Indiana
Cisco Strategic Plan
2019-2024

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Cover photo: Cisco collected by the Division of Fish and Wildlife during a survey of Crooked Lake (Noble/Whitley Co.) in 2016.

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MANAGEMENT HISTORY

Cisco (*Coregonus artedi*) are the only native salmonid species found in Indiana waters exclusive of Lake Michigan. They are a cold-water species that inhabits waters as far north as Canada and as far south as the upper mid-western United States. The glacial lakes of northern Indiana represent the southernmost extent of their native range in North America. Cisco are a small and slender, silver-colored fish that feed primarily on zooplankton. In Indiana, Cisco grow to stock size (7 inches) by age 2, quality size (12 inches) by age 4, preferred size (15 inches) by age 6, and they have been known to reach memorable size (19 inches) at around 10 years of age. The Indiana state record for Cisco is 3 pounds, 12 ounces caught from Big Cedar Lake (Whitley Co.) in 1980.

The availability of cold-water habitat (≤ 68°F and ≥ 3.0 mg/L dissolved oxygen) throughout the northern glacial lakes region of Indiana is limited by late-summer (August-September) oxy-thermal stratification, which reduces the number of suitable lakes for the species. The Division of Fish and Wildlife (DFW) has attempted to reintroduce Cisco to several cold-water lakes. In the 1960-1970s, anecdotal evidence indicated that adult Cisco were collected by an unknown individual(s) from Waubee Lake (Kosciusko Co.) and later stocked into Dillard's Pit (Kosciusko Co.). However, subsequent evaluations determined that Cisco did not persist in this waterbody. In 1979, the DFW attempted to establish a Cisco population in Gilbert Lake (Noble Co.) by stocking 300 fingerlings and again in 1987 with approximately 16,500 fry. The fry that were stocked in 1987 were reared at the Fawn River Hatchery and the brood stock was gill netted from Crooked Lake (Noble/Whitley Co.) in December. The project was deemed unsuccessful due to limited availability of cold-water habitat in Gilbert Lake that was observed through the late-1980's and early-1990's[1]. The DFW attempted to reintroduce Cisco into Green Lake (Steuben Co.) by transplanting 883 adult Cisco from South Twin Lake over three years including 1989 (265 adults), 1990 (284 adults), and 1992 (334 adults). However, subsequent surveys indicated that this reintroduction strategy also proved unsuccessful despite the presence of a consistent cold-water layer during the late-summer period at Green Lake[2]. There have been no other attempts to reintroduce Cisco in Indiana since 1992.

The DFW has taken several other steps to conserve Cisco populations over the last half century. Cisco were considered a primary forage base for stocked Lake Trout (*Salvelinus namaycush*), however the DFW phased-out predator stockings in the mid-1980's. By the 1990's, the DFW drafted non-rule policy language to restrict cold-water habitat modifications and *"establish guidelines for the assessment and determination of shoreline alterations and aquatic plant control on Cisco lakes"*. Today, Cisco are listed as a *Species of Greatest Conservation Need* and are classified as a S*pecies of Special Concern* in Indiana. 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 [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*

[1] Pearson, J. 1989. Cisco fry stocking failure at Gilbert Lake. Indiana Department of Natural Resources, Division of Fish and Wildlife. Indianapolis, IN. 3pp.

[2] Donabauer, S.B. and M.D. Linn. 2017. Cisco (Coregonus artedi) in Indiana's Glacial Lakes. Indiana Department of Natural Resources, Division of Fish and Wildlife. Indianapolis, IN. 64pp.

to protect, enhance, or somehow improve that habitat"[3]. The revised 2015 SWAP used the lake catchments of known Cisco populations to define six Conservation Opportunity Areas (COAs) in northern Indiana in order to focus the conservation community's efforts on cold-water habitat protection and restoration.

While Cisco are currently caught by anglers using traditional hook and line methods, gill netting during the fall (November-December) was historically the preferred method of Cisco anglers. Early gill netting regulations required anglers to purchase a Cisco license and restricted gill net mesh sizes[4]. Commercial take of Cisco by gill nets was established in 1881, abolished in 1901, reinstated in 1937 and phased-out in the late-1970's due to lack of angler interest. Since then, Cisco have been included among a group of fishes that are regulated without regard to a bag limit, possession limit, or size limit (312 IAC 9-7-14).

