



Environment and Natural Resources Trust Fund

2027 Request for Proposal

General Information

Proposal ID: 2027-226

Proposal Title: Understanding Cisco Dynamics Using Sentinel Lakes' Monitoring Data

Project Manager Information

Name: Lynn Waterhouse

Organization: U of MN - College of Food, Agricultural and Natural Resource Sciences

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Project Basic Information

Project Summary: Leverage Sentinel Lakes Program data to identify ecological conditions linked to changes in cisco abundance, growth rates, and mortality in four inland lakes to better inform management decisions.

ENRTF Funds Requested: \$280,000

Proposed Project Completion: December 31, 2029

LCCMR Funding Category: Small Projects (G)

Secondary Category: Fish and Wildlife (D)

Project Location

What is the best scale for describing where your work will take place?

Statewide

What is the best scale to describe the area impacted by your work?

Statewide

When will the work impact occur?

During the Project and In the Future

Narrative

Describe the opportunity or problem your proposal seeks to address. Include any relevant background information.

Cisco (*Coregonus artedii*), also known as tullibee or lake herring, are an ecologically and culturally important fish which require cold, oxygenated water and provide an energy-rich food source for piscivorous fish. Recruitment events (when large numbers of young survive to reproductive age) are sporadic and generate strong year classes that sustain cisco populations until the next major recruitment event, which may be several years later. Growth rates of cisco are enhanced by food (zooplankton) availability and sufficiently-oxygenated coldwater habitat. Drivers of cisco recruitment and growth are being investigated in large lakes and inland lakes, but are still not well-understood. While correlational studies have found many potential drivers of growth and recruitment, these relationships are difficult to identify and vary among lakes. We have an opportunity to explore the impacts of changing zooplankton prey and oxythermal habitat on year classes of cisco as they were monitored annually in a set of ecologically-distinct lakes through the Minnesota DNR Sentinel Lakes Program. For the first time in these study lakes, we will track cohorts of fish at a single-lake scale – linking fluctuations in population dynamics to changing ecological conditions.

What is your proposed solution to the problem or opportunity discussed above? Introduce us to the work you are seeking funding to do. You will be asked to expand on this proposed solution in Activities & Milestones.

We will track cohorts (year classes) of cisco in four inland lakes to understand the impact of ecological setting on major metrics of population dynamics: recruitment, growth, and mortality. We will leverage a decade of annual monitoring data collected from four of the Minnesota DNR Sentinel Lakes, including hydroacoustic data showing fish biomass, spatial distribution, and size distribution, plus gillnet data where age and length were determined for captured fish. We will re-analyze hydroacoustic data using length-at-age data to estimate the biomass and abundance of each cohort of cisco. Recruitment events will be documented as age-1 fish appear in the survey, and mortality rates will be calculated using the decrease in each cohort's abundance over time. Growth rates will be estimated from length and age data of captured fish.

We will relate annual growth and mortality rates to ecological conditions using a state-space model. Previous work in Minnesota's inland lakes has identified potential drivers of cisco population dynamics, especially zooplankton density and habitat availability. Overlaying time series of potential drivers with cisco population dynamics can provide insights into relationships. For example, after a summer with lower-than-average zooplankton and oxythermal habitat, we may observe decreased cisco growth and increased mortality.

What are the specific project outcomes as they relate to the public purpose of protection, conservation, preservation, and enhancement of the state's natural resources?

The primary project outcome is a quantitative understanding of the factors that drive cisco population dynamics in four inland lakes. Results from this project will inform conservation and sustainable management efforts by identifying the significant predictors of cisco growth, recruitment and mortality. Specific outcomes include: (1) estimates of biomass, growth, and mortality rates for cisco cohorts in four inland lakes (Carlos, Elk, Greenwood, and Ten Mile); (2) detailed understanding of how cisco biomass, growth, and mortality varies with ecological conditions; (3) integration of results with existing scientific findings for management; and (4) public webinars and outreach events communicating our findings.

Activities and Milestones

Activity 1: Estimate biomass, growth, and mortality for cisco cohorts

Activity Budget: \$97,803

Activity Description:

Here we will leverage multiple datasets collected by the Minnesota DNR (MNDNR) Sentinel Lakes Program for four inland lakes - Carlos, Elk, Greenwood and Ten Mile. We will re-analyze hydroacoustic and vertical gillnet data collected from 2013-2025 in each of the four lakes. For each lake, we will use the age and size structure of the cisco captured in gillnets to estimate biomass for each year class of fish, based on hydroacoustic backscatter. We will estimate annual growth and mortality rates by tracking cohorts of fish as they age, appearing in subsequent survey years.

