140	C	R	P	E	E
James	Kosciusko	282	C	E	E	E	E
Jimmerson	Steuben	434	C	R	P	E	E
Knapp	Noble	88	C	R	P	P	P
Lake of the Woods	Steuben/LaGrange	136	C	C	E	E	E
Lawrence	Marshall	69	C	C	C	P	E
Little Lime	Steuben	30	U	U	U	R	P
Marsh	Steuben	56	C	E	E	E	E
Martin	LaGrange	26	C	C	P	E	E
McClish	Steuben/LaGrange	35	C	C	C	C	P
Meserve	Steuben	16	U	R	R	R	P
Messick	LaGrange	68	R	R	P	E	E
Myers	Marshall	96	C	C	P	E	E
North Twin	LaGrange	135	C	R	P	E	C
Olin	LaGrange	103	C	C	P	E	E
Oliver	LaGrange	371	R	C	P	E	E
Oswego	Kosciusko	83	R	E	E	E	E
Round	Whitley	131	R	E	E	E	E
Royer	LaGrange	69	R	P	P	E	E
Sechrist	Kosciusko	105	C	E	E	E	E
Seven Sisters	Steuben	21	C	C	P	P	P
Shock	Kosciusko	37	C	E	E	E	E
Shriner	Whitley	120	C	E	E	E	E
Snow	Steuben	422	C	E	E	E	E
South Twin	LaGrange	116	C	C	C	C	C
Tippecanoe	Kosciusko	768	C	E	E	E	E
Village	Noble	12	R	E	E	E	E
Waubee	Kosciusko	187	U	E	E	E	E
Witmer	LaGrange	204	R	E	E	E	E

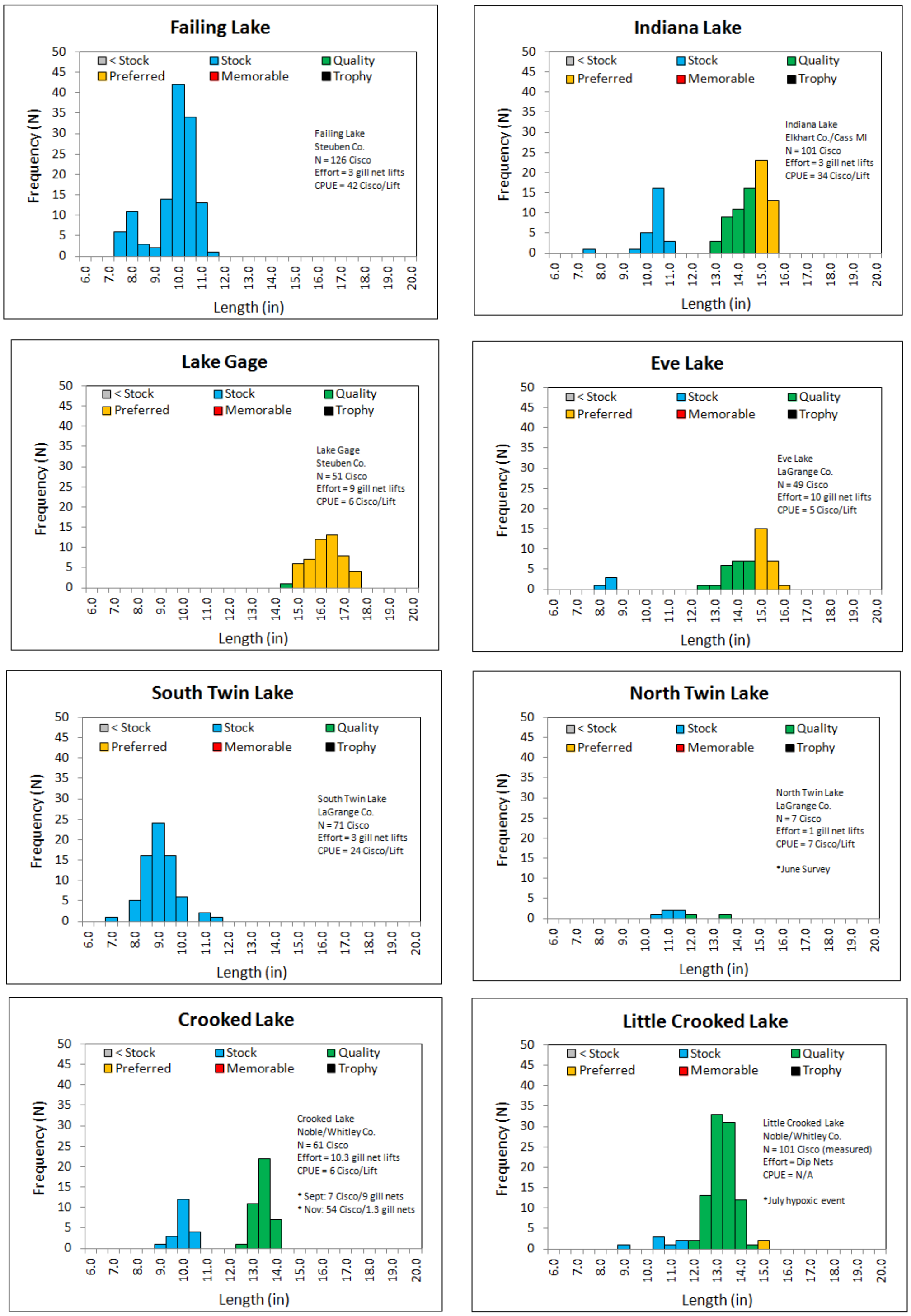


Figure 1.– Proportional size distribution classes of Cisco collected with gill nets among Indiana lakes sampled in 2012 and 2013 (North Twin Lake). Cisco collected at Little Crooked Lake were collected during a July hypoxic event with dip nets (Donabauer 2015).