POPULATION STATUS

The eutrophication of northern Indiana glacial lakes has reduced or eliminated the cold-water habitat necessary to sustain Cisco. As many as 42 lakes were known to contain Cisco in 1955[5]. The number of Cisco lakes in Indiana has since declined precipitously to 27 lakes (1975)[6], 12 lakes (1994)[7] and 13 lakes (2001)[8]. From 2012-2016, the DFW sampled all of the historical Cisco lakes and classified remnant Cisco populations (e.g., "common" or "rare"). Catch rates of Cisco ≥ 1 per gill net lift are classified as "common", whereas catch rates of Cisco < 1 per gill net lift but > 0 per gill net lift are classified as "rare". However, a single-tier system of demotion from a lake's prior designation is used to describe a lakes current designation[9]. Failing Lake (Steuben Co.), Indiana Lake (Elkhart Co.), North Twin and South Twin lakes (LaGrange Co.), Lake Gage (Steuben Co.), Eve Lake (LaGrange Co.), and Crooked Lake (Noble/Whitley Co.) were classified as having "common" populations. Green Lake (Steuben Co.) was classified as having a "rare" population, given that cold-water habitat was observed although no Cisco were collected.[9]

The catch rate and size distribution of Cisco captured at the seven lakes classified as "common" were highly variable during the most recent evaluation. The majority (57%) of Cisco were stock size (7-12 inches), followed by preferred size (15-19 inches; 26%) and quality size (12-15 inches; 17%). The highest catch-rate of Cisco was observed at Failing Lake followed by Indiana, South Twin, North Twin, Gage, Eve, and Crooked lakes (Table 1).

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[3] IDNR. 2005. Comprehensive Wildlife Strategy. Indiana Department of Natural Resource, Division of Fish and Wildlife. Indianapolis, IN. 154 pp.

[4] James, W.D. 1975. A proposal for changes in cisco netting regulations. Indiana Department of Natural Resources, Division of Fish and Wildlife. Indianapolis, IN. 10pp.

[5] Frey, D.G. 1955. Distributional ecology of the Cisco Coregonus artedi in Indiana. Investigations of Indiana Lakes and Streams 4(7):177-228.

[6] Gulish, W.J. 1975. A summary of Indiana cisco investigations, 1971-74. Indiana Department of Natural Resources, Division of Fish and Wildlife. Indianapolis, IN. 30pp.

[7] Koza, L. 1995. Current status of cisco abundance, habitat and harvest at northern Indiana lakes. Indiana Department of Natural Resources, Division of Fish and Wildlife. Indianapolis, IN. 16pp.

[8] Pearson, J. 2001. Cisco population status and management in Indiana. Indiana Department of Natural Resources, Division of Fish and Wildlife. Indianapolis, IN. 23pp.

[9] Donabauer, S.B. and M.D. Linn. 2017. Cisco (Coregonus artedi) in Indiana's Glacial Lakes. Indiana Department of Natural Resources, Division of Fish and Wildlife. Indianapolis, IN. 64pp.

Table 1. September Cisco experimental gill net catches per proportional size distribution groups including <stock (<7 inches), stock (7-12 inches), quality (12-15 inches), preferred (15-19 inches), and memorable (>19 inches) size from 2012-2013 surveys.

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Lake	**County**	**Year**	**Lifts**	**Cisco/gill net lift**	**<Stock**	**Stock**	**Quality**	**Preferred**	**Memorable**
Crooked	Noble/Whitley	2012	9	0.8	0	2	5	0	0
Eve	LaGrange	2012	10	4.9	0	4	22	23	0
Failing	Steuben	2012	3	42.0	0	126	0	0	0
Indiana	Elkhart	2012	3	33.7	0	26	39	36	0
Gage	Steuben	2012	9	5.7	0	0	1	50	0
South Twin	LaGrange	2012	3	23.7	0	71	0	0	0
North Twin*	LaGrange	2013	1	7.0	0	5	2	0	0

*Experimental gill net lift was completed in June rather than September.

