Montana Cooperative Fishery Research Unit

2021 Briefing Booklet

Coordinating Committee Meeting

14 April 2021

MONTANA FISH, WILDLIFE & PARKS

MONTANA STATE UNIVERSITY
Mountains & Minds

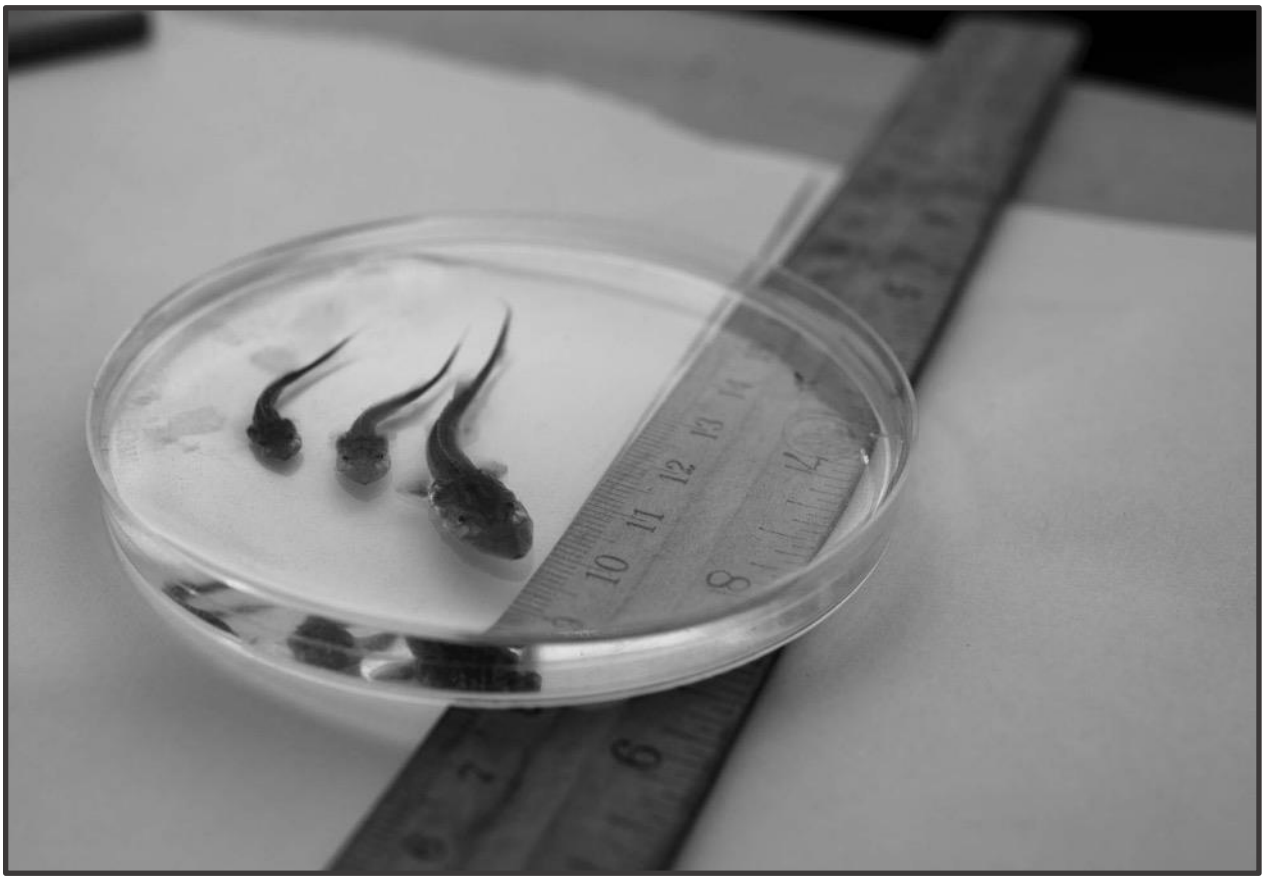
USGS
science for a changing world

U.S. FISH & WILDLIFE SERVICE
DEPARTMENT OF THE INTERIOR

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.