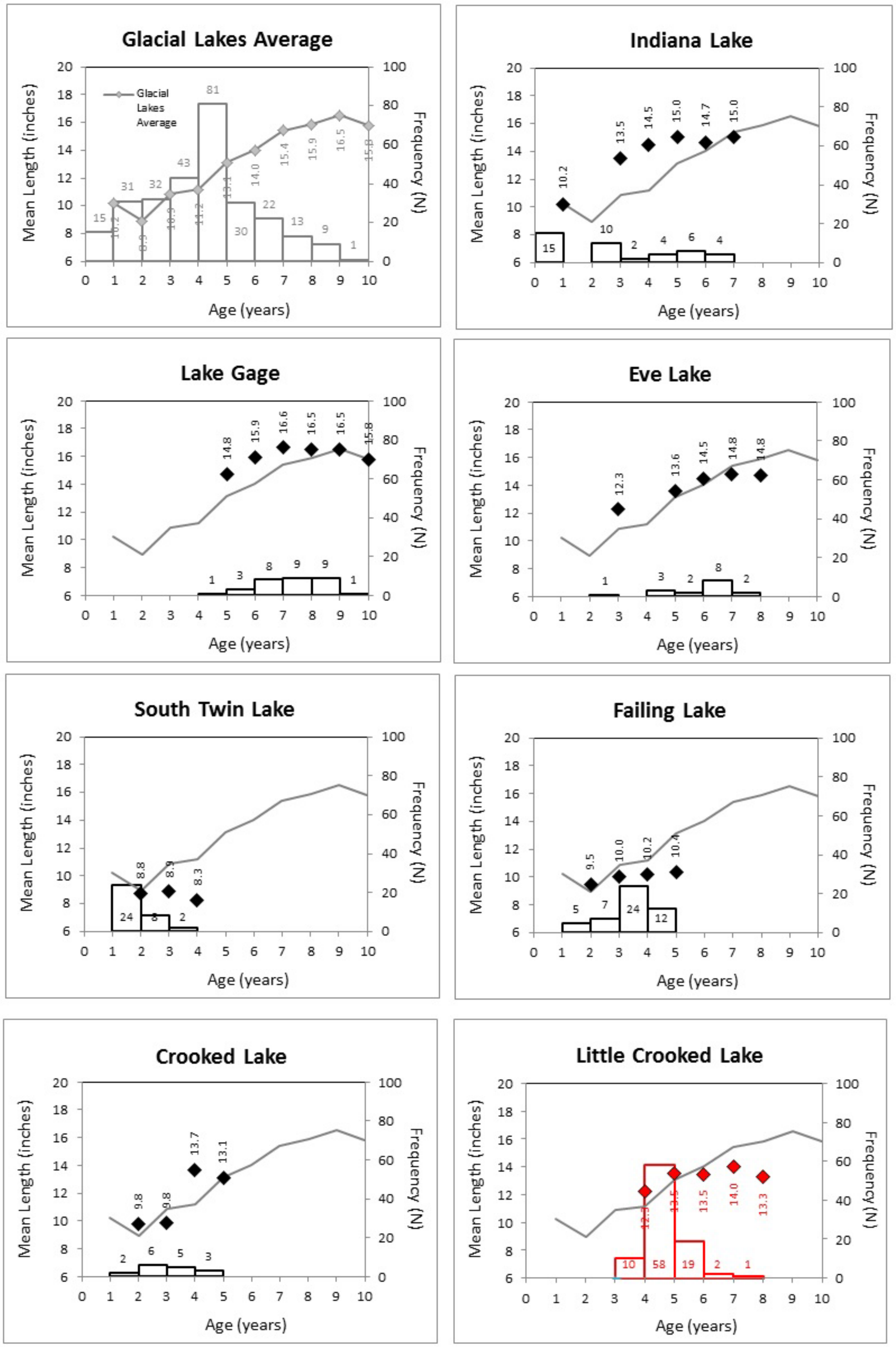


Figure 2.– Mean length-at-capture (inches) of female Cisco collected at 6 lakes (black diamonds) in September 2012 compared to growth rates based on the glacial lakes average (upper left chart; gray line throughout). No Cisco were aged from North Twin Lake. Cisco from Little Crooked Lake (red) were collected during a hypoxic event in July 2012.