ANGLER STATUS

While the harvest of Cisco using gill nets was once rather popular, statewide angler interest in Cisco is currently minimal. Less than 1% of anglers indicated that they actually fished for Cisco in the most recent licensed angler survey[10]. There are however a small number of anglers that target Cisco at the few remaining lakes where the species still persists. Angler effort has declined markedly even where Cisco angling was once rather popular. In 1980, anglers fished an estimated 1,058 hours, harvesting estimated 5,524 Cisco at Crooked Lake during the fall spawning period[11]. By 1993, interest in the species had dropped to an estimated 24 angler hours and a harvest of 20 Cisco. The Record Fish and Fish of the Year programs offers additional information on angling for Cisco in Indiana. Since 1963, 1 Cisco was entered as a Record Fish and another 12 have been entered as Fish of the Year. Cisco were caught from Big Cedar Lake (Whitley Co.; N = 1), Lake Gage (N = 2) and Little Crooked Lake (Whitley Co.; N = 10). Cisco that were entered were of quality (12-15 inches; N = 3) and preferred (15-19 inches; N = 9) sizes. Little else is known about Cisco angling or interest among other waters where this species exists in catchable numbers.

PROGRAM ANALYSIS

The 2016 licensed angler survey revealed that demand for Cisco is exceptionally low. Based on a supply:demand analysis, the Division spends $0.53 to each dollar of revenue generated from Cisco anglers. Thus, the supply:demand ratio closely approximates the 0.5:1 target established by the

[10] Responsive Management. 2017. Indiana anglers' fishing participation and their opinions on fishing management issues. Responsive Management National Office. 228 pp

[11] Pearson, J. 2010. Crooked Lake Noble-Whitley Counties Cisco Population Status. Indiana Department of Natural Resources, Division of Fish and Wildlife. Indianapolis, IN. 1pp.

DFW to sustain native sport fishing opportunities. However, substantially greater effort will be required to adequately monitor, protect, and restore Cisco populations in the coming years.

Cisco are sensitive to habitat modifications such as internal and external nutrient loading, loss of near-shore riparian habitat, and loss of vegetative habitat. The abundance and distribution of Cisco have decreased dramatically over the last 60 years as a result of these anthropogenic habitat modifications. Although the number of lakes classified as having "*common*" populations has remained steady for 20 years, the continued decline in the presence of "*rare*" populations and increase in those classified as "*probably extirpated*" and "*extirpated*" demonstrates that Cisco continue to be a vulnerable species in Indiana (Tables 2 and 3). Furthermore, Cisco mortality events are not uncommon among established populations and have been documented as far back as the 1930's[12]. Cisco mortality events have been particularly common at Crooked Lake including events in 1981, 1986[13], 2000[14], 2012[15], and 2017[16].

Efforts to sustain Cisco populations in Indiana will require an emphasis on watershed and in-lake best management practices (BMPs) that reduced nutrient loading. The need for nutrient reduction actions in Cisco catchments has been recognized by the Indiana conservation community and is reflected in the SWAP[17]. All seven remaining Cisco lakes classified as "*common*" and their catchments are identified in the 2015 SWAP as priority Conservation Opportunity Areas (COAs). The seven catchments classified as COA's total 13,385 combined acres, of which 1,952 acres (15%) is open water. There is another 3,493 acres (26%) comprised of a mixture of deciduous forest, herbaceous wetlands, and forested wetlands. Consequently, there are 7,940 acres (59%) of land among these catchments where BMPs could be applied on developed or agricultural land-uses. The increased implementation of BMPs in Cisco catchments will rely largely on the DFW's ability to effectively convey to conservation partners the urgent need to protect cold-water habitat.

Attempts to expand the distribution of Cisco should focus on identification of lakes that provide a reasonable chance of successful establishment. Reintroduction lakes should only be considered candidates if a considerable amount of watershed restoration has been undertaken to mitigate for the initial habitat degradation that led to Cisco extirpation. A recent study of Indiana lakes suggested that Green (Steuben Co.), Atwood (LaGrange Co.), Clear (Steuben Co.), and Olin (LaGrange Co.) lakes are the most similar to the current Cisco lakes and may be the most cost-effective opportunities for restoration[18]. However, water quality monitoring indicates that Atwood and Clear lakes do not contain sufficient cold-water habitat and would not be suitable for Cisco establishment unless substantial restoration is undertaken. Furthermore, reintroduction efforts at

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12 Frey, D.G. 1955. Distributional ecology of the Cisco Coregonus artedi in Indiana. Investigations of Indiana Lakes and Streams 4(7):177-228.