Personnel and Cooperators

Coordinating Committee Members

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Cooperative Research Units
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Cooperative Unit Staff

Alexander Zale
Unit Leader and Professor
Christopher Guy
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Cooperators and Collaborators

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- Diane Debinski
- Bob Garrott
- Andrea Litt
- Blake Lowrey
- Tom McMahon
- Terrill Patterson
- Jay Rotella
- Christine Verhille

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- Lance McNew

Montana State University, Department of Civil Engineering
- Matt Blank
- Joel Cahoon
- Kathryn Plymesser

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- Deborah Keil

Montana State University, College of Letters and Science
- Yves Idzerda, Dean

USGS Northern Rocky Mountain Science Center
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- George Jordan
- Kevin Kappenman
- Jeff Powell
- Wendy Sealey
- Greg Watson
- Molly Webb
- Bill West

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- Eric Oldenburg

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Graduate Students Advised by Unit Faculty

Ian Anderson	M.S.
Colter Brown	M.S.
Kristen Cook	M.S.
Kyle Crapster	M.S.
Robert Eckelbecker	Ph.D.
Hayley Glassic	Ph.D.
Madeline Lewis	M.S.
Drew MacDonald	M.S.
Andriana Puchany	M.S.
Michael Siemiantkowski	M.S.
Keith Wellstone	M.S.

Graduate Students Advised by Cooperating Faculty

Megan Conley	M.S.	advised by Kathryn Plymesser
Nicole Daigle	Ph.D.	advised by Christine Verhille
Andrew Johnson	M.S.	advised by Kathryn Plymesser
Sierra Quinn	M.S.	advised by Christine Verhille

Graduate Students Receiving Degrees

Tanner Cox graduated with a M.S. in Fish and Wildlife Management and is working for the Tennessee Cooperative Fishery Research Unit as a Project Manager/Research Associate.

Colleen Detjens graduated with a M.S. in Fish and Wildlife Management and is working for the National Park Service in Yellowstone National Park as a Fisheries Biologist.

Matea Djokic (advised by Christine Verhille) graduated with a M.S. in Fish and Wildlife Management and has begun her Ph.D. graduate research at University of California, Irvine.

Shannon Hilty (advised by Andrea Litt) graduated with a M.S. in Fish and Wildlife Management and is working for Montana Fish, Wildlife & Parks as the Region 4 Nongame Biologist.

Jason Marsh graduated with a M.S. in Fish and Wildlife Management and is working for the U.S. Fish and Wildlife Service as a Biological Science Technician.

Paige Maskill graduated with a M.S. in Fish and Wildlife Management and is working for the U.S. Fish and Wildlife Service as a Fish Biologist.

Ben Triano (advised by Tom McMahon) graduated with a M.S. in Fish and Wildlife Management. He is currently providing consulting services and is weighing his options on where to take his career next.

Haley Tupen (advised by Kathryn Plymesser) graduated with a M.S. in Civil Engineering and is working as an Ecohydrologist for CBEC Eco Engineering in California.

Nick Voss graduated with a M.S. in Fish and Wildlife Management and is working for the Idaho Cooperative Fish and Wildlife Research Unit as a Ph.D. Graduate Research Assistant.

Research Technicians

Gavin Demorest
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Hilary Treanor
Jacob Williams
Nick Voss

Fish assemblage response to habitat restoration in Elk Springs Creek, Montana: implications for Arctic Grayling (*Thymallus arcticus*) restoration

Investigator
Alexander Zale
Unit Leader

Graduate Student
Jason Marsh, M.S.

