Montana Cooperative Fishery Research Unit

2022 Briefing Booklet

Coordinating Committee Meeting

13 April 2022, Bozeman, Montana

Statement of Direction

Research of the Montana Cooperative Fishery Research Unit will continue to focus on applied fisheries-management problems and issues. Our studies are initiated in response to the needs of the Cooperators and other management agencies and are designed to provide information useful in directly improving management of aquatic resources. Technical areas of special emphasis include habitat associations and requirements of fishes, large-river fish assemblages, native aquatic community restoration, effects of exotic fishes on native species, and regulated-river and reservoir fisheries. Other topics will be addressed as needed, in keeping with the Cooperative Research Program's mission to best meet the needs of the Cooperators by remaining flexible and open to new areas of inquiry, as exemplified by our current emphasis on prairie streams. When Cooperator's needs occur outside our areas of expertise, we will recruit the assistance of appropriate University faculty.

Unit staff will advance the training and education of graduate students in fisheries science at Montana State University by teaching up to one graduate-level course per year, chairing graduate committees of Unit students, and serving on graduate committees of non-Unit students. In-service training will be provided to Cooperators and other agencies as the need exists.

In Memoriam

Bradley B. Shepard

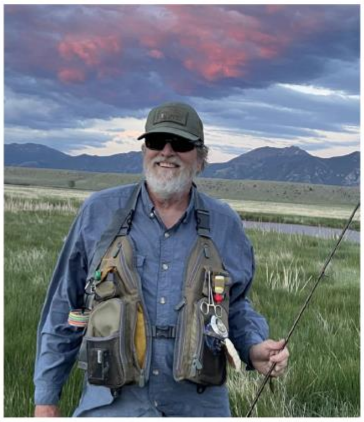
June 12, 1952 – September 23, 2021

Brad Shepard died suddenly and unexpectedly on September 23, 2021, while going fishing on his island on the Yellowstone River with his favorite fishing partner, his son Ben, by his side. Bradley Bernard Shepard was born June 12, 1952, in Dayton, Ohio. He found his passion very early in life; fishing with his grandfather at the age of 2 years. He headed west as soon as he was out of high school, settling in Bozeman, Montana. Shepard earned a BS in fish and wildlife management from Montana State University (MSU) in 1975, an MS in fisheries resources from the University of Idaho in 1981, and PhD in fish and wildlife biology from MSU in 2010.

Shepard was a legendary fisheries biologist who devoted his 40+ year career to research, management, and conservation of native fish in Montana and beyond. He worked as a fisheries biologist, manager, researcher, and professor, taking him from the largest Montana rivers with Bull Trout *Salvelinus confluentus* and sturgeon *Acipenser* spp., to the smallest mountain streams with Cutthroat Trout *Oncorhynchus clarkii* and Arctic Grayling *Thymallus arcticus*. He worked over 30 years as a fisheries biologist for Montana Fish, Wildlife, and Parks, 4 years as a senior aquatic scientist with the Wildlife Conservation Society, and 6 years as a private consultant and adjunct professor at MSU. Shepard contributed his time and expertise to numerous agencies, tribes, and conservation organizations throughout the western United States and Canada. He relished working with colleagues in the field where numerous fisheries projects were conceived through endless discussions while sampling fish or sitting around a campfire at night.

Shepard championed all native fish and habitat conservation, but there is no doubt that his tireless efforts working on issues facing Cutthroat Trout stand out as a career highlight. This work started in the mid 1980s on small populations in southwestern Montana, and by the early 1990s Shepard was guiding the development of a multilevel approach to conserve Cutthroat Trout in Montana and range-wide. Shepard was chair of a multiagency technical committee that developed guidelines for conservation and recovery efforts for native Cutthroat Trout in Montana that were adopted and carried out by state and federal agencies, tribes, and NGOs, as well as agricultural and timber industries. He led or assisted other biologists on conservation efforts that ranged from securing aboriginal Cutthroat Trout populations of fewer than 100 fish, to removing nonnative trout and introducing Westslope Cutthroat Trout *O. clarkii lewisi* into 60 miles of Cherry Creek. Shepard's research and conservation efforts helped in the development and implementation of dozens of completed and ongoing Cutthroat Trout projects in Montana and across the western USA in hundreds of stream miles and dozens of lakes. Cutthroat Trout have no better friend than Brad Shepard; he loved his "cuttie buddies."

Shepard had an insatiable curiosity, and a need to learn and make a difference, which translated into cutting-edge science, impactful management collaborations, mentorship of biologists young and old, and memorable fishing trips. He particularly enjoyed interacting with students and worked



closely with the Montana Cooperative Fishery Research Unit at MSU, where he exhibited boundless generosity and energy in helping, advising, and mentoring graduate students and technicians, most of whom are still carrying on his important work. Shepard had an enormous "biologist tree" and many of us are privileged to be branches on that tree—now the next generation will put down their roots in the shade of his legacy.

During his career, Shepard published a long list of papers on his research, many of which are considered seminal papers in fisheries science and native trout conservation. He was an active member of the American Fisheries Society, serving as President of the Montana Chapter in 1995, sharing numerous stimulating presentations at AFS meetings, earning the prestigious Career Achievement Award in 2009, and leading efforts to bring science to policy and management on many fish and habitat conservation issues across the West.

Shepard leaves his wife Mary Lennon of Livingston, Montana, and two children, Ben Shepard of Bozeman and Madison Shepard of Rohnert Park, California. AFS

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Graduate Students Advised by Unit Faculty

Ian Anderson	M.S.
Michelle Briggs	PH.D.
Colter Brown	M.S.
Kristen Cook	M.S.
Robert Eckelbecker	Ph.D.
Kaitlyn Furey	M.S.
Hayley Glassic	Ph.D.
Drew MacDonald	M.S.
Coltan Pipinich	M.S.
Keith Wellstone	M.S.

Graduate Students Advised by Cooperating Faculty

Cole Butler	M.S.	advised by Kathryn Plymesser
Nicole Daigle	Ph.D.	advised by Christine Verhille
Elisabeth Krieger	M.S.	advised by Jay Rotella

Graduate Students Receiving Degrees

Megan Conley (advised by Kathryn Plymesser) graduated with a M.S. in Civil Engineering and is pursuing a Ph.D. with Belize Lane at Utah State University.

Andrew Johnson (advised by Kathryn Plymesser) graduated with a M.S. in Civil Engineering and is working for DOWL as a Water Resources Designer/Engineer.

Madeline Lewis graduated with a M.S. in Fish and Wildlife Management and is pursuing a Ph.D. at Iowa State University.

Andriana Puchany graduated with a M.S. in Fish and Wildlife Management.

Mike Siemiantkowski graduated with a M.S. in Fish and Wildlife Management and is working for the Montana Cooperative Fishery Research Unit as a Research Assistant.

Research Technicians

Shane Barten	Abigail Feneis	Ciera Pitts
Nicole Daigle	Nate Heili	Andriana Puchany
Gavin Demorest	Olivia Jakabosky	Hilary Treanor
Addison Dove	Weston Neubauer	Nick Voss

Assess the recovery of Westslope Cutthroat Trout and Arctic Grayling in Yellowstone National Park restoration areas

Investigator
Alexander Zale
Unit Leader

Graduate Student
Andriana Puchany, M.S.

Collaborators
Todd Koel
Yellowstone National Park
Bradley Shepard
B. B. Shepard and Associates
Matthew Campbell
Idaho Fish and Game

Duration
August 2016 – May 2021
Completed

Funding
National Park Service
MSU index 4W6811

Restoration of native Westslope Cutthroat Trout *Oncorhynchus clarkii lewisi* and fluvial Arctic Grayling *Thymallus arcticus* in Yellowstone National Park is a high priority for fishery managers. Restoration of the East Fork Specimen Creek and Grayling Creek watersheds included construction of fish barriers to isolate watersheds, application of rotenone to eliminate nonnative and hybridized fish, and translocations of native fish. We sampled these watersheds in 2018 and 2019 to evaluate the success of restoration efforts by 1) estimating the stage of recovery achieved by translocated populations, 2) determining contributions of Westslope Cutthroat Trout donor sources to the translocated populations in the East Fork Specimen Creek watershed by investigating their genetic ancestries, and 3) making comparisons of recovery between the East Fork Specimen and Grayling Creek watersheds. Recovery of Westslope Cutthroat Trout in both watersheds is progressing, with expected differences in stage of recovery between the two watersheds attributable to a 5-year difference in restoration timelines. Conversely, recovery of Arctic Grayling in Grayling Creek appears improbable without management intervention, but the surprising documentation of naturally reproduced individuals engenders a hopeful future for continued Arctic Grayling recovery efforts. Interspecific hybrid introgression discovered in Westslope Cutthroat Trout populations in East Fork Specimen and Grayling creeks probably resulted from barrier failure or incomplete eradication of hybrid fish during rotenone treatments. Whereas all

Westslope Cutthroat Trout donor sources contributed to the recovering population in East Fork Specimen Creek, contributions were disproportionate to numbers translocated, indicating potential fitness differences among donor sources. Findings from this study have already helped Yellowstone National Park fishery managers make adaptive management decisions and will help inform future native fish conservation translocations.

Total Project Cost		$ 125,357.00
Beginning Balance – January 2021		3,513.54
Expenditures – January 2021 - May 2021		
Salaries and Benefits	2,990.23	
Contracted Services	0	
Supplies	0	
Communications	0	
Travel	0	
Rent	0	
Repairs and Maintenance	0	
Tuition	0	
IDCs @ 17.5%	523.31	
Total Spent		3,513.54
Balance		0
Waived IDCs		792.41

Efficacy of the nature-like fish bypass channel at Huntley Diversion Dam, Yellowstone River, Montana

Investigator
Alexander Zale
Unit Leader

Graduate Students
Ian Anderson, M.S.
Haley Tupen, M.S.
Andrew Johnson, M.S.