13 Pearson, J. 1986. Cisco Population Status, Harvest, and Brood Fish Collection at Crooked Lake. Indiana Department of Natural Resources, Division of Fish and Wildlife report. Indianapolis, IN.

14 Pearson, J. 2001. Cisco population status and management in Indiana. Indiana Department of Natural Resources, Division of Fish and Wildlife report. Indianapolis, IN. 23 pp.

15 Donabauer, S.B. 2012. Mid-summer oxy-thermal stress on cisco at Little Crooked Lake (Whitley Co.) Indiana Department of Natural Resources, Division of Fish and Wildlife report. Indianapolis, IN. 2 pp.

16 Linn, M.D. (In review). Crooked Lake (Noble and Whitley Counties) Supplemental Survey. Indiana Department of Natural Resources, Division of Fish and Wildlife report. Indianapolis, IN. 6 pp.

17 Indiana Division of Fish and Wildlife. 2015. Indiana State Wildlife Action Plan. Indiana Department of Natural Resources. Indianapolis, IN. 300 pp.

18 Honsey, A.E, S.B. Donabauer, and T.O. Höök. 2016. An analysis of lake morphometric and land use characteristics that promote persistence of Cisco in Indiana. Transactions of the American Fisheries Society 145:363-373.

Green Lake in the 1990's failed to re-establish a self-sustaining Cisco population. Lastly, the community structure of the Oliver, Olin, Martin chain of lakes is not an ideal candidate for reintroduction efforts considering Brown Trout (*Salmo trutta*) are currently stocked in the chain. There are however 14 glacial lakes where Cisco have never been detected, but sufficient late-summer cold-water habitat exists and introduction efforts should be considered.

Reintroduction and introduction efforts should also thoroughly review the genetic implications of potential Cisco stockings. Indiana Cisco populations have been in decline for decades creating populations that are now geographically and genetically isolated. Two separate studies have indicated that Indiana's inland Cisco populations are genetically isolated and unique[19,20]. Small isolated populations with restricted gene flow are more vulnerable to inbreeding depression and the resulting elevated extinction risk[21]. Reintroduction efforts from captive bred fish are also vulnerable to the effects outbreeding depression and founder effects[22]. Therefore, the selection of a Cisco brood stock population that is genetically suitable and production protocols that take into consideration conservation genetics will be necessary to ensure successful re-establishment.

In 2017, the status of Cisco in Indiana was reviewed by Indiana's Nongame Technical Advisory Committee, which recommended elevating Cisco from a *Species of Concern* to an *Endangered Species*. If Cisco are relisted as an *Endangered Species,* the DFW must work closely with conservation partners to encourage and incentivize the adoption of BMPs in Cisco catchments in order to sustain and restore Cisco abundance and distribution.

Table 2. – Number of lakes inhabited by Cisco in Indiana since 1955 by population classification (*C = common, R = rare, P = probably extirpated, E = extirpated, U = unknown status*).

Classification	1955	1975	1994	2001	2016
Common	28	13	7	7	7
Rare	14	14	5	6	1
Probably Extirpated	0	2	15	4	9
Extirpated	0	16	18	30	32
Unknown	7	4	4	2	0
Total	49	49	49	49	49

[19] John-Pike, K.A. 1999. Population differentiation and genetic variability in four allopatric Indiana cisco (Coregonus artedii) populations. Purdue University.

[20] Honsey, A.E. 2014. The decline of cisco Coregonus artedi at its southern range extent: Stock biology and management implications. Purdue University.

[21] Frankham, R. 2003. Genetics and conservation biology. C.R. Biologies. 326. S22-S29.

[22] Fave M. J. Turgeon. 2007. Patterns of genetic diversity in Great Lakes bloaters (Coregonus hoyi) with a view to future reintroduction in Lake Ontario. Conserv. Genet. 9(2):281-293.

Table 3. – Population status of Cisco in Indiana (*C = common, R = rare, P = probably extirpated, E = extirpated, U = unknown status*).

Lake	County	Acres	1955	1975	1994	2001	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

STRATEGIC PLAN

Population Goal: Maintain self-sustaining Cisco populations in Indiana.