Collaborators
George Jordan, Bill West, and Jeff Warren
U.S. Fish and Wildlife Service
Matt Jaeger
Montana Fish, Wildlife and Parks

Duration
March 2015 – January 2021
Completed

Funding
U.S. Fish and Wildlife Service
Eccles Foundation
MSU index 423077

The abundance and distribution of Arctic Grayling *Thymallus arcticus* in Montana have declined substantially during the past century as a result of habitat degradation and loss. Biologists tasked with conserving Arctic Grayling populations in the Centennial Valley of southwestern Montana implemented two habitat restoration projects to reclaim historical Arctic Grayling migration corridors and spawning habitats in Elk Springs Creek. I used before-after and before-after control-impact (BACI) study designs to evaluate the effects of these habitat restoration projects on physical habitat, water quality, and Arctic Grayling in Elk Springs and Picnic creeks. Because Arctic Grayling were rare in Elk Springs and Picnic creeks, I also examined the effects of restoration on two additional species (Brook Trout *Salvelinus fontinalis* and White Suckers *Catostomus commersonii*) with habitat requirements and life history characteristics similar to those of Arctic Grayling. I used electrofishing to monitor the abundance, biomass, and size distribution of each species before the restoration in 2016, and after the restoration during 2017 and 2018. A PIT-tag detection network monitored the seasonal movements

of Arctic Grayling, Brook Trout, and White Suckers from spring 2016 through autumn 2018. In situ data loggers measured summer stream temperatures and dissolved oxygen concentration in expected fish migration corridors both before and after restoration. The abundances and biomasses of Arctic Grayling and White Suckers were similar before and after restoration. However, Brook Trout abundance and biomass increased significantly in the restored (impacted) reaches relative to the unrestored (control) reaches two years after habitat restoration. The size-class distributions of Arctic Grayling and Brook Trout broadened after restoration. Movements of Arctic Grayling, Brook Trout, and White Suckers among unique habitat segments in Elk Springs and Picnic creeks increased after restoration, but pre-restoration movement data was sparse and limited inference. Following channel restoration, summer stream temperatures decreased, and dissolved oxygen concentration increased and equilibrated. Physical habitat improved (i.e., fine sediments decreased, and depth, percentage of pools, and gravels increased) in restored historical Arctic Grayling spawning areas. I thereby showed that channel reconnection and spawning habitat restoration can substantially improve water quality and physical habitat. However, the restoration measures implemented in Elk Springs Creek affected my target species disproportionately.

Environmental DNA as a means to estimate relative abundance of Yellowstone Cutthroat Trout spawning in tributaries to Yellowstone Lake

Investigator
Alexander Zale
Unit Leader

Graduate Student
Colleen Detjens, M.S.

Duration
January 2016 – December 2020
Completed

Collaborators
Todd Koel
Yellowstone National Park
Andrea Litt
MSU Department of Ecology
Mike Schwartz
U.S. Forest Service

Funding
National Park Service
MSU index 4W4525 (Institute on Ecosystems)

Invasive Lake Trout *Salvelinus namaycush* and whirling disease have reduced the abundance of native Yellowstone Cutthroat Trout *Oncorhynchus clarkii bouvieri* (YCT) in Yellowstone Lake, Yellowstone National Park, thereby disrupting the Yellowstone Lake ecosystem. One indication of the YCT population decline is the decrease in the number of adults returning to tributaries to spawn each spring. Yellowstone National Park implemented a gillnetting program to remove Lake Trout starting in 1995 to restore YCT abundance and size structure and thereby conserve the Yellowstone Lake ecosystem. An important metric for evaluating the success of the program is the number of YCT ascending spawning tributaries each year. Annually, 9 to 11 of these tributaries are visually surveyed on a weekly basis from May through July for the presence of spawners, but these surveys are time consuming. The use of environmental DNA (eDNA) has become increasingly common for determining presence of aquatic species and may provide managers with a more efficient tool for estimating abundances of YCT spawners. The primary objective of my study was to evaluate the efficacy and accuracy of using eDNA to detect the presence and estimate abundance of YCT spawners by collecting eDNA samples from spawning