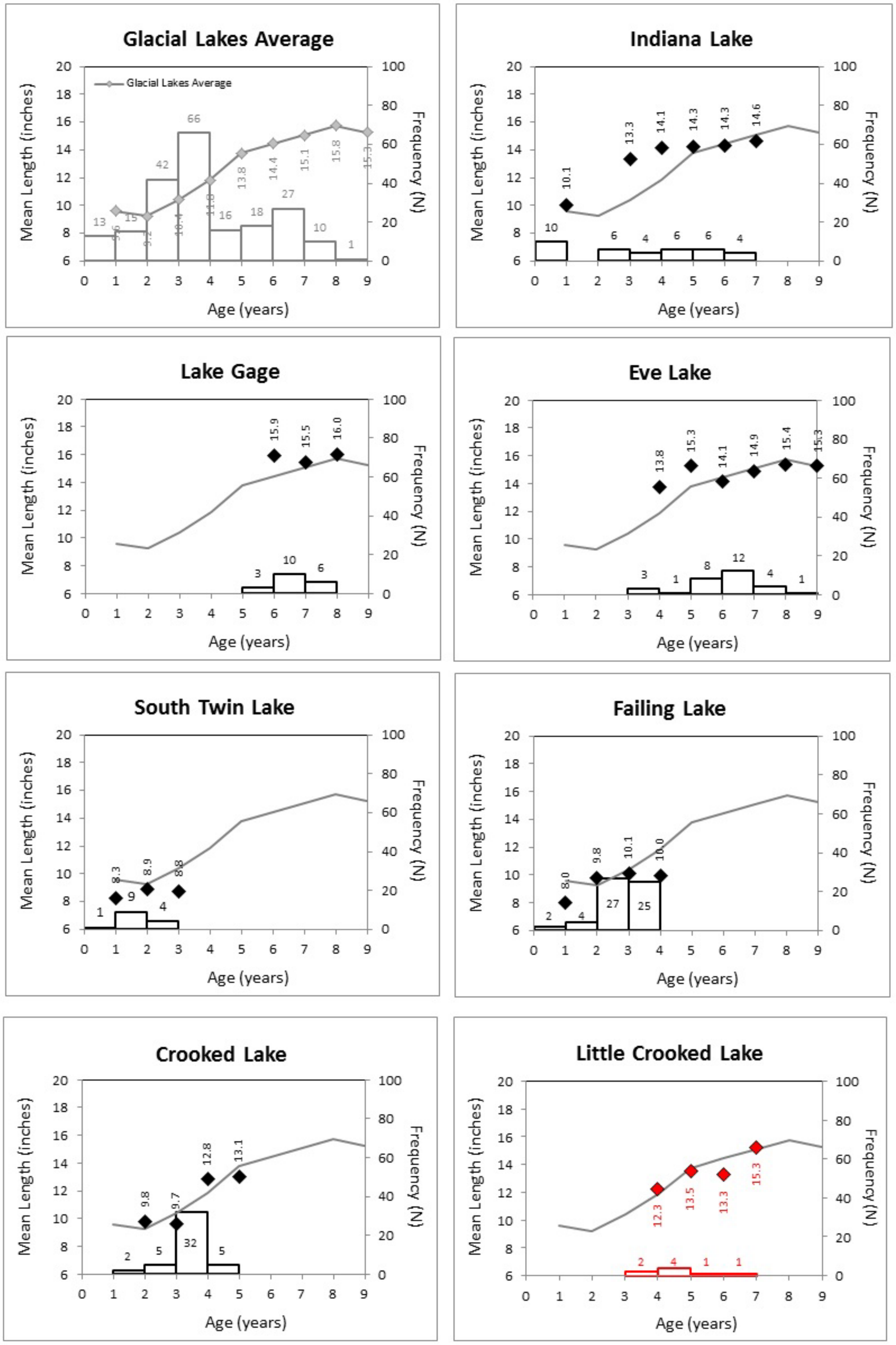
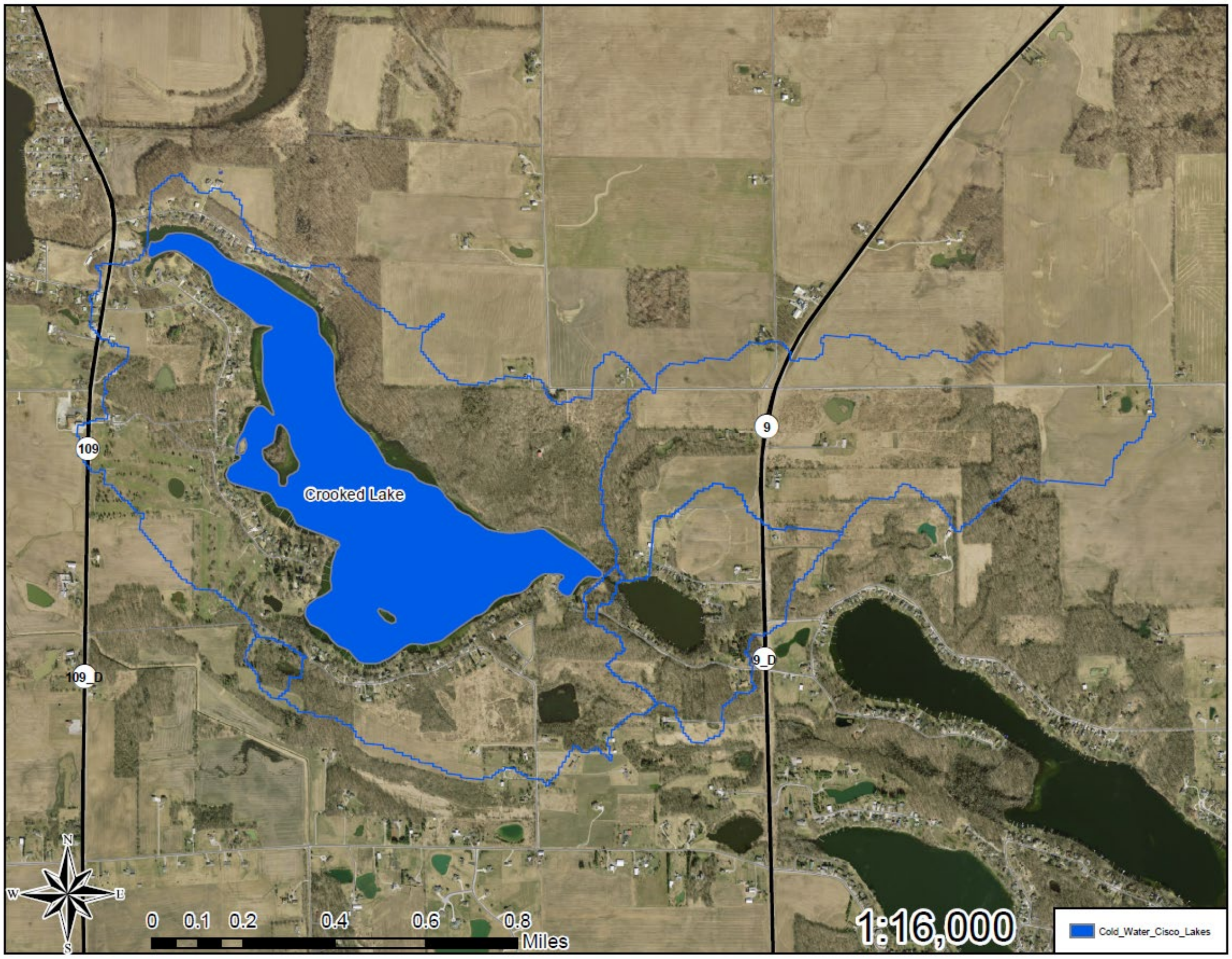
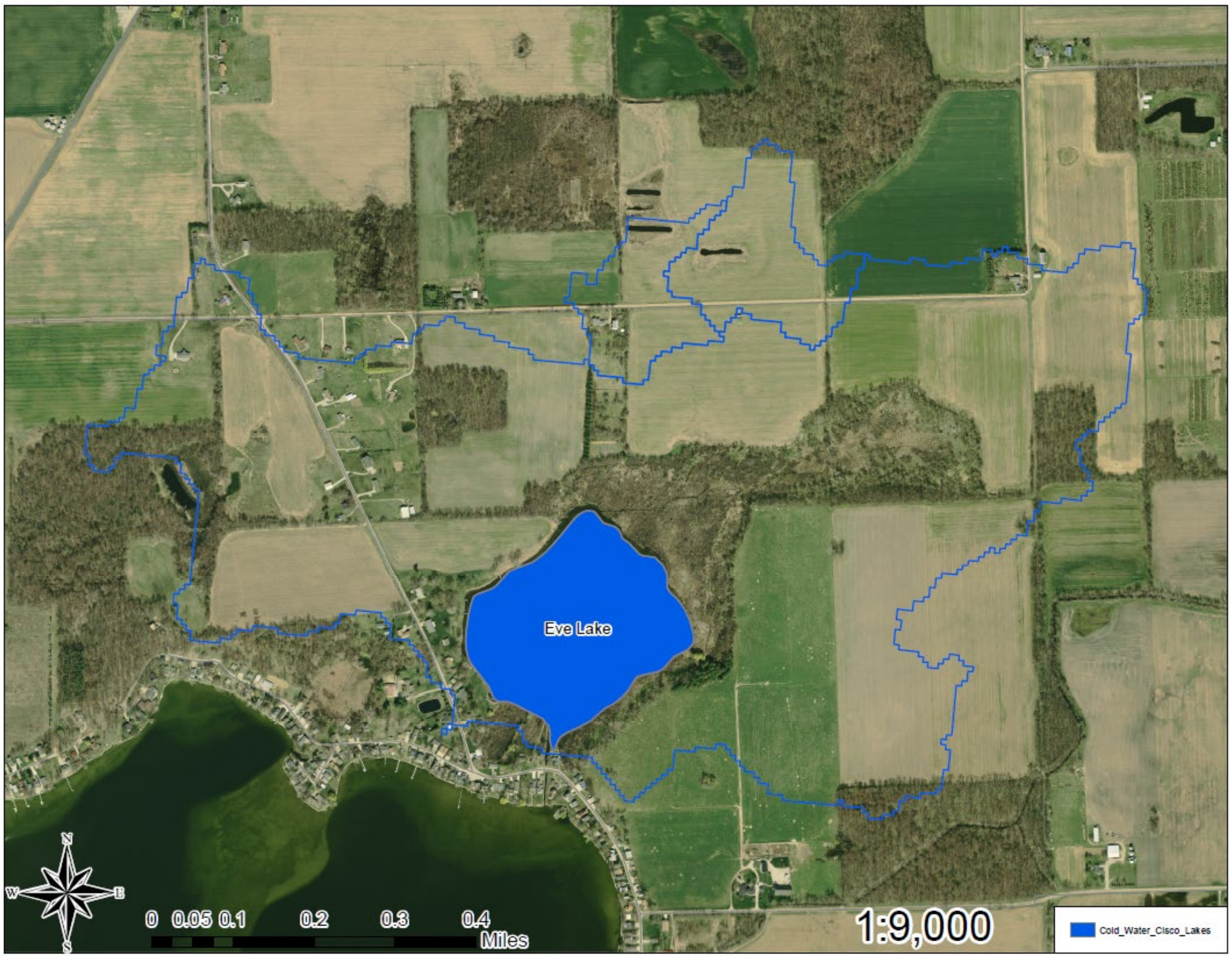


Figure 3.– Mean length-at-capture (inches) of male Cisco collected at 6 lakes (black diamonds) in September 2012 compared to growth rates based on the glacial lakes average (upper left chart; gray line throughout). No Cisco were aged from North Twin Lake. Cisco from Little Crooked Lake (red) were collected during a hypoxic event in July 2012.