Objective: Sustain a "common" population status among the remaining 7 lakes inhabited by Cisco.

- **Problem:** A monitoring program is needed to assess the naturally occurring abundance and distribution of Cisco and feasibility of introduction/reintroduction.
- **Strategies:**
  1. Design and conduct standardized gill netting surveys at glacial lakes currently inhabited by "common" and "rare" populations every 5 years.
- **Problem:** Cisco may persist at low population densities that are difficult to detect using traditional gill net surveys.
- **Strategies:**
  2. Evaluate the feasibility of using eDNA sampling methods to cost-effectively detect low-density Cisco populations.

Objective: Identify all suitable waterbodies for introduction/reintroduction stockings and establish three (3) self-sustaining Cisco populations.

- **Problem:** Cold-water habitat loss severely limits the number of suitable lakes for the establishment of Cisco populations. Additionally, previous reintroduction efforts at were deemed unsuccessful due to lack of reproduction from transported adults and poor recruitment from fry stockings[23,24].
- **Strategies:**
  3. Develop habitat monitoring guidelines to identify all lakes with suitable habitat and intensively monitor lakes prior to stockings to ensure the presence of continuous habitat for successful establishment.
  4. Explore the viability of non-traditional (e.g., excavated lakes) cold-water habitats that could serve as potential reservoirs of genetic diversity.
- **Problem:** There is uncertainty regarding the production methods necessary to establish self-sustaining Cisco populations, while maintaining the long-term viability of brood stock populations.
- **Strategies:**
  5. Examine the genetics of Cisco brood stock populations to maximize genetic diversity and reduce the influence of founder effects, inbreeding depression, and outbreeding depression on stocked lakes.
  6. Identify the minimum effective population size needed to establish self-sustaining Cisco populations.

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[23] Pearson, J. 1984. Failure to establish ciscoes in Gilbert Lake. Indiana Department of Natural Resources, Division of Fish and Wildlife report. Indianapolis, IN. 7 pp.

[24] Pearson, J. 1989. Cisco fry stocking failure at Gilbert Lake. Indiana Department of Natural Resources, Division of Fish and Wildlife report. Indianapolis, IN. 3 pp.

7. Update Cisco culture protocols as needed to produce a sufficient number of Cisco fingerlings to stock three (3) waterbodies[25].
8. Develop a monitoring and implement a program to evaluate recruitment, growth, and condition of stocked populations.

Human Dimensions Goal: Foster greater awareness of the plight of Cisco and the societal benefits of cold-water habitat preservation.

Objective: Provide educational material relevant to Cisco, cold-water habitat preservation, soil health, and water quality preservation to the catchment residents of all lakes classified as having "common" or "rare" populations of Cisco through Lake Associations and the five (5) respective county Soil and Water Conservation Districts.

- **Problem:** Residents of Cisco catchments have varied motivations for protecting soil and water resources.
- **Strategies:**
  9. Develop a targeted education and outreach campaign to protect and restore cold-water habitat that appeals to each unique demographic.
  10. Inform the public of factors detrimental to Cisco and of efforts to preserve cold-water habitat.

Objective: Quantify angling interest at Crooked Lake (Noble/Whitley Co.) and Lake Gage (Steuben Co.) where anglers currently target Cisco.

- **Problem:** Statewide interest in Cisco fishing is low, however local interest in Cisco fishing among "common" populations is unknown.
- **Strategies:**
  11. Develop and conduct creel surveys at Crooked Lake (Noble/Whitley Co.) and Lake Gage (Steuben Co.) to assess angler interest in Cisco.

Habitat Goal: Protect the cold-water habitat necessary to support Cisco populations.

Objective: Maintain a late-summer (August/September) cold-water habitat layer (minimum 1 foot layer containing $\leq 68°F$ and ≥ 3.0 mg/L dissolved oxygen) at all lakes that have a "common" or "rare" Cisco population status.

- **Problem:** Accelerated eutrophication is a threat to the sustainability of cold-water habitat and the lack of a habitat monitoring program limits the ability of managers to assess habitat sustainability.
- **Strategies:**
  12. Annually monitor cold-water habitat by conducting late-summer temperature and dissolved oxygen profiles among glacial lakes listed as having "common" and "rare" populations.