Duration
September 2018 – March 2022
Continuing

Collaborators
Mike Ruggles, Montana Fish, Wildlife and Parks
Kathryn Plymesser, Matt Blank, Joel Cahoon, MSU College of Engineering
Alicia Stickney, Douglas Martin, Montana NRDP, DOJ

Funding
Montana Natural Resource Damage Program, MT DOJ
MSU index 4W7438

We evaluated passage of a diverse fish assemblage through the nature-like fishway built around Huntley Diversion Dam, the uppermost of six low-head diversion dams on the Yellowstone River in Montana. Although nature-like fishways purportedly facilitate the passage of many species, relatively few have been evaluated, particularly on large rivers with unregulated discharge regimes. We examined seasonal and diel use of the Huntley fishway, quantified efficiencies and temporal metrics, and determined which factors influenced attraction and passage. We implanted > 3,500 fish of 14 species with passive integrated transponder tags, released most fish 250 m downstream of the fishway, and used stationary antennas to monitor movements of fish through the fishway in 2019 and 2020. Seasonal use of the fishway was generally associated with

pre-spawning movements and occurred from April to August annually, and diel use reflected the known biology of each species. Attraction efficiencies were apparently low (usually < 50%), probably because of low motivation or the inability of fish to locate the entrance. Suckers released on opposite riverbanks downstream of the fishway were similarly successful at locating the entrance. Entrance efficiencies were usually > 90%. Both transit and passage efficiencies were usually > 60%, but fewer individuals (particularly among certain species) successfully passed than were able to transit to near the fishway exit. High river discharges were associated with decreased passage success and increased exit delays, probably because of problematic hydraulic conditions near the exit. Conditions throughout the rest of the fishway were appropriate, as most fish transited to near the exit in < 1 h regardless of discharge. Fourteen species passed upstream, demonstrating the functionality of nature-like fishways on large, unregulated rivers. However, the placement of such fishways must be thoughtfully considered to ensure that they remain effective over a wide range of environmental conditions.

Total Project Cost		$ 157,429.00
Beginning Balance – January 2021		34,093.70
Expenditures – January 2021 - March 2022		
Salaries and Benefits	26,510.44	
Contracted Services	32.53	
Supplies	0	
Communications	0	
Travel	2,661.42	
Rent	0	
Repair & Maintenance	0	
Tuition	4,889.31	
Total Spent		34,093.70
Balance		0
Waived IDCs		15,001.23

Reproductive biology and phenology of Western Pearlshell mussels in Montana

Investigator
Alexander Zale
Unit Leader

Graduate Student
Kristen Cook, M.S.

Duration
May 2019 – May 2022
Continuing

Collaborators
David Stagliano, Montana Biological Survey
Michelle Anderson, University of Montana – Western
Lindsey Albertson, Chris Guy, MSU
Chris Barnhart, Missouri State University
Jim Moore, UC Davis

Funding
MT FWP State Wildlife Grants Program
U.S. Fish and Wildlife Service
SITKA Ecosystems
MSU index 4W8517

The Western Pearlshell mussel is the only native freshwater mussel inhabiting trout streams of western Montana; it has been designated a state Species of Concern because of declines in abundance and distribution. Conservation of Western Pearlshells in Montana will require fundamental information on their reproduction and life-history traits that is currently lacking. We therefore estimated the age and length at sexual maturity and incidence of hermaphroditism in mussels using histology. We determined the timing of reproductive events (spawning, brooding, embryogenesis, larval release, and larval infestation of hosts) and their relationship to temperature by collecting gonad and marsupium biopsies to identify gamete presence and embryo developmental stages, visually identifying brooding mussels, and examining captured fish for the presence of mussel larvae. We identified the hosts of Western Pearlshells in nature by quantifying the probability of infestation and larval abundances among salmonid species. Mussels reached sexual maturity at an estimated 34 mm in length and 11.5 years of age. Of 31 mature mussels examined histologically, all but one were gonadal hermaphrodites. The reproductive phenology of Montana Western Pearlshells differed among populations and years. Mussel populations brooded for about 24 to 39 days in May and June. Embryogenesis was synchronous among individuals in all populations except one and was about two to three weeks in duration. The larval infestation period generally

occurred in June and July and was about 47 to 71 days in duration. Juvenile mussels started excysting from hosts after growing > 400% in length. Gonadal recrudescence was rapid whereby mussels possessed mature or nearly mature gametes by early autumn. Photoperiod may have a larger role in Western Pearlshell reproductive events than temperature, though minimal threshold temperatures may have influenced the timing of spawning. Native Westslope Cutthroat Trout and nonnative Brook Trout were the primary hosts. Nonnative Brown Trout appeared to be a secondary host in the Flint-Rock watershed. Nonnative Rainbow Trout and native Mountain Whitefish were least likely to be infested with mussel larvae. Our findings will inform future conservation and propagation efforts of Western Pearlshells in Montana.

Total Project Cost, SITKA		$ 2,100.00
Beginning Balance – January 2021		581.98
Expenditures – January 2021 - December 2021		
Salaries and Benefits	0	
Contracted Services	0	
Supplies	156.74	
Communications	0	
Travel	425.24	
Rent	0	
Repair & Maintenance	0	
Tuition	0	
Total Spent		581.98
Balance		0
Waived IDCs		256.08

Evaluation of the management actions taken in the Lamar River watershed

Investigator
Alexander Zale
Unit Leader

Collaborators
Todd Koel, Brian Ertel
Yellowstone National Park

Graduate Student
Keith Wellstone, M.S.

Funding
National Park Service, CESU
MSU index 4W8476

Duration
August 2020 – December 2023
Continuing

Hybridization between native Cutthroat Trout and introduced Rainbow Trout is pervasive throughout western North America. Cutthroat and Rainbow trout are closely related and often exhibit geographic and temporal reproductive overlap, facilitating hybridization between the two species. This hybridization has resulted in the loss of locally adapted gene complexes and genetic diversity, reduced fitness, altered life-history expression and growth rates, and, in some cases, the genomic extinction of native Cutthroat Trout subspecies. The Yellowstone Cutthroat Trout, a subspecies of Cutthroat Trout native to the intermountain West, is threatened by climate change, habitat fragmentation and degradation, and invasive species introductions. The most recent range-wide assessment of this subspecies suggests it currently occupies 43% of its native range, with only 23% of its native range occupied by non-hybridized populations. The Lamar River watershed, in Yellowstone National Park, is a large, fluvially-connected river system that was once considered a stronghold for native, genetically unaltered Yellowstone Cutthroat Trout. Despite the federally protected status of aquatic habitats in this watershed, Yellowstone Cutthroat Trout populations are threatened by predation and displacement by hybridization with nonnative Rainbow Trout. In the early 1900s, the National Park Service intentionally stocked Rainbow Trout in the Lamar River watershed to diversify sportfishing opportunities. Though these stocking efforts ceased nearly a century ago, legacy populations still exist in waters where these fish were introduced, and they continue to invade, hybridizing with native Yellowstone Cutthroat Trout. Hybrids are now abundant in the lower Lamar River watershed, and, because of the fluvial connectivity of the system, appear to be invading the upper watershed. To mitigate the threat of hybridization in the Lamar River watershed, the National Park Service has acted to

remove Rainbow Trout and hybrids and block the upstream movement of these nonnative taxa into the upper watershed. While the National Park Service is taking actions to remove Rainbow Trout and hybrids from the Lamar River watershed, a standardized monitoring protocol is desired to assess the response of fish populations to these management actions and to monitor existing populations of Yellowstone Cutthroat Trout. We are implementing and comparing multiple monitoring designs and sampling methods (snorkeling, electrofishing, angling) to inform long-term monitoring of Yellowstone Cutthroat, Rainbow, and hybrid trout abundances in the middle and lower Lamar River watershed.

Total Project Cost		$ 137,130.00
Beginning Balance – January 2021		6,188.60
Additional Funding – 2021		118,010.00
Expenditures – January 2021 - December 2021		
Salaries and Benefits	31,540.22	
Contracted Services	0	
Supplies	5,030.71	
Communications	38.34	
Travel	3,876.04	
Rent	3,250.00	
Repairs and Maintenance	5.59	
Tuition	4,131.66	
IDCs @ 17.5%	7,094.67	
Total Spent		54,967.23
Balance		69,231.37
Waived IDCs		12,686.23

An evaluation of the genetic structure and movement of Brown Trout in the upper Missouri River in relation to habitat fragmentation by Toston Dam

Investigator
Alexander Zale
Unit Leader

Graduate Student
Coltan Pipinich, M.S.

Collaborators
Ron Spoon, Mike Duncan, Ryan Kovach, Montana Fish, Wildlife and Parks

Funding
Montana Fish, Wildlife and Parks

Duration
August 2021 – August 2024
New

Brown Trout play an important role in the sport fisheries of southwest Montana. As a top game species, preservation of abundant Brown Trout populations is a high priority for fishery managers. A declining population of Brown Trout in the Upper Missouri River has prompted an evaluation of habitat fragmentation effects on this important sport fish. A 69-km reach of the Upper Missouri River between its headwaters and Canyon Ferry Reservoir, is home to Toston Dam. This concrete gravity overflow dam allows for no upstream fish passage, and minimal downstream passage. Whereas the dam plays a vital role in halting upstream expansion of non-native species, Brown Trout are potentially vulnerable to effects of resulting habitat fragmentation. Altered mainstem river habitat makes access to the associated tributaries important, and it is thought that Sixteenmile Creek (upstream of Toston Dam) is a historically important recruitment source for Brown Trout in the river.

Biologists have been concerned with the decline in abundance of Brown Trout in this reach of the Upper Missouri River since the early 1990s. To improve management practices that could improve the fishery, we will identify the effects of habitat fragmentation on the genetic structure and movement of fish from the population. Genetic variation and natal origins will be defined by characterizing the genetic structure

of the population in conjunction with otolith microchemistry analysis. Movement of individual fish will be tracked using radio telemetry. This research will lead to a greater understanding of the effects of fragmentation by Toston Dam on this Brown Trout population and help decide whether action should be taken to force the migratory life history back into areas above the dam.

Developing small-scale Denil fishways for use in headwater streams

Investigators

Matt Blank, Joel Cahoon, Kathryn Plymesser, MSU College of Engineering
Kevin Kappenman
U.S. Fish and Wildlife Service

Graduate Student

Megan Conley, M.S.
Cole Butler, M.S.

Collaborator

Alexander Zale
Unit Leader

Funding

U.S. Geological Survey RWO 76
MSU index 4W7973

Duration

September 2019 – August 2022
Continuing

The Arctic Grayling (*Thymallus arcticus*) is a species of special concern in Montana. It inhabits several drainages and lakes in southwest Montana, including the Big Hole River and Centennial Valley. These populations are the only remaining native Arctic Grayling in the lower 48 states. Westslope Cutthroat Trout (*Oncorhynchus clarkii lewisi*) are also a species of special concern in Montana. They reside in streams west of the Continental Divide in Montana, as well as in the upper Missouri River drainage. Hydraulic structures such as irrigation diversions are common to river systems in southwest Montana. They are essential for providing water for agriculture but can be barriers to grayling and other fish. For over two decades, Montana Fish, Wildlife and Parks, the Montana Department of Natural Resources and Conservation, the Natural Resources Conservation Service, the United States Fish and Wildlife Service, local ranchers, and others have worked to balance agricultural needs with the conservation of native fish, rivers, and streams. This partnership is a model for how conservation and agriculture can be blended to maintain and ideally improve both.