tributaries to Yellowstone Lake in conjunction with visual surveys of YCT spawners. A secondary objective was to evaluate whether terrestrial or semi-terrestrial species such as grizzly bear *Ursus arctos horribilis* and North American river otter *Lontra canadensis* could be detected in a water sample from YCT spawning tributaries. Environmental DNA quantities were more effective for determining presence of YCT spawners than for predicting their abundances, but eDNA quantities were positively related to spawner abundances. The difference between eDNA rates when spawners are present versus absent may provide managers with an efficient method for monitoring YCT in tributaries throughout Yellowstone Lake basin. I also demonstrated that DNA from a terrestrial species, grizzly bear, can be detected in water samples. Incorporation of eDNA sampling with existing methods for monitoring YCT spawners in Yellowstone Lake tributaries would facilitate an increased scale of assessment and allow for detection and quantification of multiple species of current and future interest from single samples.

Identifying the threats of Smallmouth Bass to Yellowstone Cutthroat Trout in the Yellowstone River

Investigators

Alexander Zale
Unit Leader
Adam Sepulveda, Robert Al-Chokhachy
USGS Northern Rocky Mountain Science Center

Graduate Student

Nick Voss, M.S.

Collaborators

Mike Ruggles, David Schmetterling, Scott Opitz, Jason Rhoten
Montana Fish, Wildlife and Parks

Funding

Northern Rocky Mountain Science Center, USGS RWO 72, MSU index 4W5971, SITKA 4W8499

Duration

April 2016 – December 2020
Completed

Non-native fish introductions are a leading threat to freshwater biodiversity, and accurate assessments of future effects are often hindered by the challenge of anticipating future range expansion. Successful introductions of non-native Smallmouth Bass *Micropterus dolomieu* have occurred globally and often exhibit secondary spread to upstream habitat as has occurred in the Yellowstone River, Montana. Observations of adults in socio-economically valuable trout habitat have highlighted a need to better understand the controls on the upstream distribution of Smallmouth Bass in this system, particularly the influence of cold upstream climates on first-year growth and size-

selective overwinter mortality (a potential life history bottleneck at northern latitudes). We documented the phenology, growth, and survival of age-0 Smallmouth Bass in relation to water temperature between the uppermost distribution of adults and downstream regions where they are abundant. Successful reproduction (i.e., age-0 presence) was rare or absent throughout the uppermost 150 km of the upstream distribution of adults, suggesting that successful reproduction is currently prevented or discouraged farther upstream. Surprisingly, the mean late-autumn body size of age-0 Smallmouth Bass did not differ significantly among the uppermost 200 km of their distribution, despite upstream declines in ambient water temperature. Although water temperature was a key attribute affecting age-0 growth, upstream shifts towards earlier hatching mediated the expected negative effect of colder upstream climates. Furthermore, surveys of overwinter survivors and simulations of age-0 starvation mortality indicated that age-0 individuals at the upstream extent of their distribution successfully recruited to the age-1 year-class in four consecutive years. Taken together, our results suggest that Smallmouth Bass have not yet reached the thermal limit of their upstream distribution, and that first-year growth, survival, and consequent spread by this non-native predator are probably driven by the complex interactions of spawn timing and ambient thermal and hydrologic regimes in the Yellowstone River.

Total Project Cost		$ 74,858.00
Beginning Balance – January 2020		600.00
Expenditures – January 2020 – December 2020		
Salaries and Benefits	0	
Contracted Services	0	
Supplies	0	
Communications	0	
Travel	600.00	
Rent	0	
Repairs and Maintenance	0	
Tuition	0	
IDCs @ 15%	0	
Total Spent		600.00
Balance		0
Waived IDCs		264.00

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.