The outputs of this activity are population dynamic rates which inform the next activity: linking these population dynamic rates to ecological conditions. This information has not been examined previously, as most studies use just one or a few years of data. We will provide the first cohort-tracking models that incorporate both hydroacoustic and vertical gillnet data throughout a decade in these four lakes. Model outputs will be evaluated statistically and assessed in relation to previous work in similar inland lakes.

Activity Milestones:

Description	Approximate Completion Date
Acquire cisco hydroacoustic and gillnet data provided by MNDNR Sentinel Lakes Program	August 31, 2027
Estimate lake-specific growth models from age and length data from gillnet surveys	October 31, 2027
Estimate biomass of each year class using hydroacoustic & gillnet data	April 30, 2028
Model mortality rates of cohorts of fish	October 31, 2028

Activity 2: Model relationships between cisco population dynamics and lake ecology

Activity Budget: \$99,745

Activity Description:

We will use time series-based models to link annual estimates of cisco growth and mortality to annual assessments of inland lakes' zooplankton, habitat, and other factors. First, we will compile the environmental monitoring data available from the MNDNR to create time series of ecological conditions for the four study lakes. We will draw on hypotheses from previous work to identify a set of ecological predictors of cisco population dynamics. Next, models will be created to link the time series of cisco abundance and population dynamics to the time series of ecological predictors. We will statistically investigate whether variation in ecological predictors is related to variation in cisco abundance and population dynamics, and which predictors affect which components of population dynamics. We can use variations in model structure to test assumptions about ecological similarity across lakes, and interactions between ecological predictors.

The major outputs of this activity are models which identify the most important ecological predictors of cisco population dynamics and quantify their impacts over time. This knowledge will be interpreted in light of projected changes in inland lakes to inform management strategies.

Activity Milestones:

Description	Approximate Completion Date
Compile time series of inland lake monitoring data (provided by MNDNR)	January 31, 2028
Model relationship between cisco biomass and predictors	December 31, 2028
Model relationship between cisco growth and predictors	March 31, 2029
Model relationship between cisco mortality and predictors	May 31, 2029

Activity 3: Disseminate results to public and scientific communities

Activity Budget: \$82,452

Activity Description:

The objective of this activity is to share outcomes of this work with diverse audiences. We will lead an outreach activity at the Bell Museum to inform the public about factors that contribute to cisco growth, mortality, and recruitment. We will also translate scientific findings for the general public through a presentation with Minnesota Sea Grant. Outreach to the public can build trust in research and increase understanding of complex ecosystems. Interactions with students during these events will increase knowledge of potential career paths, making quantitative fisheries science more accessible and relatable.

At least one manuscript will be prepared for submission to a peer-reviewed scientific journal to disseminate findings to the scientific community. We will also archive all code and reports generated during this project in an online repository that is freely accessible to the public. We will continuously communicate with scientists at the Minnesota DNR who manage the Sentinel Lakes Program and have collected the data used in our models. This communication will be extremely valuable in forming research questions and interpreting results of data analysis. These outputs will contribute to the scientific understanding of cisco in inland lakes, which impacts management and conservation in Minnesota.

Activity Milestones:

Description	Approximate Completion Date
Outreach event with Bell Museum	August 31, 2029
Presentations with MN Sea Grant and at scientific conferences	October 31, 2029
Submit manuscript	December 31, 2029
Archive data, code & reports	December 31, 2029
Ongoing communication with MNDNR	December 31, 2029

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
To Be Named	University of Minnesota	Postdoctoral research fellow	Yes

Dissemination

Describe your plans for dissemination, presentation, documentation, or sharing of data, results, samples, physical collections, and other products and how they will follow ENRTF Acknowledgement Requirements and Guidelines.

Information generated in this project will be shared widely with the public and relevant management agencies, in accordance with ENRTF Acknowledgement Requirements and Guidelines. We will acknowledge ENRTF in all project communications and outreach, including logos when possible. Public outreach activities will occur in partnership with the Bell Museum and Minnesota Sea Grant. This project will also generate peer-reviewed scientific publications, reports to MN DNR, and data and code which will include the recommended ENRTF attribution language. All dissemination materials, presentations, and publications will include acknowledgment of ENRTF funding following current guidelines. By combining data re-analysis of a large agency funded and collected dataset, community engagement, open-access resources, and public outreach, this plan ensures that project outcomes directly support improved conservation, management, and stewardship of Minnesota's aquatic ecosystems while making the work accessible to all Minnesotans.