Denil fishways have been installed in irrigation diversions throughout the Big Hole River watershed to provide fish passage, with more structures planned in this watershed and others. They are either included as part of the standard design and installation for new diversions or are installed as a retrofit to existing diversions. The Denils are “simple” type in their configuration in terms of baffle size, shape, and spacing. They are made of steel, are 2 ft by 2 ft in cross section, and are either 6 ft or 12 ft in length. They are typically installed into the pin and plank portion of the diversion with a total vertical drop of 1 ft, regardless of length. When water is in high demand by agriculture during the summer months, these Denils can be partially or completely blocked to make more water available for irrigation, but such blockages impede fish movements. This study was developed to test smaller “scaled” Denils that would require less water for operation. The study took place at the Bozeman Fish Technology Center in its new outdoor flume using a 0.6-scale Denil (scaling based on the Standard Denil dimensions). Age-1 Arctic Grayling were tested in eight unique headwater and tailwater combinations to understand passage of the species through a smaller fishway. The grayling showed high passage percentages in all scenarios except those with the largest difference between headwater and tailwater depths (high headwater and low tailwater). Grayling preferred to pass this Denil at night, a point that was already noted in field studies but had not been tested in a lab setting to date. Our results are promising for irrigators and land managers due to the lower flow rates required to pass adequate fish numbers when implementing a smaller scale Denil. Additional lab trials will be completed on the same Denil scale using Cutthroat Trout in hopes that other fish found in the Big Hole watershed show as high of passage percentages as the grayling.

Total Project Cost		$ 99,955.00
Beginning Balance – January 2021		29,819.96
Expenditures – January 2021 - December 2021		
Salaries and Benefits	16,265.17	
Contracted Services	0	
Supplies	1,582.32	
Travel	275.60	
Tuition	4,197.19	
IDCs @ 15%	2,718.45	
Total Spent		25,038.73
Balance		4,781.23
Waived IDCs		6,472.89

Lake Trout suppression and the ecological consequences in Yellowstone Lake

Investigator
Christopher Guy
Assistant Unit Leader

Collaborator
Todd Koel
Yellowstone National Park

Graduate Student
Hayley Glassic, Ph.D.

Funding
National Park Service
MSU index 4W6204
USGS RWO 78
MSU index 4W7971

Duration
September 2016 – December 2022
Continuing

Invasive species introductions cause reductions in populations of native species and are associated with negative environmental and economic effects. Suppression techniques including chemical, mechanical, and biological controls are commonly used to manage invasive species. Understanding the ecosystem-level influence of suppression techniques selected by natural resource agencies is essential for establishment of successful mitigation against invasive species and assisting native populations in an altered ecosystem. Invasive Lake Trout within Yellowstone Lake, Yellowstone National Park, Wyoming, have greatly reduced the abundance of native Yellowstone Cutthroat Trout and disrupted the ecosystem through food-web alteration. The National Park Service gillnets juvenile and adult Lake Trout, and a portion of the Lake Trout carcasses collected are subsequently placed on Lake Trout spawning sites to suppress embryo development. The novel concentration of nutrients from Lake Trout carcasses could further influence the adult stages of Lake Trout and Yellowstone Cutthroat Trout by providing concentrated areas of prey not historically available. We will determine if carcass material is changing the diets of fishes in Yellowstone Lake and the trophic structure of the food web using diet and stable isotope analysis. We collected diets from 1,025 fish in Yellowstone Lake and tissue from 359 individual fish during the 2018 field season and 212 diets and tissue samples from fish during 2019 field season.

We analyzed 182 Yellowstone cutthroat trout and the main diet items were amphipods and cladocerans. Amphipods made up more than 0.75 of the diet by proportion by weight of Yellowstone Cutthroat Trout in all length classes. We analyzed 204 Lake Trout and the main diet items for Lake Trout > 300 mm were amphipods and Yellowstone Cutthroat Trout. Amphipods made up 0.45 (0.32 – 0.59 CI; credible interval) of diet weight of the 301 – 475 mm length class and Yellowstone Cutthroat Trout made up 0.20 (0.08 – 0.32 CI) of diet by weight, indicating that piscivory by Lake Trout on Yellowstone Cutthroat Trout begins when Lake Trout are 301 – 475 mm.

Yellowstone Cutthroat Trout and Lake Trout currently occupy different trophic space, based on stable isotope analysis. Values of $\delta^{13}C$ varied from –27.40‰ to –13.90‰ for Yellowstone Cutthroat Trout and from –27.60‰ to –14.00‰ for Lake Trout. Values of $\delta^{15}N$ varied from 4.80‰ to 8.60‰ for Yellowstone Cutthroat Trout and from 4.90‰ to 10.10‰ for Lake Trout. Based on stable isotope analysis, we have no evidence to suggest that carcass nutrients can be detected in the food web.

We used an ecosystem-based model (Ecopath with Ecosim) to determine if the Yellowstone Cutthroat Trout population will reach established conservation benchmarks, given available suppression resources, complex predator-prey dynamics, disease, and a changing climate. By using a whole-ecosystem model that accounted for whirling disease and drought, we showed that lake trout suppression effort could be reduced up to 50% from 2018 levels, saving US$1.4 million in yearly suppression costs, and still elicit recovery in Yellowstone cutthroat trout during historical climate conditions. However, if climate change increases drought conditions, Yellowstone cutthroat trout may never reach previously established recovery benchmarks, highlighting the need for adaptive conservation benchmarks and inclusion of climate in conservation decisions. With this research, we demonstrate how the feedbacks among predator-prey dynamics, disease, and drought can complicate the suppression of invasive species and the conservation of invaded ecosystems and must be concurrently considered for establishing realistic conservation benchmarks.

Total Project Cost: 4W6204		$ 183,300.00
Beginning Balance – January 2021		6,365.10
Expenditures – January 2021 - August 2021		
Salaries and Benefits	4,229.00	
Contracted Services	0	
Supplies	156.74	
Communications	0	
Travel	24.66	
Tuition	1,006.72	
IDCs @ 17.5%	947.98	
Total Spent		6,365.10
Balance		0
Waived IDCs		1,435.54

Total Project Cost: 4W7971		$ 154,974.00
Beginning Balance – January 2021		90,870.69
Additional Funding -- 2021		61,467.00
Expenditures – January 2021 - December 2021		
Salaries and Benefits	49,913.37	
Supplies	2,794.70	
Communications	7.75	
Travel	0	
Tuition	8,036.98	
IDCs @ 15%	7,907.37	
Total Spent		68,660.17
Balance		83,677.52
Waived IDCs		17,618.32

Density and distribution of juvenile Lake Trout in Yellowstone Lake

Investigator
Christopher Guy
Assistant Unit Leader

Collaborator
Todd Koel
Yellowstone National Park

Graduate Student
Drew MacDonald, M.S.

Funding
National Park Service
MSU index 4W8429

Duration
August 2020 – December 2023
Continuing

Invasive Lake Trout in Yellowstone Lake, Yellowstone National Park, Wyoming, are causing the decline of Yellowstone Cutthroat Trout and inducing a trophic cascade. Invasive species are commonly managed by means of chemical, mechanical, or biological control. In Yellowstone Lake, the main method for Lake Trout control is gillnetting. Recently, embryo suppression techniques have been evaluated using carcass material and carcass analog pellets. Both methods have caused near 100% embryo mortality in experiments conducted at Lake Trout spawning sites. Embryo suppression sites are currently prioritized by Lake Trout catch from gillnets and concurrent telemetry on Yellowstone Lake. Identification and prioritization of spawning sites are crucial to the success of embryo suppression efforts. Trawls are used in the Laurentian Great Lakes to locate Lake Trout spawning sites and to target juvenile Lake Trout to measure density, locate successful spawning sites, and assess body condition. Trawling has not been conducted in Yellowstone Lake and would add to our understanding of Lake Trout early life history. In addition to trawling, small-mesh gill nets will be used to provide additional data on the spatial distribution of juvenile lake trout in Yellowstone Lake. Our study will evaluate the distribution, density, hatch date, and diet of juvenile Lake Trout (< age 2). The data from this study will be used to prioritize suppression efforts within Yellowstone Lake.

Total Project Cost		$ 137,130.00
Beginning Balance – January 2021		10,214.04
Additional Funding --2021		120,949.00
Expenditures – January 2021 - December 2021		
Salaries and Benefits	34,339.55	
Contracted Services	432.54	
Supplies	1,976.40	
Communications	0	
Travel	2,571.43	
Rent	0	
Repairs and Maintenance	0	
Tuition	4,110.56	
IDCs @ 17.5%	6,880.99	
Total Spent		50,311.47
Balance		80,851.57
Waived IDCs		11,509.08

Investigating the current status of Yellowstone Cutthroat Trout in Yellowstone Lake to improve management and update recovery benchmarks

Investigator
Christopher Guy
Assistant Unit Leader

Collaborator
Todd Koel
Yellowstone National Park

Graduate Student
Michelle Briggs, Ph.D.

Funding
National Park Service
MSU index 4W9143

Duration
June 2021 – December 2024
New, approved

Yellowstone cutthroat trout (*Oncorhynchus clarkii bouvieri*) in Yellowstone Lake occupy protected habitat and represent the largest remaining genetically unaltered population of Yellowstone cutthroat trout, making this population of highest conservation importance. However, the population of Yellowstone cutthroat trout in Yellowstone Lake is threatened by the presence of invasive lake trout (*Salvelinus namaycush*), increasing drought conditions, and whirling disease, caused by the parasite *Myxobolus cerebralis*. Yellowstone cutthroat trout are an important prey item for numerous terrestrial and avian predators, and reductions in the Yellowstone cutthroat trout population due to these threats have had far-reaching consequences throughout the Yellowstone Lake ecosystem. The Yellowstone cutthroat trout population is recovering due to intensive efforts by the National Park Service to suppress invasive lake trout by gillnetting. Despite extensive efforts to conserve Yellowstone cutthroat trout in Yellowstone Lake, the current status of the population and its recovery progress remains understudied. Recovery benchmarks for the Yellowstone Lake population of Yellowstone cutthroat trout are based on population metrics from the 1980s, before lake trout invasion, and may be unrealistic given the persistence of lake trout in the system. Additional research is required to update recovery benchmarks and guide the conservation and management of Yellowstone cutthroat trout in Yellowstone Lake. The specific objectives of this research are to: 1) estimate abundance of adult Yellowstone cutthroat trout and examine trends in population size, size structure, and age structure; 2) to use an age-structured population model to evaluate the recovery of the Yellowstone cutthroat trout population from ; 3) use eDNA to determine which tributaries to

Yellowstone Lake are currently used for spawning by Yellowstone cutthroat trout, and make comparisons to historical use; and 4) to investigate genetic diversity of the Yellowstone cutthroat trout population in Yellowstone Lake, determine if spawning populations are genetically distinct, and investigate the spawning tributaries that contribute the most to the population.

