



Environment and Natural Resources Trust Fund

2021 Request for Proposal

General Information

Proposal ID: 2021-023

Proposal Title: Larval Fishes as Indicators of Lake Ecosystem Change

Project Manager Information

Name: David Schumann

Organization: University of Wisconsin-La Crosse

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Project Basic Information

Project Summary: Land-use practices, invasive species, and climate change threaten fish populations and lakes throughout Minnesota. Focused assessments on larval fish can provide direct insight into complex ecological stressors affecting these systems.

Funds Requested: \$410,000

Proposed Project Completion: 2024-06-30

LCCMR Funding Category: Water Resources (B)

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.

Ecological stressors such as changing land-use practices, invasive species, and climate change threaten fish populations throughout Minnesota. By monitoring 'sentinel' systems for direct indicators of change, managers can promptly detect and respond to numerous physical, chemical and biological stressors. However, these efforts have to-date overlooked the early life stages of popular sportfish species. Larval fish communities are only impacted by ecological stressors (e.g., water temperature, zooplankton availability, water quality, and system productivity) and are not subject to angler impacts (i.e., no harvest), and as such provide a direct link to basin-based (e.g., land-use practices) and lake-level (e.g., invasive species) change. By understanding the variability associated with larval fish community structure and foraging behaviors, we can better understand how changing stressor gradients will influence fish survival and growth to harvestable sizes. This information can be utilized as direct indicators of lake ecosystem change by leveraging existing data (i.e., Sentinel Lakes Long-Term Ecological Monitoring Program).

The goal of this project is to understand how ecological stressors during the critical first year of life impact larval sportfish community structure and foraging behaviors in Minnesota Lakes.

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

Focused assessments of the larval fish communities and their zooplankton diets will:

- (1) Quantify the timing and relative abundances of native fish larval communities throughout the reproductive season (April – October 2022 and 2023)
- (2) Describe the feeding habitats of larval sportfish species to understand how system change influences their development and survival

Why larval fish? Changes to the larval fish community structure and the diets of developing sportfishes have large effects on survival during their first growing season. Larval fish are typically better ecological indicators than adult sportfish species, because they respond directly to ecological stressors in measurable ways. For example, changes to the zooplankton community caused by invasive species directly influence larval fish feeding habits and subsequently growth and survival, but these same changes would be undetectable if sampling only adult sportfish that no longer rely on zooplankton diets. Growth and survival during the larval lifestage define future harvestable sportfish abundances but diagnosing the reasons for failed adult year-classes and limited angling opportunities are difficult years after disturbance events. Furthermore, this critical life stage can be sampled using gears that facilitate the precise estimation of fish density and biomass, rather than indices of catch attained through traditional sportfish surveys.

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?

Detailed study of the larval lifestage can provide direct insight into the complex ecological stressors affecting Minnesota lakes statewide using Tier one Sentinel Lakes. The composition of larval fish communities and the timing of peak reproductive output are highly responsive to environmental disturbances; however, the response of larval fish to zooplankton communities, productivity, and climatic gradients common to Minnesota lakes is unknown. Additionally, the foraging behaviors and feeding habitats of larval fish can provide insight into the influence of invasive species, such as spiny water flea (*Bythotrephes longimanus*).

Activities and Milestones

Activity 1: Using the duration and relative abundances of native larval fish during the reproductive season to understand lake ecosystem change.

Activity Budget: \$190,515

Activity Description:

Larval fish in altered lake habitats are generally less resilient to seasonal change and disturbance events. The ability of fish to respond to environmental or biotic change depends on its reproductive success during or immediately following specific disturbances. In unaltered systems, fish utilize differing spawning cues and sometimes multiple spawning events to increase the likelihood that larvae abundance coincides with peaks in resource availability. Currently, the environmental and biotic drivers of larval community structure are largely unknown, likely due to the expertise needed for the sampling and identification. We will quantify the abundance and age structure of larval fishes during two reproductive seasons (2022 & 2023 year-classes) to understand the mechanisms that structure larval fish assemblages in Minnesota lakes. Larval fish will be captured using two specialized gears targeting pelagic (Bongo-style larval trawls) and littoral (quatrefoil light traps) habitats. Catch data will be paired with Sentinel Lakes sampling efforts across a gradient of environment conditions in eight Tier One lakes that represent a climatic gradient. By adding larval fish data to the Sentinel Lakes monitoring data, we will provide a robust description of the drivers of larval fish community structure that can be used to directly link environmental change to fish reproduction.