[25] Fischer, G.J, K.L. Holmes, and E.M. Wiermaa. 2018. Lake Herring (Coregonus artedii) Intensive Culture Manual. University of Wisconsin-Stevens Point. 42pp.

13. Forge partnerships with stakeholders to leverage funding to reduce nutrient loading among the Conservation Opportunity Areas identified for cold-water glacial lake habitats in the 2015 SWAP.
14. Develop and support policy or legislation that will:
    - Protect shoreline and riparian habitats.
    - Encourage vegetation control methods that prevent excessive nutrient recycling.
    - Reduce external and internal nutrient loading to cold-water lakes.

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PRIORITIZED STRATEGIES

DFW staff were provided the opportunity to prioritize strategies using a voting system. Each staff member was provided a total of five (5) votes which could be distributed amongst multiple strategies or as few as one (1) strategy. The table below ranks strategies from highest priority to lowest priority based on the cumulative number of votes received by DFW staff. The percentage of votes each strategy received of all available votes is provided for reference.

Priority Rank	Strategy #	Strategy	Percent (%)
1	13	Forge partnerships with stakeholders to leverage funding to reduce nutrient loading among the Conservation Opportunity Areas identified for cold-water glacial lake habitats in the 2015 SWAP.	27%
2	9	Develop a targeted education and outreach campaign to protect and restore cold-water habitat that appeals to each unique demographic.	16%
3	1	Design and conduct standardized gill netting surveys at glacial lakes currently inhabited by "common" and "rare" populations every 5 years.	11%
4	3	Develop habitat monitoring guidelines to identify all lakes with suitable habitat and intensively monitor lakes prior to stockings to ensure the presence of continuous habitat for successful establishment.	11%
5	14	Develop and support policy or legislation that will: protect shoreline and riparian habitats, encourage vegetation control methods that prevent excessive nutrient recycling, and educe external and internal nutrient loading to cold-water lakes.	11%
6	12	Annually monitor cold-water habitat by conducting late-summer temperature and dissolved oxygen profiles among glacial lakes listed as having "common" and "rare" populations.	9%
7	4	Explore the viability of non-traditional (e.g., excavated lakes) cold-water habitats that could serve as potential reservoirs of genetic diversity.	4%
8	2	Evaluate the feasibility of using eDNA sampling methods to cost-effectively detect low-density Cisco populations.	2%
9	5	Examine the genetics of Cisco brood stock populations to maximize genetic diversity and reduce the influence of founder effects, inbreeding depression, and outbreeding depression on stocked lakes.	2%
10	7	Update Cisco culture protocols as needed to produce a sufficient number of Cisco fingerlings to stock three (3) waterbodies.	2%
11	8	Develop a monitoring and implement a program to evaluate recruitment, growth, and condition of stocked populations.	2%
12	10	Inform the public of factors detrimental to Cisco and of efforts to preserve cold-water habitat.	2%
13	6	Identify the minimum effective population size needed to establish self-sustaining Cisco populations.	0%
14	11	Develop and conduct creel surveys at Crooked Lake (Noble/Whitley Co.) and Lake Gage (Steuben Co.) to assess angler interest in Cisco.	0%

PROGRAM ACTIONS (2015-present)

2015

- Cisco were detected at Crooked Lake (Noble/Whitley Co.) during a standard June Status & Trends fish community survey.

- State Wildlife Action Plan was completed and Conservation Opportunity Areas in northeastern Indiana were defined as 6 catchments (among 7 lakes) classified as having a "common" population status for Cisco.

2016

- Cisco were detected at Crooked Lake (Noble/Whitley Co.) during a standard June Status & Trends fish community survey.

2017

- Cisco were detected at Crooked Lake (Noble/Whitley Co.) during a standard June Status & Trends fish community survey.

- Cisco were detected at Lake Gage (Steuben Co.) during a spot check.

- Cisco eggs were successfully collected at Crooked Lake (Noble/Whitley Co.) in December using egg mats. Cisco eggs collected using this method were successfully hatched at the Purdue University aquaculture facility.

- Dead/dying Cisco were observed and collected during a period of oxy-thermal stress at Crooked Lake (Whitely Co.) in mid-October.

- Discussions proceed on developing a cross-divisional Cold-Water Lake Habitat team among DFW administrators; advisory and working group staff identified and project proposal written and disseminated.