Total Project Cost		$ 39,780.00
Beginning Balance – January 2021		39,780.00
Additional Funding --2021		0
Expenditures – January 2021 - December 2021		
Salaries and Benefits	8,369.49	
Contracted Services	0	
Supplies	2,161.73	
Communications	0	
Travel	240.00	
Rent	0	
Repairs and Maintenance	0	
Tuition	2,027.84	
IDCs @ 17.5%	1,884.98	
Total Spent		14,684.04
Balance		25,095.96
Waived IDCs		3,891.27

Lake Trout telemetry, Swan Lake, Montana

Investigators
Christopher Guy
Assistant Unit Leader

Collaborators
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Creston Fish and Wildlife Center

Graduate Student
Mike Siemiantkowski, M.S.

Funding
US Fish Wildlife Service
CESU MSU index 4W7111

Duration
February 2018 – January 2022
Completed

Expansion of an invasive Lake Trout *Salvelinus namaycush* population in Swan Lake, Montana threatens a core area population of Bull Trout *Salvelinus confluentus* in Montana. Given the increased efficacy of suppression using novel embryo suppression methods, there is renewed interest in Lake Trout suppression in Swan Lake. The specific questions of this study were: 1) where are Lake Trout spawning, 2) where are the most used spawning sites, 3) what is the amount of spawning habitat, 4) does the estimated spawning area differ between estimates from telemetry locations and side-scan sonar imagery of suitable spawning substrate, and 5) how much phosphorous and nitrogen would be added to Swan Lake if carcass-analog pellet treatments were implemented? Acoustic tags were implanted in 85 Lake Trout in July and August of 2018 and 2019. Nightly tracking efforts during September, October, and November of 2018 and 2019 resulted in 1,744 relocations for 49 individual Lake Trout. Kernel-density analysis was used to evaluate Lake Trout aggregation locations identifying 10 distinct spawning sites — corroborating previous studies. Visual observation of Lake Trout embryos confirmed spawning at three sites with the remaining seven sites considered to be unconfirmed spawning sites. All confirmed spawning sites were located in the littoral zone along areas of steep bathymetric relief and were the most used across both spawning seasons. In 2019, side-scan sonar imaging was used to classify and quantify the total area of suitable spawning substrate, which comprised 12.8% of the total surface area estimated for confirmed sites and 11.4% for unconfirmed spawning sites. Simultaneous treatment of all confirmed and unconfirmed spawning sites would require 205,709 ± 86 kg of carcass-analog pellet material, resulting in 370.4 ± 0.2 kg of phosphorous and 7,487.9 ± 3.1 kg of nitrogen inputs to Swan Lake. Thus, pellet treatment would increase the Carlson's trophic state index (TSI) values from 20.8 to 27.7 for total phosphorous, and

from 22.1 to 26.2 for total nitrogen. Based on a TSI threshold value of < 40 for an oligotrophic lake, the use of carcass-analog pellets could be a feasible addition to renewed Lake Trout suppression efforts in Swan Lake.

Total Project Cost		$ 136,590.00
Beginning Balance – January 2021		26,075.53
Expenditures – January 2021 - December 2021		
Salaries and Benefits	18,911.69	
Contracted Services	.23	
Supplies	723.46	
Communications	0	
Travel	22.96	
Rent	0	
Repair and Maintenance	239.00	
Tuition	2,696.15	
IDCs @ 17.5%	3,482.04	
Total Spent		26,075.53
Balance		0
Waived IDCs		5,987.28

Bull Trout emigration study

Investigator
Christopher Guy
Assistant Unit Leader

Collaborator
Eric Oldenburg
Avista Corporation

Graduate Student
Madeline Lewis, M.S.

Funding
Avista Corporation
MSU index 4W7227

Duration
May 2018 – December 2021
Completed

In the lower Clark Fork River, Montana, a two-way trap-and-haul program is implemented to conserve the adfluvial life-history strategy in Bull Trout *Salvelinus confluentus* populations in the presence of hydropower dams. We used the infrastructure in place for the program, including a permanent weir trap and multiple stationary PIT antennas, to evaluate the demographic characteristics and out-migration dynamics of juvenile bull trout, and assess the efficacy of the downstream trapping component of the trap-and-haul program. We PIT-tagged 821 juvenile Bull Trout in Graves Creek, and 144 Bull Trout in East Fork Bull River in the summer of 2019 and summer of 2020. Bull Trout in Graves Creek were primarily age 1 and age 2, with a small number of age-3 Bull Trout present (< 1%). In East Fork Bull River, age-3 Bull Trout represented 14% – 46% of the population, with a small number of age-4 and older Bull Trout present (4% – 6%). From July 2019 through December 2020, 308 tagged Bull Trout outmigrated from Graves Creek, and most out-migrants were age 2 (n = 221). In East Fork Bull River, 18 Bull Trout out-migrated, and most out-migrants were age 3 (n = 13). Capture efficiency of the permanent weir in Graves Creek varied from 83% to 100% in autumn 2019 and 2020 and was substantially lower in the spring (14%). The majority of Bull Trout out-migrated from Graves Creek during autumn 2019, spring 2020, or autumn 2020 trapping seasons (n = 276). In Graves Creek, the largest Bull Trout within the 2018 year-class were five times more likely to out-migrate at age 1 when compared to smaller fish within the cohort. The magnitude of age-1 out-migration was positively related to density. Relative changes in abiotic factors, including discharge, water temperature, and photoperiod, were cues to out-migration, and the direction of change varied by season. Understanding the demographic characteristics and outmigration dynamics of the Bull

Trout in Graves Creek and East Fork Bull River enables more informed management of the trap-and-haul program and can be used to inform conservation efforts of other migratory Bull Trout populations.

Total Project Cost		$ 138,204.00
Beginning Balance – January 2021		23,975.24
Additional Funding -- 2021		20,200.00
Expenditures – January 2021 - December 2021		
Salaries and Benefits	12,286.78	
Contracted Services	0	
Supplies	688.96	
Communications	0	
Travel	0	
Tuition	3,049.20	
IDCs @ 20%	3,204.98	
Total Spent		19,229.92
Balance return to sponsor		24,945.32
Waived IDCs		3,845.99

Spawning characteristics and juvenile sampling for Mountain Whitefish in the Green River, Wyoming

Investigator
Christopher Guy
Assistant Unit Leader

Graduate Student
Colter Brown, M.S.

Collaborators
Darren Rhea, Mark Smith
Wyoming Game and Fish
Molly Webb, USFWS Bozeman
Fish Technology Center

Duration
July 2018 – June 2022
Continuing

Funding
Wyoming Game and Fish
MSU index 4W7263

Mountain Whitefish *Prosopium williamsoni* are a salmonid native to the northern Rocky Mountains that has experienced declines in population abundance in rivers throughout Idaho, Colorado, Wyoming, and Montana. Problems with recruitment are suspected, but often the specific mechanisms causing population declines are unknown. Our approach to better understand the mechanisms that influence Mountain Whitefish population dynamics was to compare population characteristics between the Green River, Wyoming and the Madison River, Montana populations. Boyer et al. (2017a) conducted an extensive study on the movement and reproductive ecology of Mountain Whitefish in the Madison River, and we used that study as a template to make direct comparisons between the populations. Our primary research questions were 1) what is the age and length at first maturity, spawning periodicity, fecundity, and age structure of Mountain Whitefish, 2) what is the spatial and temporal distribution of Mountain Whitefish through their spawning period, and what influence do abiotic factors have on spawning and movement, and 3) what is the spatial distribution and habitat use of age-0 Mountain Whitefish? We collected otoliths and gonadal samples from 127 Mountain Whitefish in the Green River, implanted 100 fish with radio transmitters and tracked them from

September 1 to early November in 2019 and 2020, determined spawning period and locations using egg mats, kick netting, and angling, and sampled age-0 Mountain Whitefish using a beach seine in slow-water habitats. The geographic separation and difference in hydrogeomorphic conditions between the systems allowed us to form generalizations about Mountain Whitefish in the Intermountain West. We found Mountain Whitefish in both systems mature between ages 2 and 4, primarily spawn annually, have a similar relative fecundity, spawning movements vary, males begin movement prior to females, and age-0 fish drift downstream of spawning locations and use slow-water silt-laden habitats after hatching. The main disparities between systems were that in the Green River water temperature was more suitable for embryo development, and age structure was more uniform and older. This research enhanced our understanding of Mountain Whitefish reproductive and juvenile ecology and provided evidence for factors that may influence recruitment of Mountain Whitefish.

Total Project Cost		$ 227,809.00
Beginning Balance – January 2021		104,549.70
Expenditures – January 2021 - December 2021		
Salaries and Benefits	25,088.54	
Contracted Services	0	
Supplies	1,848.63	
Communications	0	
Travel	1,068.38	
Rent	75.00	
Repair & Maintenance	0	
Tuition	3,578.22	
IDCs @ 20%	6,331.69	
Total Spent		37,990.46
Balance		66,559.24
Waived IDCs		7,598.11

Quantifying Brown Trout predation on Burbot: are non-native predators contributing to the decline of native fish populations in Torrey Creek drainage?

Investigator
Christopher Guy
Assistant Unit Leader

Graduate Student
Robert Eckelbecker, Ph.D.

Collaborators
Paul Gerrity, Joe Deromedi, Craig Armadio, Wyoming Game and Fish Department

Duration
July 2019 – June 2023
Continuing

Funding
Wyoming Game and Fish
MSU index 4W7910

Burbot are a native sportfish species in Wyoming and classified as a species of greatest conservation need. Biologists have become concerned with the decline in abundance of Burbot in the Torrey Creek drainage since the 1990s. A potential cause of the decline could be attributed to the introduction of Brown Trout, which probably entered the drainage in the early 1950s. Confirmation of Brown Trout predating on Burbot was observed in 2017 when Burbot occurred in 33% of Brown Trout diets. We will estimate the age distribution of Brown Trout in the Torrey Creek drainage: Trail Lake, Ring Lake, Torrey Lake, and Torrey Creek. In addition, diets of Brown Trout will be collected in the spring, summer, and autumn and used in a bioenergetics model. The bioenergetics model coupled with the previous abundance estimates will be used to estimate the effects of Brown Trout predation on the Burbot population in the Torrey Creek drainage, which will inform management decisions regarding the effects of non-native predators on native species.