Activity Milestones:

| Description | Completion Date |
|---|-----------------|
| Visit potential study sites for preliminary sampling and student training | 2021-10-31 |
| Complete sampling season number one | 2022-10-31 |
| Complete sampling season number two | 2023-10-31 |
| Analysis of environmental and biotic drivers of larval fish population dynamics | 2024-01-31 |
| Final report to LCCMR and draft research publication | 2024-06-30 |

Activity 2: Describe the feeding habitats of larval sportfish species to better understand the variability associated with system change

Activity Budget: \$219,485

Activity Description:

Fish undergo several diet shifts during the first year of life as endogenous feeding from maternal sources diminishes and exogenous feeding on zooplankton, invertebrates, and fish prey begins. Each diet shift is facilitated by growth and generally occurs when predators are able to overcome size limitations of the larger, more energetically valuable prey sources. However, the mechanisms that control these diet shifts and the consequences of mis-matched prey availability from environmental change or invasive species establishment are not fully understood. Small differences in length may lead to differences in the timing of ontogenetic diet shifts and have population-level influence on the survival and growth of sportfish species. We will describe the variability of these ontogenetic diet shifts for several age-0 sportfish species (Walleye, Lake Trout, Yellow Perch, and Northern Pike) and important forage fish (e.g., Cisco) associated with environmental conditions, invasive species establishment, and differences in hatch dates. Sampling efforts will be standardized across a gradient of environment conditions at the same eight Minnesota lakes as activity #1.

Activity Milestones:

| Description | Completion Date |
|---|-----------------|
| Visit potential study sites for preliminary sampling and student training | 2021-10-31 |
| Complete sampling season number one | 2022-10-31 |
| Complete sampling season number two | 2023-10-31 |
| Analysis of age-0 sportfish diets and feeding habits | 2024-01-31 |
| Final report to LCCMR and draft research publication | 2024-06-30 |

Project Partners and Collaborators

| Name | Organization | Role | Receiving Funds |
|-----------------------|---|---|-----------------|
| Dr. Casey Schoenebeck | Minnesota Department of Natural Resources | Dr. Schoenebeck will inform site selection and help collect data associated with the Sentinel Lakes Program including continuous temperature and dissolved oxygen arrays. | No |
| Dr. Gretchen Hansen | University of Minnesota - Twin Cities | Dr. Hansen will oversee the sampling and analysis of proposed Activity #2 as described in the project narrative. | Yes |

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 be funded?

Focused assessments on larval fish can provide direct insight into complex ecological stressors that affect Minnesota lakes and facilitate projections of fish assemblage change in the future. By understanding the variability associated with larval fish communities and foraging behaviors, we can better understand how changing stressors will influence fish survival and growth to harvestable sizes. Ultimately, helping managers forecast the resiliency of fish species and assemblages to changes in seasonal water temperature, precipitation, and the spread of invasive species. If successful, this sampling regime could be incorporated into the routine sampling of The Sentinel Lakes Long-Term Ecological Monitoring Program.

Project Manager and Organization Qualifications

Project Manager Name: David Schumann

Job Title: Assistant Professor of Fisheries Ecology

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

Dr. Schumann has approximately 12 years of experience in aquatic ecology and the management of fisheries resources. He has published numerous peer-reviewed publications in the fisheries ecology and management disciplines and has overseen research that quantified the influence of environmental conditions on larval fish communities in the larger rivers of eastern South Dakota. Dr. Schumann has the specific expertise necessary to conduct larval fish sampling efforts and the knowledge base required to identify fish larvae. In addition, he has developed and/or has experience with quantitative tools (i.e., multi-species co-occurrence models, apriori algorithms) used to evaluate fish assemblage structure.

Organization: University of Wisconsin-La Crosse

Organization Description:

The University of Wisconsin-La Crosse (UWL) is one of eleven four-year, comprehensive campuses that focus primarily on educating undergraduate students within the University of Wisconsin System, which is ranked 13th in Reuters' Top 100: The World's Most Innovative Universities (2016). The UWL campus community's commitment to fostering faculty and student research is echoed by the College of Science & Health which provides several targeted funding programs annually. The Department of Biology employs a full-time academic department associate, who provides day-to-day administrative support for grant-funded work, including purchasing and paperwork processing. In addition to college and department resources, the PI's grant administration efforts are supported by a full-time grant accountant housed in the university's Business Services office, who oversees the fiscal administration and reporting for grants. The university's Office of Research & Sponsored Programs staff provides support for the PI's programmatic reporting, award

modifications, correspondence with the sponsor, research compliance, and navigating award administration. Overall, the scientific environment in which the proposed project will take place provides substantive support in terms of financial and physical resources, as well as a strong student research training environment.