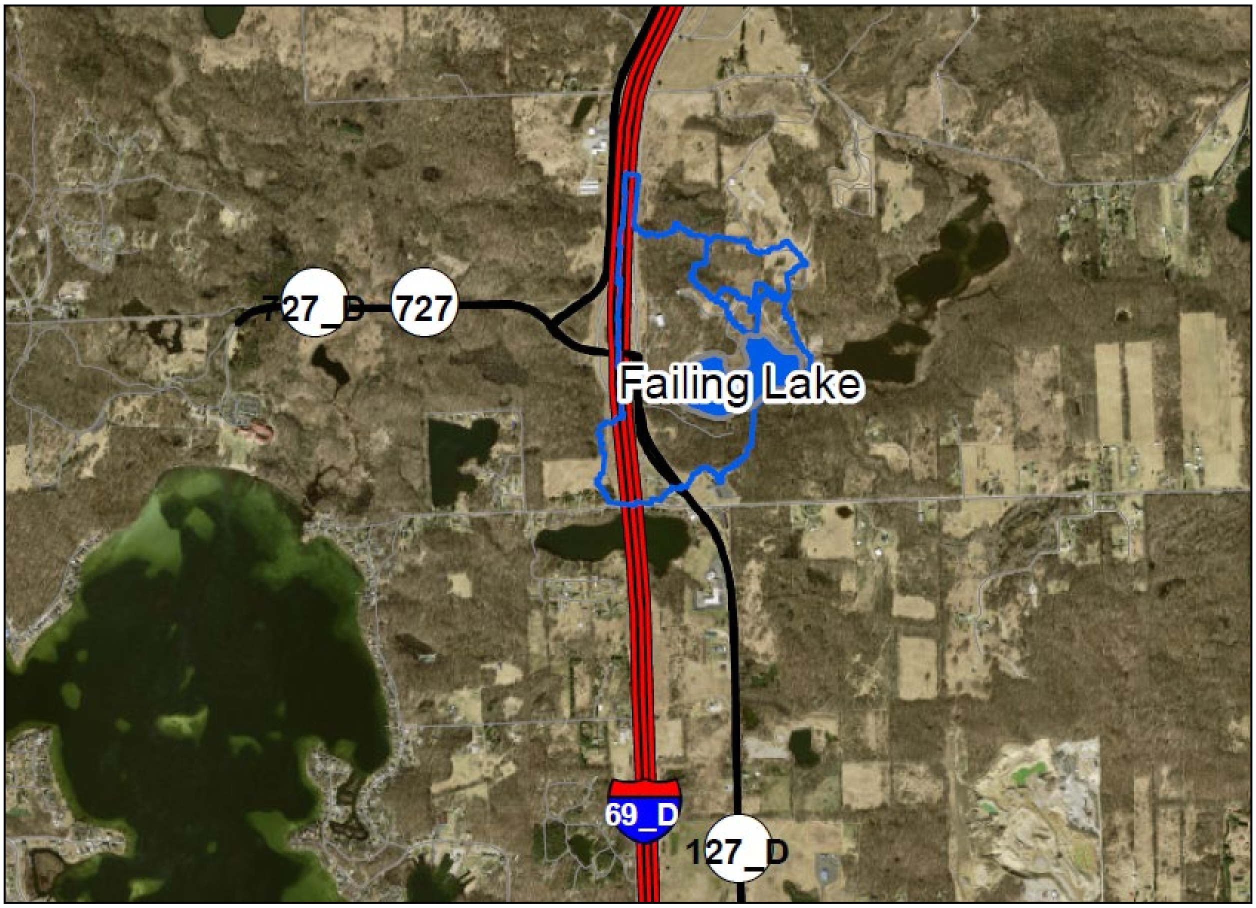
Appendix A.– Conservation Opportunity Area (COA) for implementation of the 2015 State Wildlife Action Plan, defined as the total catchment area for Crooked Lake (Noble/Whitley Co.). Catchment data were delineated by Purdue University (Jarrod Doucette, personal communication) during Phase-I of the Midwest Glacial Lakes Partnership's (MGLP) inventory of selected physical attributes of all glacial lakes throughout the upper Midwest.