The bioenergetics model requires input parameters of water temperature and diet proportion. In spring of 2020, water temperature loggers were placed in Torrey, Ring, and Trail lakes, and in Torrey Creek and will continue to collect water temperature data until October 2022. To obtain diet proportion, Brown Trout, Lake Trout, and Burbot were sampling during spring, summer, and autumn of 2020 and 2021. Diets were collected from 414 Brown Trout, 28 Lake Trout, and 56 Burbot. To date, Burbot have been identified in the diets of three Brown Trout. Tissue samples have been collected from 601 individual fish to compare short term dietary contents to stable isotope ratios found within muscle tissue.

In the autumn of 2021, sampling for an abundance estimate on Brown Trout occurred in Torrey Creek, Torrey Lake, Ring Lake, and Trail Lake. Brown Trout were marked with individually numbered FD-94 Fly T-bar anchor tags. After the final recapture event, 154 Brown Trout otoliths were collected to develop an age distribution and growth model. This study will provide information regarding the interactions among Burbot, Brown Trout, and Lake Trout and provide insight if persistence of Burbot is possible with intraguild predation and changing environmental conditions.

Total Project Cost		$ 188,459.00
Beginning Balance – January 2021		68,281.52
Additional Funding -- 2021		74,323.00
Expenditures – January 2021 - December 2021		
Salaries and Benefits	34,186.48	
Contracted Services	95.78	
Supplies	471.81	
Communications	0	
Travel	5,203.03	
Rent	800.00	
Repair & Maintenance	0	
Tuition	4,081.66	
IDCs @ 20%	8,967.75	
Total Spent		53,806.51
Balance		88,798.01
Waived IDCs		10,761.31

Adaptive monitoring for salmonids given changing abiotic conditions of the Yellowstone River

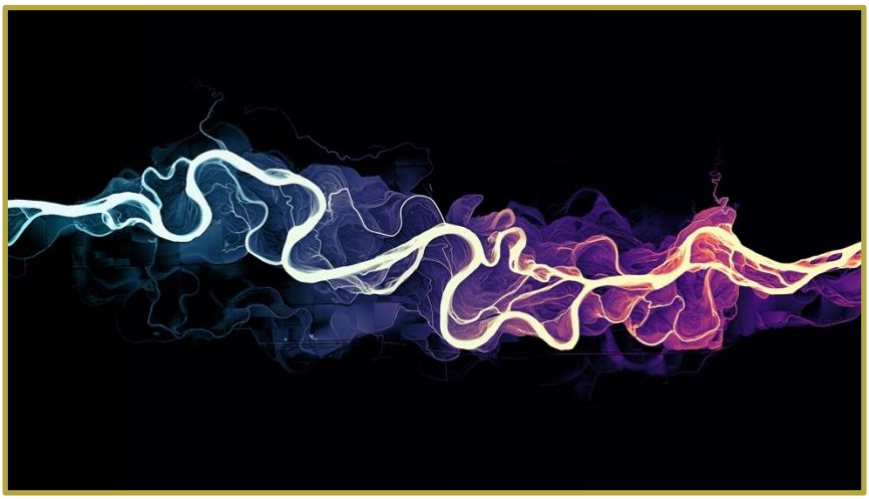
Investigator
Christopher Guy
Assistant Unit Leader

Graduate Student
Michelle Briggs, Ph.D.

Collaborators
David Schmetterling, Scott Opitz, Montana Fish, Wildlife and Parks

Duration
August 2021 – June 2023
New, approved

Funding
Montana Fish, Wildlife and Parks
MSU index 4W9217



The Yellowstone cutthroat trout (*Oncorhynchus clarkii bouvieri*), rainbow trout (*Oncorhynchus mykiss*), and brown trout (*Salmo trutta*) fisheries in the upper Yellowstone River, Montana are important recreational fisheries that are highly valued by Montana Fish, Wildlife & Parks and anglers within and outside Montana. Though the Yellowstone River trout fishery is predominantly catch-and-release, fish populations are still susceptible to stressors including increases in angling pressure, increased susceptibility to disease due to elevated water temperatures, and changes in the seasonal hydrograph pattern due to a changing climate. Maintaining a monitoring program for salmonid populations in the Yellowstone River provides important information to natural resource agencies regarding population structure, vital rates, abundance, and distribution in response to environmental stressors. Additionally, identifying and understanding trends in the fishery can provide natural resource agencies with information necessary to adapt management strategies to mitigate for stressors and ensure the salmonid fisheries in the Yellowstone River are available for future generations to enjoy. Montana Fish, Wildlife & Parks has used a standardized monitoring program to evaluate the abundance, size structure, and geographic distributions of trout in the upper Yellowstone River using batch mark-recapture techniques since 1981. These data have been used to monitor the trout populations and inform management decisions. However, fisheries biologists have recently found that standardized sampling events are becoming less effective or cannot be completed due to changing snowmelt patterns, resulting in an altered hydrograph and turbidity regime. Consequently, fisheries biologists are considering using novel analytical methods that

could account for the logistical challenges and continue to provide time-series abundance data. Such analytical methods would be especially pertinent for native Yellowstone cutthroat trout, a species of Special Concern for the state of Montana. The objectives of this project are: 1) to determine if the current Yellowstone River trout mark-recapture database contains the appropriate data structure to estimate abundance and survival using more robust methods (e.g., N-mixture models), and 2) to determine if the current sampling plan could be improved to provide more efficient and effective sampling. Given the changing abiotic conditions, novel analytical methods and improved sampling strategies will be vital to future monitoring and management of these valuable trout fisheries.

Total Project Cost		$ 44,660.00
Beginning Balance – August 2021		44,660.00
Expenditures – August 2021 - December 2021		
Salaries and Benefits	0	
Contracted Services	0	
Supplies	0	
Communications	0	
Travel	0	
Rent	0	
Repair & Maintenance	0	
Tuition	0	
Total Spent		0
Balance		44,660.00
Waived IDCs		0

Georgetown Lake diet study

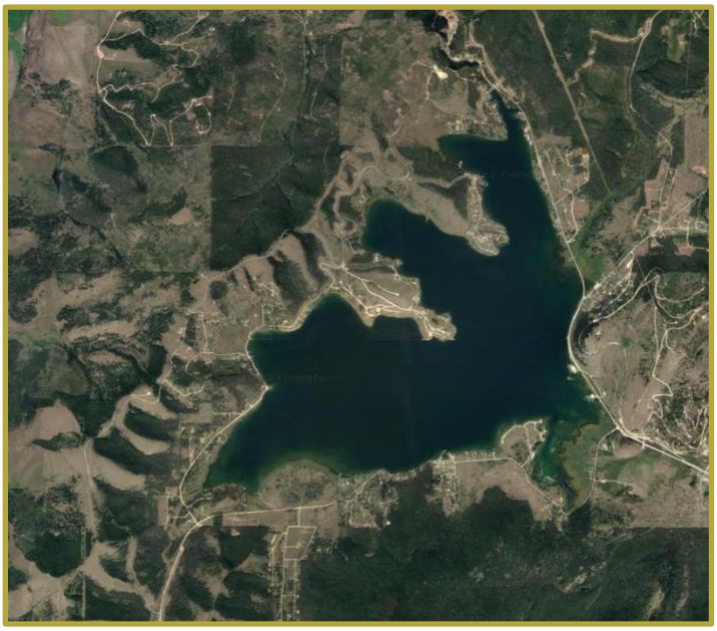
Investigator
Christopher Guy
Assistant Unit Leader

Graduate Student
Kaitlyn Furey, M.S.

Duration
January 2022 – December 2024
New, approved

Collaborators
David Schmetterling, Brad Liermann, Montana Fish, Wildlife and Parks

Funding
Montana Fish, Wildlife and Parks
MSU index 4W9576



Georgetown Lake is a highly productive reservoir and known for producing large numbers of quality-sized rainbow trout (*Oncorhynchus mykiss)*, abundant kokanee (*Oncorhynchus nerka*), and is a premier location for catching trophy brook trout (*Salvelinus fontinalis*). Georgetown Lake routinely ranks in the top 10 in Montana for angling pressure and is equally important as a summer and winter ice-fishing destination. The rainbow trout fishery in Georgetown Lake is sustained by annual stocking from Montana Fish, Wildlife and Parks. Three rainbow trout strains occupy Georgetown Lake, Gerrard-strain rainbow trout, Eagle Lake-strain rainbow trout, and Arlee-strain rainbow trout. Although many anglers enjoy targeting kokanee in Georgetown Lake for the quantities they can catch, the length of kokanee has typically been considered unsatisfactory by managers and many anglers. In 2015, Montana, Fish, Wildlife and Parks began stocking the piscivorous Gerrard-strain rainbow trout into the system to increase predation on kokanee, reduce their density and improve the average size of kokanee. In the past five years, there has been an increase in average size of rainbow trout and kokanee. The mechanisms affecting the observed changes in growth and relative abundance of rainbow trout and kokanee are currently unknown. Our proposed research will investigate the trophic relationship among salmonid species in Georgetown Lake, which will provide insight into whether predatory mechanisms are influencing the abundance and size of kokanee. Results of our work will allow Montana Fish, Wildlife and Parks to refine the stocking program in Georgetown Lake to continue providing a premier sports fishery.