Budget Summary

| Category / Name | Subcategory or Type | Description | Purpose | Gen. Ineligible | % Benefits | # FTE | Classified Staff? | \$ Amount |
|--|---------------------|---|---------|-----------------|------------|-------|-------------------|-----------|
| Personnel | | | | | | | | |
| Co-Principal Investigator | | Time spent overseeing and training graduate students and research technicians at the University of Wisconsin-La Crosse about standardized data collection, larval fish identification, and advising student researchers | | | 43.99% | 0.34 | | \$36,848 |
| Co-Principal Investigator | | Time spent overseeing and training graduate students and research technicians at the University of Minnesota about standardized data collection, larval fish identification, and diet analytical tools | | | 26.7% | 0.12 | | \$20,596 |
| Graduate student at UW-La Crosse (Stipend) | | Provide student ample time to successfully complete research program without financial concerns and need to work elsewhere. | | | 15.63% | 1.25 | | \$54,407 |
| Graduate student at UW-La Crosse (Tuition) | | Provide student ample time to focus on the research program with numerous opportunities to collect standardized data and utilize robust analyses. | | | 15.63% | 1.25 | | \$25,047 |
| Graduate student at University of Minnesota (tuition & stipend) | | Provide students ample time and education to successfully complete research program. | | | 46% | 1.25 | | \$123,019 |
| 2 undergraduate field and lab students at UW-La Crosse | | Assist with field data collection for zooplankton and larval fish sampling and measuring environmental conditions. Includes 2 people @\$10/hour for 40 hours/week for 15 weeks in both years 1 and 2 | | | 4.63% | 0.46 | | \$20,089 |
| Field and lab tech (10 hours per week) - University of Minnesota | | Assist with field data collection for zooplankton and larval fish sampling and measuring environmental conditions. Includes 1 person @\$15/hour for 10 hours/week for 15 weeks in both years 1 and 2 | | | 24.1% | 0.14 | | \$5,931 |
| Field and lab tech (40 hours | | Assist with field data collection for zooplankton and larval fish sampling and measuring environmental | | | 24.1% | 0.38 | | \$15,816 |

| | | | | | | | | | |
|---|--------------------------|---|--|--|--|--|--|----------------------|------------------|
| per week) - University of Minnesota | | conditions. Includes 1 person @\$15/hour for 40 hours/week each for 10 weeks in years 1 and 2. | | | | | | | |
| | | | | | | | | Sub Total | \$301,753 |
| Contracts and Services | | | | | | | | | |
| | | | | | | | | Sub Total | - |
| Equipment, Tools, and Supplies | | | | | | | | | |
| | Tools and Supplies | Sample processing and collection tools including ethanol, PPE, buckets, ziplock bags, jars, filters, trays, slides, mounting media, forceps, probes, paper, writing utensils, and ice. | Supplies required to collect, process, and quantify larval fish and zooplankton relative abundance, age structure, and fish diets.. | | | | | | \$10,000 |
| | Equipment | Nikon SMZ-1270 stereomicroscope, specialized Bongo style larval fish nets with flowmeters and cod-end accessory, zooplankton nets, flourometer and DO/temperature meters for measuring system productivity, and a saw to process fish otoliths for age estimation. | Would be used to identify and catalog larval fish samples | | | | | | \$25,367 |
| | | | | | | | | Sub Total | \$35,367 |
| Capital Expenditures | | | | | | | | | |
| | | | | | | | | Sub Total | - |
| Acquisitions and Stewardship | | | | | | | | | |
| | | | | | | | | Sub Total | - |
| Travel In Minnesota | | | | | | | | | |
| | Miles/ Meals/ Lodging | Bi-weekly travel eight (8) lakes from April - October 2022 & 2023 (14 sample events per lake per year), including fuel, lodging, and meals | This research requires repeated samples from each lake throughout the reproductive season to quantify larval fish communities and foraging behaviors through time. | | | | | | \$62,880 |

| | | | | | | | | |
|---------------------------------|---|---|--|--|--|--|--------------------|------------------|
| | | | | | | | Sub Total | \$62,880 |
| Travel Outside Minnesota | | | | | | | | |
| | Conference Registration Miles/ Meals/ Lodging | Travel for four to regional and national conferences to present research outcomes | Travel to present research outcomes to aquatic ecology community for feedback and utilization in other regions | | | | | \$7,000 |
| | | | | | | | Sub Total | \$7,000 |
| Printing and Publication | | | | | | | | |
| | Publication | Anticipated costs associated with publishing the research results in primary literature and popular outlets for dissemination | Broad dissemination of research results in both academic and popular publications | | | | | \$3,000 |
| | | | | | | | Sub Total | \$3,000 |
| Other Expenses | | | | | | | | |
| | | | | | | | Sub Total | - |
| | | | | | | | Grand Total | \$410,000 |