Duration
August 2016 – December 2020
Continuing

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

Funding
National Park Service
MSU index 4W6811

Restoration of Westslope Cutthroat Trout and fluvial Arctic Grayling 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 estimate population recovery, compare pre- and post-restoration population metrics, and determine contributions of Westslope Cutthroat Trout donor sources to the recovering population in East Fork Specimen Creek. As expected, Westslope Cutthroat Trout had reached later stages of population recovery in East Fork Specimen Creek than in Grayling Creek but downstream dispersal in both watersheds was limited. Few Arctic Grayling were captured in Grayling Creek, probably because of low survival and downstream emigration. However, we unexpectedly documented the first evidence of natural reproduction of fluvial Arctic Grayling in Yellowstone National Park in decades—a group of 10-15 fry were confirmed as Arctic Grayling through genetic analysis. Whereas all Westslope Cutthroat Trout donor sources contributed to the recovering Westslope Cutthroat Trout population in East Fork Specimen Creek, contributions were not proportional to numbers stocked, suggesting differences in donor source fitness. Furthermore, hybrids were found in both watersheds, probably resulting from barrier failure or incomplete eradication. Our findings have already helped Park managers

make adaptive management decisions and will help inform future conservation translocations.

Total Project Cost		$ 125,357.00
Beginning Balance – January 2020		32,005.79
Expenditures – January 2020 - December 2020		
Salaries and Benefits	20,415.40	
Contracted Services	22.92	
Supplies	0	
Communications	13.22	
Travel	762.46	
Rent	0	
Repairs and Maintenance	0	
Tuition	3,565.79	
IDCs @ 17.5%	3,712.46	
Total Spent		28,492.25
Balance		3,513.54
Waived IDCs		6,566.65

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, Montana DOJ

Funding

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

The Huntley Diversion Dam was constructed in 1934 at river km 566 on the Yellowstone River 15 km downstream of Billings, Montana. A nature-like fish bypass channel was constructed around the dam in the late 1990s to facilitate fish passage and was reconfigured to a more appropriate design in 2015. Nature-like bypass channels are unique in that they ostensibly allow the passage of a wide range of species because of their low gradients and reduced water velocities. However, site-specific evaluations of these structures are needed to determine their overall effectiveness and identify corrective measures if needed. The nature-like bypass channel at Huntley Diversion Dam has not yet been evaluated. Therefore, our objectives are to 1) quantify attraction, entrance, transit, and passage efficiencies (%) of fish of a variety of species through the bypass, 2) examine temporal, seasonal, and daily patterns of bypass use, 3) examine the effects of fish length and environmental variables on attraction and passage, and 4) characterize and model water depths, velocities, and flow patterns in and adjacent to the bypass channel.

We implanted a total of 3,861 fish of 14 species with passive integrated transponder (PIT) tags in 2019 and 2020, released them upstream or downstream of Huntley

Diversion Dam, and then used stationary PIT antennas to monitor their movement through the bypass channel. We detected 969 tagged fish in the bypass, representing all 14 species, during the study. Most fish movements occurred from April through August of each year, and mostly on the ascending limb of the hydrograph. Efficiencies varied among species, years, and locations of release. We are now estimating temporal metrics and performing detailed evaluations of attraction and passage. Observed fish telemetry data will be compared with output from the hydraulic models to more accurately locate passage bottlenecks, areas of high velocities, and periods of possible passage for a number of species to determine the overall effectiveness of the bypass channel.