Total Project Cost		$ 44,000.00
Beginning Balance – January 2022		44,000.00
Expenditures – August 2021 - December 2021		
Salaries and Benefits	0	
Contracted Services	0	
Supplies	0	
Communications	0	
Travel	0	
Rent	0	
Repair & Maintenance	0	
Tuition	0	
Total Spent		0
Balance		44,000.00
Waived IDCs		0

Enhancing survival and condition of first feeding larval Pallid Sturgeon through diet

Investigators
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Research Associate
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Collaborator
Wendy Sealey
U.S. Fish and Wildlife Service

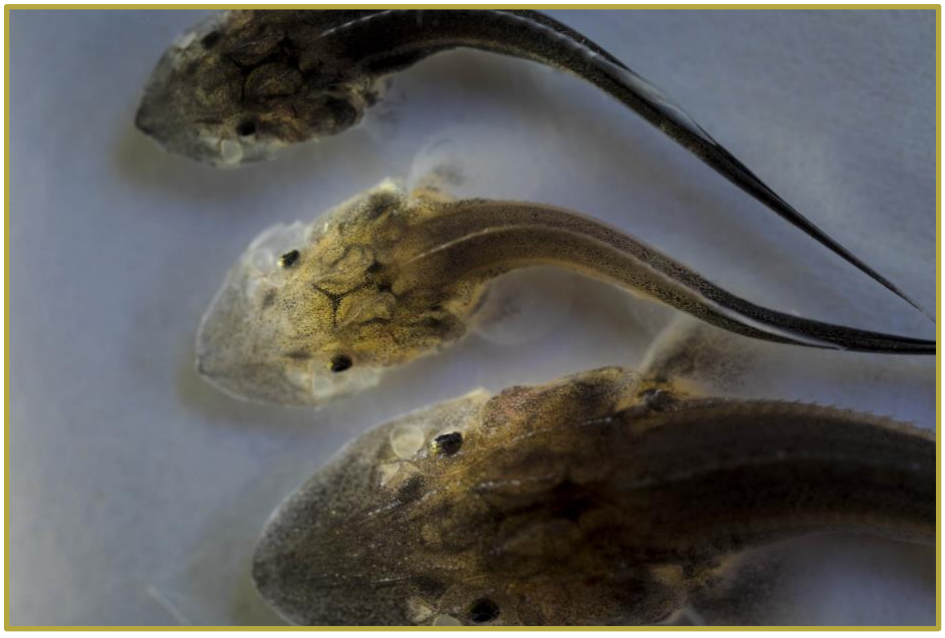
Funding
USGS RWO 77 SSP
MSU index 4W7764

Duration
April 2019 – December 2022
Continuing

Conservation propagation facilities are currently experiencing variable survival of first feeding larval Pallid Sturgeon. Hatchery-induced "selection" can ultimately have unintended, negative consequences on genetic representation of Pallid Sturgeon returned to the Missouri and Yellowstone rivers. The observed variability in larval survival at conservation propagation hatcheries may be a result of poor response to feed offered to larvae. Evidence shows that first feeding larvae are unable to properly digest formulated diets because they lack the digestive enzymes necessary to process and assimilate a diet high in protein typical of commercial dry diets. The objectives of this study are to 1) identify a diet that improves parity of survival and condition (i.e., weight) of first feeding larval Pallid Sturgeon, regardless of genetic lot; 2) determine length of time required to feed the diet identified in objective 1 that enhances survival, condition, and weaning success, regardless of genetic lot; 3) determine if diet and feeding duration identified in objectives 1 and 2 can be applied successfully at Pallid Sturgeon propagation facilities; and 4) develop a feeding regimen for implementation at upper basin conservation propagation hatcheries. In 2021, we completed trials with two genetically distinct families. We determined that the live diet (*Artemia*) improved survival and condition within each genetic lot in comparison to the commercial diet (Otohime). Survival in both families was higher for individuals fed *Artemia* – either exclusively or in combination with Otohime – than for those fed solely Otohime, suggesting that *Artemia* confers a survival benefit to first feeding larval Pallid

Sturgeon. Our individual weight data demonstrated that *Artemia* produced heavier fish, and individuals fed solely *Artemia* were heavier than those fed solely Otohime.

Total Project Cost		142,033.00
Beginning Balance – January 2021		21,817.12
Additional Funding -- 2021		37,582.00
Expenditures – January 2021 - December 2021		
Salaries and Benefits	27,782.39	
Contracted Services	3,783.75	
Supplies	2,037.40	
Travel	0	
IDCs @ 15%	5,040.51	
Total Spent		38,644.05
Balance		20,755.07
Waived IDCs		9,745.03



Pallid Sturgeon condition evaluation

Investigator
Christine Verhille
MSU Department of Ecology

Collaborator
Kevin Kappenman
U.S. Fish and Wildlife Service

Graduate Student
Matea Djokic, M.S.

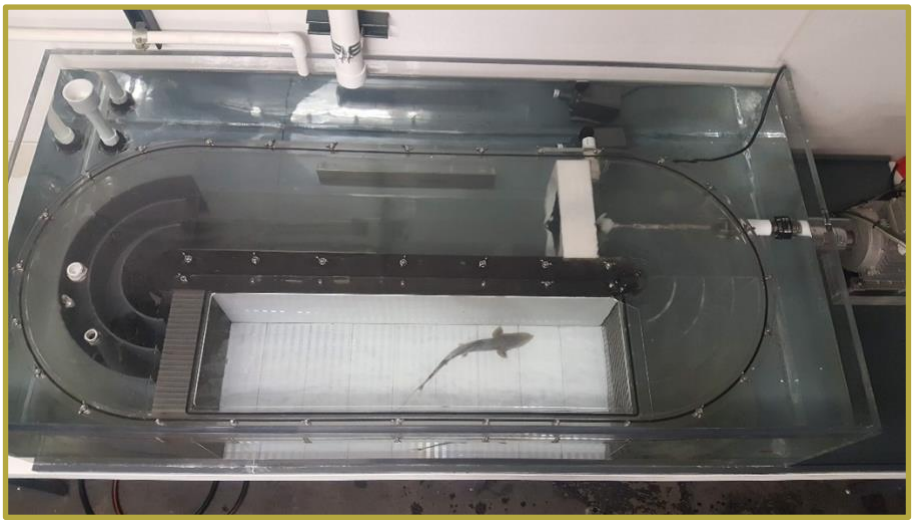
Funding
Montana Fish, Wildlife and Parks
MSU index 4W7302

Duration
July 2018 – January 2022
Completed

Stream-side non-invasive physiological assessments are related to performance outcomes of wild-captured salmonids. However, assessments of wild Pallid Sturgeon populations are based on measurements of size and survival, which provide poor resolution and slow detection times of population health responses to fluctuations in habitat conditions. We proposed to develop a life-stage-specific Pallid Sturgeon field health assessment criterion through a hatchery experiment and streamside assessments of wild-captured juvenile Pallid Sturgeon performed in conjunction with existing monitoring efforts. Assessments involved an extensive suite of assessment variables for prediction of overall health of Pallid Sturgeon. Measurements included blood and tissue biochemistry (e.g., metabolic substrates and end products as well as stress and reproductive hormones), a visual fish health index, and non-invasive microwave and bioelectrical impedance determinations of whole-body energy concentration.

Lethal sampling was performed on juvenile hatchery Pallid Sturgeon for blood biochemistry measurements as well as for direct determination of whole-body energy concentration to confirm indirect, but non-invasive, microwave measurements of whole-body energy. Microwave measurements were determined to be moderately effective at estimating whole body energy of juvenile Pallid Sturgeon when combined with size and relative condition values. We are finalizing a manuscript summarizing reference ranges for hatchery-reared juvenile Pallid Sturgeon blood biochemistry. We are also in the beginning stages of a manuscript comparing these hatchery-reared ranges with blood biochemistry measurements on wild-captured Pallid Sturgeon. A set of blood biochemistry analytes and body composition variables that both co-vary and predict recent growth of juvenile hatchery Pallid Sturgeon were identified but determined to be ineffective at forming a cohesive field health-assessment criterion. However, wild-captured Pallid Sturgeon blood biochemistry will be compared to ranges observed in wild captured juvenile Pallid Sturgeon as the priority life stage identified by Upper Missouri River Basin biologists and managers to infer their body composition and recent growth.

Total Project Cost		$ 172,114.00
Beginning Balance – January 2021		23,065.33
Expenditures – January 2021 - December 2021		
Salaries and Benefits	20,706.14	
Contracted Services	0	
Supplies	2,359.19	
Communications	0	
Travel	0	
Tuition	0	
Total Spent		23,065.33
Balance		0
Waived IDCs		10,148.75



Mechanisms underlying emaciation in adult Pallid Sturgeon evaluation

Investigator
Christine Verhille
MSU Department of Ecology

Graduate Students
Sierra Quinn, M.S.
Nicole Daigle, Ph.D.

Duration
February 2019 – September 2022
Continuing

Collaborators
Kevin Kappenman
U.S. Fish and Wildlife Service
Kirk Steffensen
Nebraska Game and Parks Commission

Funding
U.S. Army Corps of Engineers
USGS RWO 75, MSU index 4W7686

"Skinny" reproductive-age Pallid Sturgeon have been captured with increasing frequency between Gavins Point Dam and the Kansas River (Central Lowlands Management Unit) since 2011. Managers have approached the "skinny fish" phenomenon as a food limitation issue and directed efforts towards hatchery reconditioning programs aimed at fattening wild-captured reproductive age sturgeon for the next spawning year. However, the evidence in support of Pallid Sturgeon food limitations within the Central Lowlands Management Unit habitat and hatchery reconditioning practices is tenuous to non-existent. Our research addresses these problems through two objectives. The first objective is to develop evidence-based criteria for assessing the health and reproductive status of adult Pallid Sturgeon. These criteria will primarily involve blood and tissue biochemistry, energy reserves, and condition measurements that can be applied to monitor hatchery reconditioning progress and assess health of captured wild Pallid Sturgeon. The second objective is to test hypotheses explaining the biological mechanism within the Central Lowlands Management Unit habitat causing some adult Pallid Sturgeon to become excessively emaciated. Understanding the biological causes of emaciated Central Lowlands Pallid Sturgeon will guide managers to effectively allocate resources towards reconditioning or habitat restoration to address this issue that threatens jeopardy of this endangered species. A hatchery study designed to create maximum variation within an experimental

population of adult hatchery Pallid Sturgeon through feed ration manipulation was completed in March 2020. A suite of physiological measurements was performed on fish at the end of this study to develop criteria for non-lethally assessing health status of adult Pallid Sturgeon and to test and calibrate a non-invasive microwave energy meter for determinations of whole-body energy concentration. We found the microwave energy meter to be effective at estimating whole-body energy concentration of adult pallid sturgeon. Four field seasons of monitoring non-lethal physiological measurements on wild-captured adult Pallid Sturgeon within the Central Lowlands Management Unit were completed. These data will be compared with data from the hatchery study to infer health status of wild-captured fish. Plans to investigate environmental contaminants as a mechanism underlying emaciated adult Pallid Sturgeon, were pivoted to a study evaluating the effects of tissue biopsy collection on hatchery reared adult pallid sturgeon (an essential step to secure permits from the U.S. Fish and Wildlife Service for future biopsy collections). We found negligible short-term effects of biopsy collection on hatchery adult Pallid Sturgeon. This project also takes advantage of the underused National Pallid Sturgeon Database to investigate whether characteristics predicting later emaciation could be identified. We have concluded that relative condition at capture is a weak, but significant predictor of apparent future survival.