Classified Staff or Generally Ineligible Expenses

| Category/Name | Subcategory or Type | Description | Justification Ineligible Expense or Classified Staff Request |
|---------------|---------------------|-------------|--|
|---------------|---------------------|-------------|--|

Non ENRTF Funds

| Category | Specific Source | Use | Status | Amount |
|------------------|--|--|----------------------------|-----------------|
| State | | | | |
| Cash | Personnel: Dr. Casey Schoenebek, MN Department of Natural Resources (120 hours of support) | Collect data associated with the Sentinel Lakes Program including continuous temperature and dissolved oxygen arrays | Pending | \$5,200 |
| In-Kind | MN Department of Natural Resources - Boat use throughout the study duration for sampling zooplankton & larval fishes | Use of a boat for sampling activities at Sentinel Lakes. | Pending | - |
| | | | State Sub Total | \$5,200 |
| Non-State | | | | |
| In-Kind | Unrecovered indirect costs from the University of Wisconsin-La Crosse. 36% modified total direct costs (UWL's federal negotiated rate) | Unrecovered indirect funds | Secured | \$70,182 |
| | | | Non State Sub Total | \$70,182 |
| | | | Funds Total | \$75,382 |

Attachments

Required Attachments

Visual Component

File: [3e7545d7-624.pdf](#)

Alternate Text for Visual Component

The visual describes the lifecycle of a representative sportfish species in Minnesota, Walleye. It demonstrates how our proposed research will provide novel insight into the factors that affect survival of young individuals during two critical periods. This research will inform managers about the conditions that best support survival and growth to harvestable sizes. Proposed activity one would describe the duration and relative abundances of larval fish during the reproductive season, which will provide insight into how lake ecosystem change affects larval fish during the first critical period. Proposed activity two will describe the feeding habitats of larval sportfish to gain learn about the variability associated with lake system change during the second critical period.

Optional Attachments

Support Letter or Other

| Title | File |
|---------------------------------|----------------------------------|
| Submission Authorization Letter | f585f175-228.pdf |
| FY2018 Single Audit | a4c329db-0ac.pdf |
| Minnesota DNR Letter of Support | d8a5a502-9be.pdf |

Administrative Use

Does your project include restoration or acquisition of land rights?

No

Does your project have patent, royalties, or revenue potential?

No

Does your project include research?

Yes

Does the organization have a fiscal agent for this project?

No

SPORTFISH DEVELOPMENT

ADULT STAGE

Years of formative stressors and food habitats result in a relatively small number of individuals reach harvestable sizes



Critical period 1

YOLK-SAC STAGE

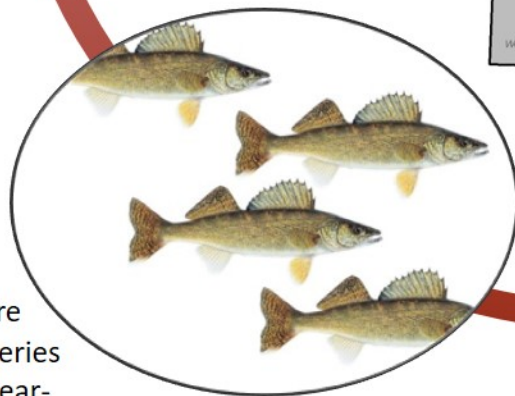
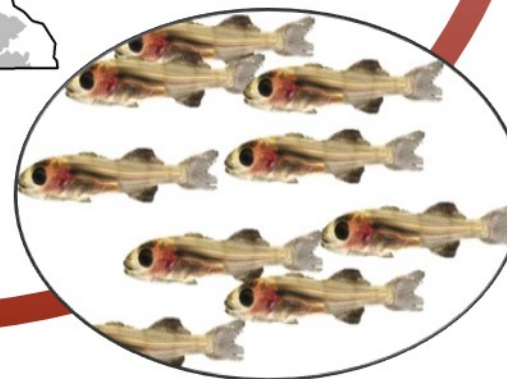
Survival of larval sportfish is only impacted by ecological stressors & land-use practices



Critical period 2

POST YOLK-SAC STAGE

The diets of larval sportfish have large effects on growth & survival during their first growing season



JUVENILE STAGE

It takes years before sportfish are susceptible to conventional fisheries gears so the reasons for failed year-classes & limited angling opportunities are hard to explain without sampling of larval fish

Activity #1: Using the duration and relative abundances of larval fish during the reproductive season, we will better understand lake ecosystem change during the first critical period

Activity #2: We will describe the feeding habitats of larval sportfish to gain new insight about the variability associated with lake system change during the second critical period