We collected hydrologic and topographic measurements (water stage, flow rates, channel roughness, and detailed channel bathymetry) in the bypass channel throughout 2019 and 2020 and built two-dimensional hydraulic models of the entire bypass structure and surrounding Yellowstone River, with special emphasis on the downstream attraction flow and the upstream exit. Velocity outputs from these models were compared to species-specific swimming capabilities of four representative Yellowstone River fish species. Additionally, hydraulics at the downstream bypass entrance were evaluated for disorienting hydraulic formations that might prevent fish from locating the bypass entrance. Velocity results indicated that Sauger *Sander canadensis* successfully ascended the bypass on all but five days of the modeled hydrograph and may face occasional difficulty in returning to their pre-spawning upstream habitat. Burbot *Lota lota*, Channel Catfish *Ictalurus punctatus*, and Smallmouth Bass *Micropterus dolomieu* are unlikely to successfully ascend the bypass for much of May, June, and July, which holds significant implications for Channel Catfish and Smallmouth Bass, both of which move upstream to spawn in the months of May and June. Hydraulics at the downstream end of the bypass indicate high attraction at high flows, but lower flows probably create disorienting hydraulic characteristics at the entrance and lead to low fish attraction. Hydraulic sampling in 2020 focused on water velocities at the upstream exit of the bypass where velocities during peak runoff may exceed swimming abilities of all species of fish.

Total Project Cost		$ 157,429.00
Beginning Balance – January 2020		75,675.92
Expenditures – January 2020 - December 2020		
Salaries and Benefits	27,155.88	
Contracted Services	1,257.74	
Supplies	3,498.67	
Communications	0	
Travel	2,899.72	
Rent	1,350.00	
Repair & Maintenance	0	
Tuition	5,420.21	
Total Spent		41,582.22
Balance		34,093.70
Waived IDCs		18,296.18

Reproductive and basic life-history traits of Western Pearlshell mussels in Montana

Investigator
Alexander Zale
Unit Leader

Graduate Student
Kristen Cook, M.S.

Duration
May 2019 – May 2021
Continuing

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

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

The Western Pearlshell mussel is the only freshwater mussel inhabiting western Montana's trout streams and is a species of concern in the state. The decline of this species is particularly alarming considering the benefits that freshwater mussels provide to aquatic ecosystems. Conservation of Western Pearlshells in Montana will require fundamental information on their reproduction and life-history traits that is currently lacking. Our objectives are to (1) determine the timing and duration of reproductive events of Western Pearlshells in Montana, (2) determine if Western Pearlshell mussels in Montana are hermaphroditic, and (3) identify fish host species of Western Pearlshell populations in Montana. Reproductive events include gonadal development, fertilization, brooding of eggs or embryos, larval release, and larval infestation of hosts. We investigated the life-history traits of Western Pearlshell reproductive events in the Big Hole and Rock Creek watersheds in western Montana in 2019 and 2020. We extracted gonadal fluid and marsupial gill contents to identify gametes and embryo developmental stages, visually identifyied brooding mussels, collected stream drift to quantify larval presence, and electrofished to determine the timing and duration of larval infestation. Hermaphroditism was assessed histologically. Finally, we are identifying host species by capturing salmonids at mussel beds and examining their gills for larval infestation. The reproductive phenology of Montana Western Pearlshells differed among populations and years. Western Pearlshells brooded embryos for several weeks starting by mid-May or mid-June, and released larvae in mid-May to mid-July, depending on the population. Fish hosts were

infested with larvae from mid-May to early-September, depending on the stream. Infestations persisted for about 8 weeks during which larvae grew about five-fold in size before excystment. Adult mussels started developing eggs and sperm for the next spawning season by late-summer. Of 31 mature mussels histologically examined, all but one were gonadal hermaphrodites. Mussels reached sexual maturity at about 11 years of age, or 35 mm in size. We documented Westslope Cutthroat Trout, Brook Trout, Brown Trout, Rainbow Trout, and Mountain Whitefish infested with Western Pearlshell larvae to varying degrees. The probability of larval infestation, and the number of larvae per fish, were greatest for Westslope Cutthroat Trout and Brook Trout. Brown Trout, Rainbow Trout, and Mountain Whitefish were less likely to carry Western Pearlshell larvae. Our findings will inform future propagation and conservation efforts in Montana.