Total Project Cost		$ 127,540.56
Beginning Balance – January 2021		61,549.38
Expenditures – January 2021 - December 2021		
Salaries and Benefits	24,839.04	
Contracted Services	6,480.00	
Supplies	208.86	
Communications	0	
Travel	0	
Awards	0	
IDCs @ 15%	4,729.05	
Total Spent		36,256.95
Balance		25,292.43
Waived IDCs		9,143.10

Delineating and mapping ungulate seasonal ranges and movement corridors in Montana

Investigators
Jay Rotella, Robert Garrott
MSU Department of Ecology

Research Associate
Blake Lowrey, MSU

Collaborator
Kelly Proffitt
Montana Fish, Wildlife and Parks

Duration
May 2019 – June 2022
Continuing

Funding
Montana Fish, Wildlife and Parks
MSU index 4W8069
U.S. Geological Survey RWO 80
MSU index 4W8304

Recognizing the need to protect and conserve big-game winter range and migration corridors to sustain robust ungulate herds across Montana, Montana Fish, Wildlife and Parks prioritized a broad effort to delineate migration routes and seasonal ranges of elk, mule deer, and pronghorn using rigorous methodologies that account for varied terrain, habitat, and big game migration behaviors across the state. This effort was bolstered by Secretarial Order 3362, which mandated that Department of Interior bureaus work with state wildlife agencies to enhance and improve habitat quality of big game winter range and migration corridors. The mapping effort and associated research will help fulfill local information needs as well as contribute to regional coordinated mapping efforts across the western U.S. We used existing GPS data from elk and mule deer herds across Montana to develop methods for delineating seasonal ranges and migration corridors. The elk populations were predominantly located in southwest and western Montana with a few populations in the northwest and eastern parts of the state. The mule deer populations were distributed across the state. We estimated 50, 95, and 99 percent home range contours for winter, summer, and annual periods for each individual year, which were then averaged to create population-level ranges. The contours represented the smallest areas where the probability of relocating an individual from the herd is equal to the given percentage (i.e., 50, 95, and 99 percent). Mule deer and elk mapping efforts were completed, and the focus of this work is shifting to 1) delineating pronghorn seasonal ranges and migration corridors and 2) using existing deer and elk telemetry data to generate statewide predictive maps of winter range habitat suitability. We are currently recruiting a postdoc to lead these

analyses. We will also continue to work with Montana, Montana Fish, Wildlife and Parks to provide the required data layers to populate a web page that will serve as an internal resource where Montana, Montana Fish, Wildlife and Parks staff can download herd-specific maps as well as an online tool for the general public to learn about Montana, Montana Fish, Wildlife and Parks research projects.

Total Project Cost 4W8069		$ 136,000.00
Beginning Balance – January 2021		60,908.63
Expenditures – January 2021 - December 2021		
Salaries and Benefits	34,264.34	
Travel	0	
Total Spent		34,264.34
Balance		26,644.29
Waived IDCs		15,076.31

Total Project Cost 4W8304		$ 38,640.00
Beginning Balance – January 2021		38,640.00
Additional Funding -- 2021		18,208.00
Expenditures – March 2021 - December 2021		
Salaries and Benefits	0	
Travel	0	
IDCs @ 15%	0	
Total Spent		0
Balance		56,848.00
Waived IDCs		0

Elk habitat management in Montana

Investigators
Jay Rotella
MSU Department of Ecology

Collaborator
Kelly Proffitt
Montana Fish, Wildlife and Parks

Graduate Student
Elisabeth Krieger, M.S.

Funding
Montana Fish, Wildlife and Parks
MSU index 4W8829

Duration
November 2020 – June 2025
Continuing

A recent focus in the western United States has been to identify and conserve big game migration corridors and winter ranges as highlighted in 2018 Secretarial Order 3362. Seasonal range and movement information is lacking for many elk populations in Montana, particularly in the central and eastern portions of the State. The project is building on results from previous security habitat studies in Montana and provides information and recommendations as to population and habitat management strategies for elk in central Montana and the prairie environments of eastern Montana by collecting, analyzing, and interpreting elk movement data in the Devil's Kitchen, Custer Forest, and Missouri Breaks areas. The specific objectives of this project are to (1) collect elk movement data and delineate seasonal range and migration corridors for three elk populations, (2) evaluate landscape factors associated with problematic elk distributions and provide information regarding elk habitat selection to enhance management strategies aimed at achieving more desirable distributions and harvest management objectives, and (3) evaluate elk habitat selection and the effects of hunter access management and provide information to enhance elk management. We are actively collecting location data from collared elk in these three study areas and will continue data collection throughout the next 2 years. A postdoc (John Draper) will join the project in March 2022 and begin analyses evaluating landscape factors associated with problematic elk distributions.

Total Project Cost		$ 385,955.00
Beginning Balance – January 2021		60,375.00
Additional Funding 2021		241,680.00
Expenditures – January 2021 - December 2021		
Salaries and Benefits	41,142.00	
Contracted Services	14,495.64	
Supplies	91,785.49	
Travel	0	
Tuition	2,001.88	
Total Spent		149,425.01
Balance		152,629.99
Waived IDCs		65,747.01

Effects of livestock grazing management on the ecology of sharp-tailed grouse, grassland birds, and their predators in mixed grass prairie habitats of Montana

Investigators

Lance McNew
Mandy Lipinski
MSU Department of Animal and Range Sciences

Collaborator

Lorelle Berkeley
Montana Fish, Wildlife and Parks

Duration

February 2016 – June 2021
Completed

Funding

Montana Fish, Wildlife and Parks
MSU index 4W5907

We assessed the effects of livestock grazing management and rangeland conditions on the population and spatial ecology of sharp-tailed grouse, grassland birds, and their predators. The primary objectives of this study were to 1) investigate rest-rotation grazing as a rangeland management technique to improve habitat conditions for sharp-tailed grouse and 2) develop a mechanistic understanding of the effects of grazing management on the occurrence and abundance of grassland passerines and meso-predators. Our study site was in eastern Montana on properties enrolled in the Upland Game Bird Enhancement Program and adjacent properties not enrolled in conservation programs with prescriptive grazing. Field work was conducted during 2016–2019 and final analyses completed during 2020–2021. We addressed seven potential effects of grazing management and habitat conditions on sharp-tailed grouse: nest site selection, nest survival, breeding season home ranges and habitat selection, brood habitat selection, adult female survival, and population growth and viability. Our monitoring efforts during the 4-year study period included 12 leks, 118 radio-marked females monitored for 180 bird-years, 7,178 individual locations of radio-marked females, 188 nesting attempts, and 95 broods that were monitored until they failed or reached independence at 60 days.

Nest site selection of sharp-tailed grouse was not affected by grazing system. Grazing system did not influence nest survival. Home range sizes were less variable within pastures managed with summer rotation grazing compared to those in other systems, but grazing system did not have a significant effect on average size of home ranges. Grazing system did not affect breeding season habitat selection of home ranges. During 2016–2018, 22 broods spent most of the time in rest-rotation pastures, 30 spent the

majority of time in summer rotation pastures, 29 spent the majority of time in season-long pastures, and 14 split time between multiple grazing systems. Brood success was 0.59 ± 0.10, 0.80 ± 0.07, 0.66 ± 0.09, and 0.43 ± 0.13 for broods located on the rest-rotation, summer rotation, season-long and multiple systems, respectively. The proportion of chicks that survived was 0.55 ± 0.08, 0.54 ± 0.06, 0.59 ± 0.07, and 0.32 ± 0.09 for broods located on the rest-rotation, summer rotation, season-long and multiple systems, respectively. Overall, 86% of mortality events were due to predation, with the remaining mortality events due to hunter harvest (8%) or unknown causes (6%). Overall annual survival was similar for females that spent the majority of their time in the three grazing systems; however, we observed variability in seasonal mortality risk among the three systems. We developed an integrated population model (IPM) to estimate annual rates of finite population changes and evaluate the cumulative effects of livestock grazing management on sharp-tailed grouse populations. Results indicated declining population of sharp-tailed grouse at our study area during 2016–2018. We did not find support for cumulative effects of grazing system on population growth rates of sharp-tailed grouse; 95% credible intervals of rates of population change for each grazing system overlapped.

We detected a total of 68 species of birds, 31 of which were grassland-associated species. In contrast to our expectations, rest-rotation grazing did not support greater local abundances of three native ground-nesting grassland obligate birds relative to summer-rotation or season-long grazing systems during our 2-year study, despite modest differences among grazing systems in vegetation composition and structure. Rather, associations among local abundance, grazing system, stocking rate, and rangeland production potential were species-specific and do not support ubiquitous grazing management recommendations for grassland bird conservation. Grassland bird community size and composition was similar across the three grazing systems; only 2% of the variation in community composition could be attributed to the livestock grazing system. Relative use of mesocarnivores was highest in rest-rotation grazing systems, followed by season-long and summer-rotation grazing systems, and generally increased with stocking rates of livestock.

Total Project Cost		$ 591,335.00
Beginning Balance – January 2021		134,643.19
Expenditures – January 2021 - December 2021		
Salaries and Benefits	56,065.07	
Contracted Services	14,666.82	
Supplies	9,591.85	
Communications	0	
Travel	75.64	
Rent	1,182.42	
Repairs and Maintenance	31.09	
Total Spent		81,612.89
Balance returned to sponsor		53,030.30
Waived IDCs		35,909.68

Taxonomic and ecological service project account

Investigator
Alexander Zale
Unit Leader

Funding
No new funding
MSU Index 433295

Duration
Continuing

Unit personnel provide services and workshops periodically.

Beginning Balance – January 2021		$ 5,414.15
Additional Funding		0
Expenditures – January 2021 - December 2021		
Salaries and Benefits	0	
Contracted Services	0	
Supplies	0	
Communications	0	
Travel	0	
Rent	0	
Repairs and Maintenance	0	
Tuition	0	
Administrative Fee @ 6%	0	
Total Spent		0
Balance		5,414.15

MTCFRU service project account

Investigators

Alexander Zale
Unit Leader

Duration

Continuing

Funding

MT Fish, Wildlife and Parks
MSU Index 433309

This account manages non-grant work including consulting for database development and student internships that the Montana Cooperative Fishery Research Unit performs in association with cooperators and collaborators.

Beginning Balance – January 2021		$ 2,426.92
Additional Funding –		0
Expenditures – January 2021 - December 2021		
Salaries and Benefits	0	
Contracted Services	0	
Supplies	0	
Communications	0	
Travel	0	
Rent	0	
Repairs and Maintenance	0	
Tuition	0	
Administrative Fee @ 6%	0	
Total Spent		0
Balance		2,426.92


Adrian Sanchez-Gonzalez

MTCFRU Gift Account

Investigators
Alexander Zale
Unit Leader

Funding
Eccles Foundation
MSU Index 423077

Duration
Continuing

This account manages support from foundations and NGOs for graduate students in the Cooperative Fishery Research Unit program.

