Environment and Natural Resources Trust Fund

2021 Request for Proposal

General Information

Proposal ID: 2021-201

Proposal Title: Status of Bigmouth Buffalo Populations in Minnesota

Project Manager Information

Name: Mark Clark

Organization: U of MN - Duluth

Office Telephone: (218) 726-8358

Email: meclark@d.umn.edu

Project Basic Information

Project Summary: Bigmouth Buffalo from Minnesota are the most long-lived freshwater fish, but recruitment failure may occur in some drainages. We will complete a comprehensive assessment of populations in the state.

Funds Requested: $196,000

Proposed Project Completion: 2023-06-30

LCCMR Funding Category: Small Projects (H)

Secondary Category: Foundational Natural Resource Data and Information (A)

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?

In the Future

Narrative

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

Bigmouth Buffalo (Ictiobus cyprinellus), an iconic native fish of Minnesota, may face threats in significant portions of its historic range in Minnesota. Management of Bigmouth Buffalo populations previously relied on life history information suggesting this fish matures rapidly and has a short lifespan (Johnson 1963) like the White Sucker (Catostomus commersoni) (Thompson and Beckman 1995). However, recent findings indicate that Bigmouth Buffalo from Minnesota are the oldest freshwater teleost (with many individuals surviving over 90 years) and take more than five years to reach sexual maturity (Lackmann et al. 2019). We have since built on this evidence and found age and size distributions of Bigmouth Buffalo collected from Minnesota that indicate recruitment failure since the 1930s in populations from both the Red River of the North (henceforth Red River) and Upper Mississippi River basins (Fig. 1). Bigmouth Buffalo are a significant economic resource for Minnesota, supporting both a commercial fishery and a newly emerging recreational fishery in the state. Updated information on the reproductive success and lifespan of Buffalofish in Minnesota is necessary to ensure viable populations are sustained throughout the state.

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.

We will assess current recruitment, longevity and distribution of Bigmouth Buffalo populations in the Red, Minnesota, Upper and Lower Mississippi River basins in Minnesota. Historic range of Bigmouth Buffalo spans shallow lakes and rivers within the Red, Minnesota, Upper and Lower Mississippi River basins in Minnesota (Eddy and Underhill 1974). We will complete size-at-age analysis and size/age at maturity analysis on samples collected from at least three populations within each (i.e., Red, Minnesota, Upper Mississippi, Lower Mississippi) basin. We will analyze large-scale geographic patterns in recruitment in Bigmouth Buffalo populations across these basins using fisheries survey data collected by the Minnesota Department of Natural Resources (MN DNR) (Minnesota Department of Natural Resources 2020). Finally we will use the MN DNR fisheries survey data to estimate the current Bigmouth Buffalo distribution across the state.

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?

Outcome 1: We will produce a basin-wide recruitment map for Bigmouth Buffalo populations in Minnesota (July 2022).
Outcome 2: We will quantify demographic profiles (Age Distribution, Maturation Rate & Longevity) for populations in the Four (Red River of the North, Minnesota, Upper & Lower Mississippi) principal Minnesota basins inhabited by Bigmouth Buffalo (June 2023).
Outcome 3: We will provide a current distribution map, contrasted with the historical distribution map, for Bigmouth Buffalo in Minnesota (June 2023).

Activities and Milestones

Activity 1: Basin-Level Profile of Bigmouth Buffalo Recruitment

Activity Budget: $78,800

Activity Description:
We will develop basin-level profiles of recruitment by conducting catch-effort analysis of the MN DNR fisheries and lake survey data (Minnesota Department of Natural Resources 2020) for Bigmouth Buffalo. The MN DNR fisheries database provides standardized sampling information across the principal drainage basins in Minnesota, but has not been analyzed for Bigmouth Buffalo. We will analyze geographic layers for gradients in recruitment in the Red, Minnesota, Upper and Lower Mississippi River Basins. In particular we will analyze the database to determine if there are significant differences among basins in capture of young-of-the-year Bigmouth Buffalo, which would identify areas in which reproductive success is in decline.