Total Project Cost, SITKA		$ 2,100.00
Beginning Balance – June 2020		2,100.00
Expenditures – June 2020 - December 2020		
Salaries and Benefits	633.95	
Contracted Services	765.00	
Supplies	89.99	
Communications	29.08	
Travel	0	
Rent	0	
Repair & Maintenance	0	
Tuition	0	
Total Spent		1,518.02
Balance		581.98
Waived IDCs		667.93

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
New, approved

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 will implement and compare multiple monitoring designs and sampling methods to inform long-term monitoring of Yellowstone Cutthroat, Rainbow, and hybrid trout abundances in the middle and lower Lamar River watershed.

Total Project Cost		$ 19,120.00
Beginning Balance – August 2020		19,120.00
Expenditures – August 2020 - December 2020		
Salaries and Benefits	6,615.50	
Contracted Services	0	
Supplies	1,828.08	
Communications	0	
Travel	140.88	
Repairs and Maintenance	0	
Tuition	2,844.67	
IDCs @ 17.5%	1,502.27	
Total Spent		12,931.40
Balance		6,188.60
Waived IDCs		3,028.72

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 – August 2021
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. This study will provide information that will allow for an understanding of the consequences associated with a novel suppression action in Yellowstone Lake.

Total Project Cost: 4W6204		$ 183,300.00
Beginning Balance – January 2020		66,205.46
Expenditures – January 2020 - December 2020		
Salaries and Benefits	33,247.98	
Contracted Services	4,151.56	
Supplies	1,673.34	
Communications	43.45	
Travel	371.26	
Tuition	11,440.39	
IDCs @ 17.5%	8,912.38	
Total Spent		59,840.36
Balance		6,365.10
Waived IDCs		13,495.92

Total Project Cost: 4W7971		$ 46,997.00
Beginning Balance – January 2020		44,855.80
Additional Funding -- 2020		46,510.00
Expenditures – January 2020 - December 2020		
Salaries and Benefits	268.80	
Travel	161.73	
IDCs @ 15%	64.58	
Total Spent		495.11
Balance		90,870.69
Waived IDCs		124.86

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
New, approved

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, trawling in Yellowstone Lake would add additional metrics to current Lake Trout spawning site prioritization. Our study will evaluate the distribution, density, hatch date, and diet of juvenile Lake Trout (< age 2) using benthic trawling. The data from this study will be used to prioritize suppression efforts among spawning sites.

Total Project Cost		$ 16,181.00
Beginning Balance – August 2020		16,181.00
Expenditures – August 2020 - December 2020		
Salaries and Benefits	1,592.88	
Contracted Services	0	
Supplies	1,720.43	
Communications	0	
Travel	0	
Rent	0	
Repairs and Maintenance	0	
Tuition	2,073.82	
IDCs @ 17.5%	579.83	
Total Spent		5,966.96
Balance		10,214.04
Waived IDCs		1,427.59

Lake Trout telemetry, Swan Lake, Montana

Investigators
Christopher Guy
Assistant Unit Leader

Collaborators
Carter Fredenberg, USFWS
Creston Fish and Wildlife Center

Graduate Student
Mike Siemiantkowski, M.S.

Funding
US Fish Wildlife Service
CESU MSU index 4W7111

Duration
February 2018 – October 2022
Continuing

Expansion of the Lake Trout population in Swan Lake, Montana, threatens one of the core area populations of Bull Trout in Montana. An experimental gillnetting program was conducted to suppress the Lake Trout population between 2009 and 2016. Unfortunately, the Lake Trout suppression program in Swan Lake ended because of monetary constraints and potential increases in Bull Trout bycatch. However, given the increased efficacy of embryo suppression methods, interest in Lake Trout suppression in Swan Lake is renewed. The specific objectives of this study were to identify Lake Trout spawning sites and quantify their area. Acoustic tags were surgically implanted in 48 Lake Trout in 2018, with an additional 37 Lake Trout implanted in 2019. Nightly tracking efforts during the autumn of 2018 resulted in 759 individual locations of 29 Lake Trout and 991 of 40 in 2019. Kernel-density analysis was used to evaluate Lake Trout locations and 10 putative spawning locations were identified—corroborating previous studies. For example, spawning continues to occur along the Highway 83 roadcut on the east shore of Swan Lake. In 2019, side-scan imaging was used at the 10 putative spawning locations to describe the composition and total area of suitable spawning substrate. Divers verified substrate assignments from side-scan imaging at 3 of the 10 locations. Quantification of the total area of spawning substrate where concentrations of Lake Trout occurred during the spawning seasons in Swan Lake will inform managers of the feasibility of implementing embryo suppression as a complementary technique to traditional gillnetting in Swan Lake.