Beginning Balance – January 2021		12.16
Additional Funding – 2021		0
STIP Interest 2021		0
Expenditures – January 2021 - December 2021		
Salaries and Benefits	0	
Supplies	0	
Travel	0	
Repairs and Maintenance	0	
Tuition	0	
Total Spent		0
Balance		12.16

Montana Cooperative Fishery Research Unit Vehicle Account

Administrator

Alexander Zale
Unit Leader

Funding

Designated Account - projects are charged mileage based on project use
MSU index 433099

The purpose of the Unit vehicle account is to cover all expenses related to Unit vehicles, which includes replacement, repairs and maintenance, insurance, and fuel.

Beginning Balance – January 2021		$ 67,954.52
Expenditures – January 2021 - December 2021		
Repairs and Maintenance	4,339.09	
Fuel	4,289.00	
New	0	
Administrative Assessment Fee @ 6%	517.67	
Total Spent		9,145.76
Total Revenue Reimbursed		17,834.98
Balance		76,643.74

Adrian Sanchez-Gonzalez

Montana Cooperative Fishery Research Unit Watercraft Account

Administrator

Alexander Zale
Unit Leader

Funding

Designated Account - projects are charged a daily fee when using boats
MSU index 433301

The purpose of the Unit watercraft account is to cover expenses related to Unit research vessels, including replacement, repairs, and maintenance.

Beginning Balance – January 2021		29,168.81
Expenditures – January 2021 - December 2021		
Repairs and Maintenance	1,830.06	
Fuel and Supplies	2,063.85	
New	0	
Administrative Assessment Fee @ 6%	233.65	
Total Spent		4,127.56
Total Revenue Reimbursed		4,769.48
Balance		29,810.73

Adrian Sanchez-Gonzalez

Montana Cooperative Fishery Research Unit Operations Account

Administrator

Alexander Zale
Unit Leader

Funding

$15,000 yearly from MSU VP for Research, Economic Development, and Graduate Education
MSU index 436899

Beginning Balance – January 2021		$8,671.76
Expenditures – January 2021 - December 2021		
Maintenance	0	
Contracted Services	0	
Supplies	0	
Communications	717.00	
CCM	0	
Rent (storage unit)	9,600.00	
Parking expense	2,880.00	
Administrative Assessment Fee @ 6%	792.00	
Total Spent		13,989.00
Total Revenue from VPR		7,500.00
Balance		2,182.76

Monetary Equivalence for MSU Services and Facilities
January 2021 - December 2021

Program Manager salary and benefits	$ 65,645.86
Office space	
Staff - 515 sq. ft. @ $13/sq. ft.	6,695.00
Students - 742 sq. ft.@ $13/sq.ft	9,646.00
Laboratory space - 40% of 942 sq. ft. @ $16/sq. ft.	6,028.80
Storage space - AJMJ cages (2) - 71.5 sq. ft. @ $3.24/ sq. ft.	231.66
Museum facilities - 12.5% of 936 sq. ft. @ $16/ sq. ft.	1,872.00
Library @ 0.8% of total expenditures ($785,850)	6,286.80
Utilities - General @ 12% of total expenditures ($785,850)	94,302.00
Unit Operations Account	7,500.00
Waived IDCs	243,626.00
Total	**441,834.12**

Montana Fish, Wildlife and Parks Annual Contribution
Montana Cooperative Fishery Research Unit Operations

Administrator
Alexander Zale
Unit Leader

Funding
Montana Fish, Wildlife and Parks
MSU index 4W5335, 4W8602

Beginning Balance – January 2021		$ 41,745.13
Additional Funding – 2021		40,000.00
Expenditures – January 2021 - December 2021		
Salaries and Benefits	19,918.38	
Contracted Services	8,199.76	
Supplies	19,704.30	
Communications	51.02	
Travel	3,059.46	
Rent	150.00	
Repairs and Maintenance	1,887.67	
Tuition	2,001.75	
Equipment	0	
Total Spent		54,972.34
Total Returned MT FWP		1,479.23
Balance		25,293.56

Federal Budget
January 2020 - December 2020

Salaries and Benefits	$ 435,673.83
Supplies	2,149.44
Total	$ 437,823.27

Unit Equipment Inventory
(items with acquisition values greater than $5,000)

USGS

2019 Dodge Ram ¾ Ton, 4x4 crew cab (dk green/black)
Property No. 434650 – Serial No. 3C6UR5CJ1KG676584
Acquisition value $30,559
Mileage 740

2016 Chevrolet Silverado 2500, 4x4 crew cab (white)
Property No. 434174 – Serial No.1GC1KUE80GF252052
Acquisition value $35,644
Mileage 17,410

2011 Ford F250 4×4 crew cab (green)
Property No. 433429 – Serial No 1FT7W2BTOBEA70586
Acquisition value $31,697
Mileage 64,998

2005 Chevrolet Silverado 2500, 4×4 crew cab (green)
Property No. 430750 - Serial No. 1GCHK23G15F926039 (2005)
Acquisition value $22,948
Mileage 144,175

2002 Chevrolet 4×4 Suburban (white)
Property No. 261052 - Serial No. 3GNGK26U52G249012
Acquisition value $31,988
Mileage 148,344

Hewes Craft 270 Boat
Property No. 1387575 – Serial No. HEW96582J021
EZ Loader Trailer – Serial No. 1ZETARYZ7MA005548
Acquisition value $113,987 (2020)

Smith-Root Electrofisher
Serial No. 302352

Acquisition value $9,965 (2020)

Leica S8APO Microscope
Serial No. B1407890
Acquisition value $6014 (2016)

2016 Honda BF-225 Outboard Motor
Serial No. BAGJ-1800419
Acquisition value $14,860 (2016)
For 2004 Wooldridge boat

Halltech Backpack Electrofisher
Serial No. B433MK5
Acquisition value $7,694 (2016)

Leica M165 C Stereomicroscope System
Serial No. 5766180
Leica DFC450 Digital Camera
Serial No. 12730411
Acquisition value $20,936

Wooldridge 20' Custom Boat and Trailer with a Honda 200 Four Stroke Motor and Electrofishing combo.
Property No. Boat 4005308 - Serial No. WLG20635I405
Property No. Trailer 430697 - Serial No. 47AVA221250061126
Property No. Motor 4005305 - Serial No. BAEJ-1300065 replaced 2016
Property No. Electrofisher Combo 4005309
Acquisition value $50,871 (2004)

Hyde Aluminum Drift Boat
Property No. 3800001 - Serial No. TAD00230D696
Acquisition value $5,262 (1996)

VideoRay Pro3-XE-N ROV System
Property No. 4005775 - Serial No. G09028
Acquisition value $25,424 (2009)
Upgrade new model (2017) $49,984

Electrofisher SRI Backpack Combo
Serial No. BC-170057
Acquisition value $7,468 (2004)

Olympus BX40 microscope
Property No. 6001157 - Serial No. 9810089
Acquisition value $5,601 (1999)

U.S. Army Corps of Engineers

Wooldridge Jet Boat
Serial No. WLG18428K596
Acquisition value $19,447 (1996)

Montana State University

2020 Dodge Ram ½ Ton 4x4 Crew Cab (white)
Serial No. 1C6RR7ST2LS100291
Acquisition Value $28,078
Mileage 8,844

2017 Ford F150 Supercab (blue)
Serial No. 1FTFX1EF0HKD34442
Acquisition Value $26,826
Mileage 8,501

2014 Dodge Ram 2500 (white)
Property No. 135050
Serial No. 3C6TR5DT0EG281683
Acquisition Value $29,197
Mileage 57,778

2008 Ford Escape Hybrid 4WD (grey)
Property No. 132775
Serial No. 1FMCU59H78KA13346
Acquisition Value $26,554 (2007)
Mileage 45,249

2005 GMC Sierra 2500 crew cab truck (green)
Property No. 132353
Serial No. 1GTHK23G65F944780
Acquisition Value $24,463 (2005)
Mileage 177,479

2017 Hewes Craft with Yamaha 115 hp motor
VIN HEW80240K617
Yamaha Serial No. 6EKX-1047110
EZ Loader Trailer Serial No. 1ZEAAMPK1HA006148
Acquisition value $34,434 (2018)

Smith-Root Backpack Electrofisher
Serial No. F01157
Acquisition value $8,269 (2016)

2012 Wooldridge 18’ Custom Boat with a Mercury 150 Optimax motor
Serial No. WLG18379H112
Mercury Serial No. 1B881822
EZ Loader trailer Serial No. 1ZEAAAMC5CA001832
Acquisition Value $36,081 (2011)

BRP Evinrude 200 hp (for 1996 Wooldridge boat)
Serial No. 05257091
Acquisition value $10,444 (2009)

2008 Crestliner 18’ Boat
Serial No. CRC36198J708
90 hp Evinrude engine, Serial No. 05265364
19’ Shorelander trailer VIN No. IMDAPLP188A402650
Acquisition value $16,107 (2009)

2008 18’ Wooldridge Custom Boat
Serial No. WLG18099B808
150 hp Yamaha engine Serial No. 63PL1070949
EZ Loader Trailer Serial No. 1ZEADAMB08A152874
Acquisition value $32,182 (2008)

Smith-Root Electrofisher
Serial No. 11363T
Acquisition value $14,074 (2007)

2008 Workskiff Custom Boat
Serial No. MGN19S06D808
135 hp Honda engine Serial No. BARJ-1301242
EZ Loader Trailer Serial No. 1ZEADMPK28A158379
Acquisition value $36,615 (2008)

2013 Jayco Jay Flight 26BH Travel Trailer
Serial No. 1UJBJ0BP4D77R0223
Acquisition value $19,600 (2013)

HT 2000 Backpack Electrofisher
Serial No. B068MK4
Acquisition value $6,162 (2006)

Electrofisher Backpack
Property No. 131644
Serial No. C00162
Acquisition value $5,792 (2003)

Acoustic Doppler Current Profiler
Property No. 133442

Serial No. StreamPro930
Acquisition value $16,975 (2009)

YSI Water Quality Monitor
Serial No. 08F100275, 08F100274, 08E100745
Acquisition value $15,923 (2008)

SRX 400A Datalogging Coded Series Receivers with W31 CT Firmware (2)
Property No. 132057
Serial No. 11826A
Acquisition value $7,950 (2004)
Property No. 132058
Serial No. 11827A
Acquisition value $7,950 (2004)