Activity Milestones:

Description	Completion Date
Synthesize Bigmouth Buffalo capture data by size, year, site and effort for each basin.	2022-01-31
Complete catch-effort analysis of the Bigmouth Buffalo capture data synthesis; prepare GIS layers of recruitment.	2022-07-31
Prepare final draft of manuscript summarizing findings from catch-effort analysis and submit for publication.	2022-10-31

Activity 2: Demographic Traits for Representative Populations in Four Principal Basins where Bigmouth Buffalo Occur

Activity Budget: $76,920

Activity Description:
We will quantify size-at-age and reproductive investment-at-age profiles for 12 populations (three from the Red River basin, three from the Minnesota River basin, three from the Upper Mississippi basin and three from the Lower Mississippi basin). We will obtain fish samples from three locations within each major drainage basin in Spring prior to spawning. After obtaining size measurements, individual fish will be dissected to remove gonads and otoliths for determination of reproductive output and age. Gonad mass (and estimated fecundity and ova stage in females) will be used to model gonadosomatic index as a function of body size and age, and quantify age at maturation using logistic regression. Age estimates will be determined from compound microscope images of otolith thin sections (Campana et al. 2008). A subsample of 10 otoliths will be prepared for bomb-radiocarbon analysis to further document the radiocarbon reference chronology in Minnesota (Campana 2001).

Activity Milestones:

Description	Completion Date
Obtain Buffalofish from 12 locations and prepare samples for lab analysis.	2022-08-31
Complete age analysis from otolith samples, select otolith subsample for bomb radiocarbon validation.	2022-11-30
Complete age & maturation analysis, and complete bomb radiocarbon validation.	2023-02-28
Submit age & maturation analysis in manuscript for publication in peer review journal.	2023-06-30

Activity 3: Current Distribution Map for Bigmouth Buffalo in Minnesota

Activity Budget: $40,280

Activity Description:

We will use occupancy modeling to estimate the current distribution of Bigmouth Buffalo from temporal presence-absence data in the MN DNR fisheries and lake survey database. Occupancy models provide a statistical framework for quantifying the likelihood that a population persists using presence-absence data collected over long time periods and large geographic scales (MacKenzie 2006; MacKenzie et al. 2002). We will format the MN DNR fisheries database Bigmouth Buffalo catch data into a presence-absence format over time to develop a current map of the likely distribution of the species. We can then compare the change in distribution within river basins to highlight areas where range contraction is greatest to identify areas of special concern for the species.

Activity Milestones:

Description	Completion Date
Synthesize presence/absence data from fisheries database for statistical analysis.	2022-10-31
Complete presence/absence modeling analysis, begin distribution map development.	2023-02-28
Complete GIS layer of estimated current Bigmouth Buffalo distribution.	2023-06-30

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?

This project capitalizes on previous work by the MN DNR in establishing and maintaining the lake survey fisheries database. Our findings will be disseminated to MN DNR staff associated with aquatic habitat and species management.

Project Manager and Organization Qualifications

Project Manager Name: Mark Clark

Job Title: Professor

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

Mark Clark is a Professor in the Department of Biology at UMD, with research expertise in population biology. He has been a faculty member for over 18 years, advising 13 graduate students (3 Ph.D., 10 M.S.) and 1 postdoctoral fellow. His research projects have spanned a diverse array of vertebrates, including effects of timing of nesting on colonial waterbirds, life history variation in several fish species and waterborne parasite dynamics in small mammals. His work especially emphasizes the development of population models incorporating individual physiology and behavior (see https://sites.google.com/site/clarkreedecologylab/). Recent work from his lab highlights longevity in Bigmouth Buffalo, including changes in the immune function with age.