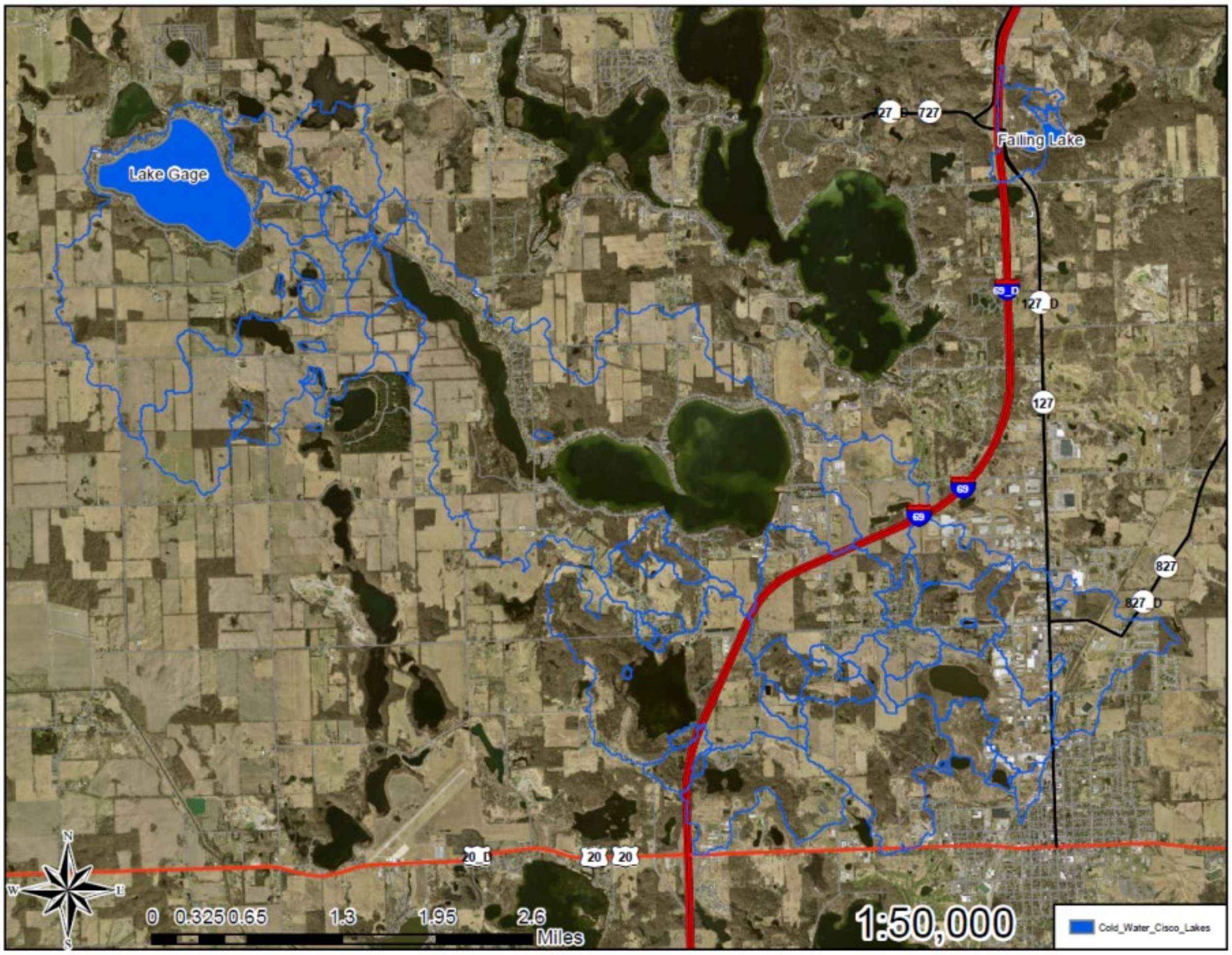
Appendix B.– Conservation Opportunity Area (COA) for implementation of the 2015 State Wildlife Action Plan, defined as the total catchment area for Eve Lake (LaGrange Co.). Catchment data were delineated by Purdue University (Jarrod Doucette, personal communication) during Phase-I of the Midwest Glacial Lakes Partnership's (MGLP) inventory of selected physical attributes of all glacial lakes throughout the upper Midwest.