- The 2017 Cisco assessment report was shared with the Aquatics Technical Advisory Committee; they recommended the DFW consider relisting Cisco from a *Species of Concern* to *Endangered* during the 2018-19 Administrative Rule revision process.

2018

- The Indiana Cold-Water Lake Habitat Initiative comprised of DFW staff was created to foster the protection of glacial lake cold-water habitat catchments.

- Presentations introducing the Indiana Cold-Water Lake Habitat Initiative were given at the 2018 Indiana Lakes Management Society Conference at Pokagon State Park and the 2018 Northeast Indiana Conservation Conversation on the campus of IPFW.

- Cisco were detected at Crooked Lake (Noble/Whitley Co.) during a standard June Status & Trends fish community survey.

- Late-summer cold-water habitat evaluations were completed at 14 glacial lakes.

- Provided Crooked Lake Cisco tissue samples to the Wisconsin Cooperative Fisheries Research Unit at the University of Wisconsin Stevens Point to evaluate genetic similarity to other great lakes Cisco populations.

- An Aquatic Vegetation Permit Biologist was hired to consolidate the permitting responsibilities formerly held by District Fisheries Biologist; the AVPB was briefed on cold-water lake classifications and the guidelines established for vegetation permitting among cold-water lakes.

SUMMARY REPORTS (2015-present)

Donabauer, S.B. 2015. Mid-summer oxy-thermal stress on Cisco at Little Crooked Lake (Whitley Co.). Indiana Department of Natural Resources, Division of Fish and Wildlife report. Indianapolis, IN. 2 pp.

Donabauer, S.B. 2015 .Crooked Lake (Noble/Whitley Co.) Cisco: Common. Indiana Department of Natural Resources, Division of Fish and Wildlife report. Indianapolis, IN. 4 pp.

Donabauer, S.B. 2015. Eve Lake (Lagrange Co.) Cisco: Common. Indiana Department of Natural Resources, Division of Fish and Wildlife report. Indianapolis, IN. 4 pp.

Donabauer, S.B. 2015. Failing Lake (Steuben Co.) Cisco: Common. Indiana Department of Natural Resources, Division of Fish and Wildlife report. Indianapolis, IN. 2 pp.

Donabauer, S.B. 2015. Gordy Lake (Noble Co.) Cisco: Probably Extirpated. Indiana Department of Natural Resources, Division of Fish and Wildlife report. Indianapolis, IN. 2 pp.

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APPENDIX A

Preference Calculation

The preference was calculated by using the top 3 fish species selected during 2016 Indiana Licensed Angler Survey (LAS).

% Preference = species LAS Top 3/total of all LAS top 3 %*100

% Cisco preference = 0.00005 / 230.47*100 = 0.00002%

From 2011 National Survey of Fishing, Hunting, and Wildlife Recreation- Indiana:

Anglers (inland) - 745,290

Days of fishing (inland) - 20,719,290

Total expenditures (all waters) - $671,840,000

Total expenditures (inland): $665,138,060 ((427,310,000+244,530,000)-6,701,940)

Trip related (All waters) - $427,310,000

Equipment and other (All waters) - $244,530,000

Lake Michigan Expenditures: $6,701,940

Average total expenditures per angler day- $32.10 ($665,138,060/20,719,000 angler days). This figure includes all inland expenditures. ($ used for our creels)

Economic value:

Total Fishing Trip Expenditures (Inland species)=$665,138,060

Species trip expenditures=% Species preference*$665,138,060 (total expenditures)

Cisco trip expenditures=0.00002*665,138,060=$13,303

APPENDIX B

Preference Calculation

See Appendix A.

From 2016 National Survey of Fishing, Hunting, and Wildlife Recreation- Indiana:
Anglers – 477,680

Economic Value:

Cisco licenses= Cisco preference*angler licenses
Cisco licenses=0.00002*477,680=10

State-wide License value = $4.6M Sport Fish Restoration grant+$1.53M DFW matching funds = $6.13M
Individual license value=477,680 licensed anglers/$6.13M=$25.67
Indiana Cisco license revenue =10*25.67=$245.24

Because Division of Law Enforcement receives roughly half of license revenue:
Net Cisco license revenue=Indiana Cisco license revenue*0.5
Net Cisco license revenue=$245.24*0.5=$122.6