Long-Term Implementation and Funding

Describe how the results will be implemented and how any ongoing effort will be funded. If not already addressed as part of the project, how will findings, results, and products developed be implemented after project completion? If additional work is needed, how will this work be funded?

We will collaborate with MN DNR to align our work with partner priorities and research needs as the project develops, so that results may be effectively incorporated into management and conservation decisions. At the conclusion of the project, we will share all approved data, code, and reports in a public repository hosted by the University of Minnesota. All data sharing will first be reviewed and approved by MN DNR. Peer-reviewed publication(s) will be published in an open-access format to disseminate findings to the scientific and wider community.

Other ENRTF Appropriations Awarded in the Last Six Years

Name	Appropriation	Amount Awarded
Predicting the Future by Understanding the Past	M.L. 2023, , Chp. 60, Art. 2, Sec. 2, Subd. 03g	\$170,000
Leveraging Statewide Datasets for Native Rough Fish	M.L. 2025, First Special Session, Chp. 1, Art. 2, Sec. 2, Subd. 03q	\$250,000

Project Manager and Organization Qualifications

Project Manager Name: Lynn Waterhouse

Job Title: Assistant Professor

Assistant Unit Leader, Fisheries - Minnesota Cooperative Fish and Wildlife Research Unit

Provide description of the project manager's qualifications to manage the proposed project.

Lynn Waterhouse is the Assistant Unit Leader in Fisheries at the Minnesota Cooperative Fish and Wildlife Research Unit (MNCFWRU) which is a USGS Cooperative Research Unit at the University of Minnesota (UMN). L. Waterhouse is also an Assistant Professor in the Department of Fisheries, Wildlife, and Conservation Biology at UMN. L. Waterhouse has a PhD

in Biological Oceanography and MS degrees in Fisheries Science and Statistics. L. Waterhouse joined UMN and MNCFWRU in June 2021. L. Waterhouse has experience working with and leading collaborative research projects. L. Waterhouse just concluded working on a large collaborative project assessing the growth of bigeye tuna in the Atlantic ocean with researchers from Europe, Africa, South America, and North America. Currently her lab has two main research focuses - developing and leveraging quantitative models to support healthy fish populations and developing environmental DNA tools to support healthy fish habitats. L. Waterhouse currently oversees 12 research projects through her lab at UMN and supervises 1 research scientist, 1 postdoctoral research fellow, 1 PhD student, and 3 MS students. As part of UMN, funds awarded to L. Waterhouse will go to UMN and have oversight from accounting people there (Kelsey Grachek, grach013@umn.edu). L. Waterhouse is able to bring in additional students and postdoctoral fellows through UMN Department of Fisheries, Wildlife, and Conservation Biology and graduate students in Water Resource Sciences, both of which are strong research programs. L. Waterhouse has training in science outreach. As part of her job with MNCFWRU, L. Waterhouse works closely with other scientists from Minnesota Department of Natural Resources (MNDNR), USGS, and the US Fish and Wildlife Services.

Organization: U of MN - College of Food, Agricultural and Natural Resource Sciences

Organization Description:

In the College of Food, Agricultural and Natural Resources Sciences (CFANS) we look at the bigger picture. We use science to find answers to the world's grand challenges and solve tomorrow's problems. The goal of CFANS is to advance Minnesota as a global leader in food, agriculture, and natural resources through extraordinary education, science-based solutions, and dynamic public engagement that nourishes people and enhances the environment in which we live. Few other public universities come close to the breadth of our expertise, allowing us to tackle challenges in novel ways. We develop leaders that see more possibilities and produce solutions that work for real people. This creates a powerful force for change. The university also hosts a cutting edge Minnesota Supercomputing Center which researchers use to tackle cutting edge problems. Twelve academic departments and 10 research and outreach centers make up our college, along with the Minnesota Landscape Arboretum, the Bell Museum, and dozens of interdisciplinary centers. The Department of Fisheries, Wildlife, and Conservation Biology has about 20 faculty, 40 staff, 60 graduate students, 200 undergraduates, 1200 alumni, and many friends; all working together to advance our knowledge of fisheries, wildlife, and conservation biology.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	\$ Amount
Personnel								
Postdoctoral research assistant		TBN- Post-doctoral researcher, fisheries scientist; (100% FTE, 2.5 years, at UMN) (fringe 26.1%) Year 1 salary \$69,000/yr, Year 2 3% increase to \$71,030/yr, Year 3 (half year) 3% increase to \$73,170/yr			26.1%	2.5		\$222,712
							Sub Total	\$222,712
Contracts and Services								
							Sub Total	-
Equipment, Tools, and Supplies								
	Tools and Supplies	external hard drives for backing up project	External hard drives to back up project data as part of sound scientific practices. Ensures data is not lost in event of computer failure.					\$1,145
	Tools and Supplies	materials for outreach at bell museum (fish models, timer buzzers, 3D sensory art model)	Materials for outreach event at Bell Museum of Science sharing project results and findings. Materials will continue to be used for outreach after project concludes.					\$500
							Sub Total	\$1,645
Capital Equipment								
		Echoview Analysis Suite – perpetual license and Echoview Maintenance and Technical Support	Software license for Echoview software which is the software used in analyzing hydroacoustics data. The software license is good for one computer and includes updates and support during the duration of the project.	X				\$35,000
							Sub Total	\$35,000

Acquisitions and Stewardship								
							Sub Total	-
Travel In Minnesota								
	Conference Registration Miles/ Meals/ Lodging	MN AFS February 2028. Using Duluth as placeholder from 2026 costs, with 5% increase per year. Registration (\$90/student \$255/professional = \$345). Hotel (\$159/night federal allowance plus 50% university allowance) x2 rooms x 2 nights (\$763.20). Mileage (330 miles x \$.725/mile = \$239.25). Per diem (\$64.50/per travel day x 2 days + \$86/day x 1 day x 2 people = \$430). 2026 cost: \$1968 for 2 people. 2028 projection: \$2170	Present work at MN AFS to share ongoing research progress and project results.					\$2,170
	Conference Registration Miles/ Meals/ Lodging	MN AFS February 2029. Using Duluth as placeholder from 2026 costs, with 5% increase per year. Registration (\$90/student \$255/professional = \$345). Hotel (\$159/night federal allowance plus 50% university allowance) x2 rooms x 2 nights (\$763.20). Mileage (330 miles x \$.725/mile = \$239.25). Per diem (\$64.50/per travel day x 2 days + \$86/day x 1 day x 2 people = \$430). 2026 cost: \$1968 for 2 people. 2029 projection: \$2278	Present work at MN AFS to share research findings and project results, organize symposium dedicated to eDNA methods.					\$2,278
	Miles/ Meals/ Lodging	Travel to Sentinel Lakes in summer 1. Mileage rate \$0.725/mile in 2026, avg. distance of 200 miles round trip, 20 trips	Travel to Sentinel lakes in summer 2027 to observe and participate in hydroacoustic surveys, gillnet surveys, and other surveys that result in similar data to that being used in this study. Necessary to observe surveys to appropriately address model assumptions.					\$2,900
	Miles/ Meals/ Lodging	Travel to Sentinel Lakes in summer 2. Mileage rate \$0.725/mile in 2026. avg. distance of 200 miles round trip, 20 trips	Travel to Sentinel lakes in summer 2028 to observe and participate in hydroacoustic surveys, gillnet surveys, and other surveys that result in similar data to that being used in this study. Necessary to observe surveys to appropriately address model assumptions.					\$2,900

	Miles/ Meals/ Lodging	Travel to meet with MN DNR. Mileage rate \$0.725/mile in 2026. Average trip 300 miles with \$220/night per diem hotel plus 50% UMN allowance and \$64.50 for days of travel per diem. 1 night, 2 day trips. add 5% for cost increase from 2026 for hotel and per diem. 2027 estimated per trip total is \$699.45. 9 trips total	Travel to meet with MN DNR throughout entire project. Meetings will focus on data exchange and discussion, sharing ongoing project results, and final project findings.					\$6,295
							Sub Total	\$16,543
Travel Outside Minnesota								
							Sub Total	-
Printing and Publication								
	Printing	Print materials for outreach event with Bell Museum of Science	Printed materials for outreach event at Bell Museum of Science sharing project results and findings. Materials will continue to be used for outreach events after project concludes.					\$300
							Sub Total	\$300
Other Expenses								
		non-capital: laptop and dual monitor setup for post-doc to analyze data and complete reports (laptop \$3,000 and dual monitors \$800)	Necessary computer equipment to complete stated project goals and objectives.	X				\$3,800
							Sub Total	\$3,800
							Grand Total	\$280,000

Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request
Capital Equipment		Echoview Analysis Suite – perpetual license and Echoview Maintenance and Technical Support	Necessary equipment to properly analyze hydroacoustic data, including running the Echoview software. Some of the data pipelines for processing hydroacoustic data take a long time to run so it is necessary to have a dedicated machine to ensure we can complete the work as written in this proposal. Additional Explanation : Necessary equipment to properly analyze hydroacoustic data, including running the Echoview software. Some of the data pipelines for processing hydroacoustic data take a long time to run so it is necessary to have a dedicated machine to ensure we can complete the work as written in this proposal. Additional Explanation : This software is necessary for analyzing hydroacoustic data and will continue to be used for processing hydroacoustic data for the entirety of the software's useful lifespan.
Other Expenses		non-capital: laptop and dual monitor setup for post-doc to analyze data and complete reports (laptop \$3,000 and dual monitors \$800)	Necessary computer equipment to properly analyze hydroacoustic data, including running the Echoview software. Some of the data pipelines for processing hydroacoustic data take a long time to run so it is necessary to have a dedicated machine to ensure we can complete the work as written in this proposal. Additional Explanation : This equipment is necessary for analyzing hydroacoustic data and will continue to be used for processing hydroacoustic data for the entirety of the computer's lifespan.

Non ENRTF Funds

Category	Specific Source	Use	Status	Amount
State				
			State Sub Total	-
Non-State				
Cash	Cash University of Minnesota unrecovered indirect cost return (54% MDTC, updated beginning July 2024)	\$280,000 direct total x .54 = \$151,199.77 unrecovered IDC If this award is reduced from the requested amount, the proposed cost sharing will be reduced proportionately.	Secured	\$151,200
			Non State Sub Total	\$151,200
			Funds Total	\$151,200

Total Project Cost: \$431,200

This amount accurately reflects total project cost?

Yes

Attachments

Required Attachments

Visual Component

File: [abf9fa48-3c5.pdf](#)

Alternate Text for Visual Component

Map of DNR Sentinel Lakes. Images of Cisco growing and plankton.

- Cisco are monitored annually in Minnesota inland lakes using nets & SONAR
- We will follow cohorts of fish through life in different environments
- Re-analyze survey data to estimate annual growth & mortality rates
- Determine relationships between cisco growth & mortality and time...

Supplemental Attachments

Capital Project Questionnaire, Budget Supplements, Support Letter, Photos, Media, Other

Title	File
UMN SPA Approval letter for submission	bf47527d-98f.pdf

Administrative Use

Does your project include restoration or acquisition of land rights?

No

Do you understand that travel expenses are only approved if they follow the "Commissioner's Plan" promulgated by the Commissioner of Management of Budget or, for University of Minnesota projects, the University of Minnesota plan?

Yes, I understand the UMN Policy on travel applies.

Does your project have potential for royalties, copyrights, patents, sale of products and assets, or revenue generation?

No

Do you understand and acknowledge IP and revenue-return and sharing requirements in 116P.10?

N/A

Do you wish to request reinvestment of any revenues into your project instead of returning revenue to the ENRTF?

N/A

Does your project include original, hypothesis-driven research?

Yes

Does the organization have a fiscal agent for this project?

Yes, Sponsored Projects Administration

Does your project include the pre-design, design, construction, or renovation of a building, trail, campground, or other fixed capital asset costing \$10,000 or more or large-scale stream or wetland restoration?

No

Do you propose using an appropriation from the Environment and Natural Resources Trust Fund to conduct a project that provides children's services (as defined in Minnesota Statutes section 299C.61 Subd.7 as "the provision of care,

treatment, education, training, instruction, or recreation to children")?

No

Provide the name(s) and organization(s) of additional individuals assisting in the completion of this proposal:

UMN SPA reviewed. Dept Head Review.

Do you understand that a named service contract does not constitute a funder-designated subrecipient or approval of a sole-source contract? In other words, a service contract entity is only approved if it has been selected according to the contracting rules identified in state law and policy for organizations that receive ENRTF funds through direct appropriations, or in the DNR's reimbursement manual for non-state organizations. These rules may include competitive bidding and prevailing wage requirements

N/A