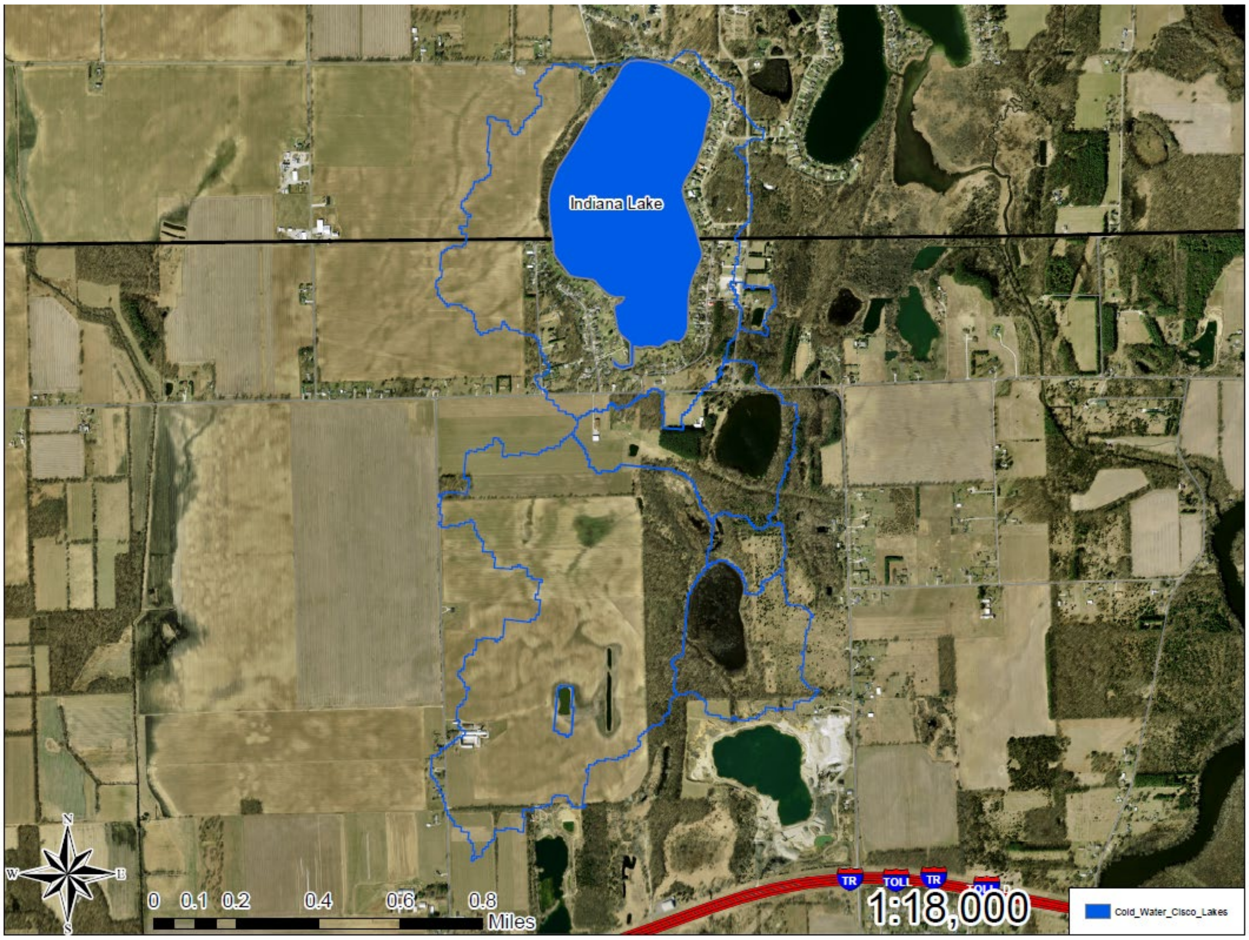
Appendix C.– Conservation Opportunity Area (COA) for implementation of the 2015 State Wildlife Action Plan, defined as the total catchment area for Failing Lake (Steuben Co.). Catchment data were delineated by Purdue University (Jarrod Doucette, personal communication) during Phase-I of the Midwest Glacial Lakes Partnership's (MGLP) inventory of selected physical attributes of all glacial lakes throughout the upper Midwest.



Appendix D.– Conservation Opportunity Area (COA) for implementation of the 2015 State Wildlife Action Plan, defined as the total catchment area for Lake Gage (Steuben Co.). Catchment data were delineated by Purdue University (Jarrod Doucette, personal communication) during Phase-I of the Midwest Glacial Lakes Partnership's (MGLP) inventory of selected physical attributes of all glacial lakes throughout the upper Midwest.



Appendix E.– Conservation Opportunity Area (COA) for implementation of the 2015 State Wildlife Action Plan, defined as the total catchment area for Indiana Lake (Elkhart Co.). Catchment data were delineated by Purdue University (Jarrod Doucette, personal communication) during Phase-I of the Midwest Glacial Lakes Partnership's (MGLP) inventory of selected physical attributes of all glacial lakes throughout the upper Midwest.



Appendix F.– Conservation Opportunity Area (COA) for implementation of the 2015 State Wildlife Action Plan, defined as the total catchment area for North and South Twin Lakes (LaGrange Co.). Catchment data were delineated by Purdue University (Jarrod Doucette, personal communication) during Phase-I of the Midwest Glacial Lakes Partnership's (MGLP) inventory of selected physical attributes of all glacial lakes throughout the upper Midwest.