Organization: U of MN - Duluth

Organization Description:

The University of Minnesota Duluth is a highly-ranked regional research and liberal arts university with a global reputation for freshwater research. UMD students can choose from more than 93 undergraduate and post-baccalaureate degrees, and from graduate programs in more than 20 different fields. The Department of Biology lies within the Swenson College of Science and Engineering (SCSE), the largest college at UMD and the third largest in the University of Minnesota System. It currently has an enrollment of over 3,200 undergraduate and 200 graduate students. This research fits in with one of the grand challenges of the college, i.e. developing an international reputation in the nascent areas of materials science, water, sustainable energy and mining innovation.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Mark Clark, Professor		PI			0%	0.02		-
Alec Lackmann, Postdoctoral Research Associate		Co-PI			20.2%	2		$130,780
Undergraduate Research Assistants		Lab & Field Assistants			0%	2.5		$27,996
							Sub Total	**$158,776**
Contracts and Services								
TBD	Professional or Technical Service Contract	Radiocarbon analysis of otoliths. A subset of 10 otoliths will be prepared for bomb radiocarbon analysis for validation of age estimates. Preparation includes slide mount, micro milling and final radiocarbon analysis at Woods Hole Oceanographic Institute. Based on previous analysis we estimate the total cost of $804 per sample.				-		$8,120
							Sub Total	**$8,120**
Equipment, Tools, and Supplies								
	Tools and Supplies	Miscellaneous field supplies (e.g., waders, nets, scales, coolers, ice)	Various field supplies needed for surveying and collecting fish, dissection and transport of material for analysis at the lab.					$4,334
	Tools and Supplies	Miscellaneous lab supplies (e.g., storage vials, microscope slides, isomet blades, image analysis computer software)	Expendable items used to store samples in the lab, prepare samples for analysis and analyze otolith images for age determination.					$4,860

	Tools and Supplies	Buffalofish purchased from commercial harvesters	Sample sites in some basins will include populations subject to commercial harvest, and we will work purchase fish from commercial anglers in those instances. We anticipate approximately 2500 lbs purchased at $2 per pound					$5,000
							Sub Total	**$14,194**
Capital Expenditures								
							Sub Total	**-**
Acquisitions and Stewardship								
							Sub Total	**-**
Travel In Minnesota								
	Miles/ Meals/ Lodging	Trip to field sites (20 total). We assume 400 miles per trip @ $0.575 per mile, 2 hotel rooms per trip @ $98 per room, $55 per diem per person and 2 persons per trip. Twenty trips are estimated, to determine appropriate sites and ensure the capture of sufficient samples.	Trips to collect/survey Bigmouth Buffalo (Activity 2)					$11,820
							Sub Total	**$11,820**
Travel Outside Minnesota								
							Sub Total	**-**
Printing and Publication								
	Publication	2 Manuscripts for Scientific Journals	Dissemination of findings through peer-reviewed scientific journals					$3,090
							Sub Total	**$3,090**
Other Expenses								

							Sub Total	**-**
							Grand Total	**$196,000**

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				
In-Kind	Unrecovered F & A at 54%	Research	Secured	$107,800
			State Sub Total	**$107,800**
Non-State				
			Non State Sub Total	**-**
			Funds Total	**$107,800**

Attachments

Required Attachments

Visual Component

File: 4cd51da9-001.pdf

Alternate Text for Visual Component

Minnesota is the Land of 10,000 Lakes and Century-old fish. This file shows images of Bigmouth Buffalo, their habitat and appeal to anglers, but evidence that year classes have not been produced in more than 50 years in some Minnesota river basins. Bigmouth Buffalo from Minnesota are the oldest freshwater fish, and evidence indicates they have not successfully reproduced in large parts of the state since the 1930s and 1940s. These recent discoveries have upended the previous understanding of this species' biology and status. We will complete a comprehensive assessment of MN populations to identify which drainages have reproducing populations, the age at which individuals mature, and understand their size-structure so that resource managers can develop plans to maintain this iconic species and the fishery it supports.

Optional Attachments

Support Letter or Other

Title	File
References	4e871df7-c39.docx
Figure 1	d5a6913f-80a.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?

Yes, Sponsored Projects Administration

Minnesota: Land of 10,000 Lakes and Century-old Fish

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Year class distribution
(binned by 5-year intervals)