Total Project Cost		$ 136,590.00
Beginning Balance – January 2020		55,855.09
Expenditures – January 2020 - December 2020		
Salaries and Benefits	19,419.95	
Contracted Services	<16.24>	
Supplies	493.11	
Communications	0	
Travel	594.87	
Rent	0	
Repair and Maintenance	0	
Tuition	5,701.81	
IDCs @ 17.5%	3,586.06	
Total Spent		29,779.56
Balance		26,075.53
Waived IDCs		6,941.28

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
Continuing

The Clark Fork River historically served as a migration corridor for adfluvial Bull Trout that used Montana tributaries for spawning and rearing, and Lake Pend Oreille for growth to maturity. Three main-stem dams fragment the Clark Fork River and isolate previously migratory Bull Trout populations. In 2000, Avista, owner and operator of the Noxon Rapids and Cabinet Gorge dams, implemented a manual transport program to restore and maintain connectivity for Bull Trout populations between the lower Clark Fork River and Lake Pend Oreille. To address passage issues regarding juvenile Bull Trout, Avista implemented the Tributary Trapping and Downstream Juvenile Bull Trout Transport Program. In this program, juvenile Bull Trout are trapped when out-migrating from their natal tributary and transported directly downstream to Lake Pend Oreille, eliminating any potential risk associated with passage through the reservoirs or physical downstream passage of the dams. Initially, management of the downstream program was generally based on trial and error, with the primary goal of maximizing the number of juvenile Bull Trout captured. More recently, efforts have been focused on using applied research to better inform decisions regarding program objectives. Graves Creek and East Fork Bull River are the focus of research efforts because they currently have the necessary infrastructure to allow for understanding Bull Trout outmigration dynamics. The objectives of this study are to estimate capture efficiency, abundance, and age distribution of out-migrating juvenile Bull Trout, timing distribution of out-

migration events, and biotic-abiotic factors that influence out-migration in Graves Creek and East Fork Bull River.

A total of 823 juvenile Bull Trout were captured and PIT-tagged in Graves Creek during the summer of 2019 and the summer of 2020. The mean density of Bull Trout in Graves Creek during the summer of 2019 was 7.7/100 m^2 (± 1.05) and 5.6/100 m^2 (± 1.00) in 2020. Using the permanent PIT-tag monitoring station and the permanent weir trap, 310 of these previously tagged Bull Trout were determined to have out-migrated over the duration of the study. The majority of out-migration of tagged fish occurred during the autumn trapping seasons (2019: n = 90, 2020: n = 104), and the spring 2020 trapping season (n = 87). The remaining 29 Bull Trout out-migrated when the trap was not fishing in the summer and winter months. In East Fork Bull River, 144 juvenile Bull Trout were captured and PIT-tagged in the summer of 2019 and the summer of 2020. The mean density of Bull Trout in East Fork Bull River during the summer of 2019 was 0.9/100 m^2 (± 0.33) and 1.2/100 m^2 (± 0.32) in 2020. Of these PIT-tagged juvenile Bull Trout, 18 were determined to have out-migrated over the duration of the study. The majority of out-migration of tagged Bull Trout occurred in the autumn of 2020 (n = 14), followed by the autumn of 2019 (n = 2), with one Bull Trout out-migrating in the spring of 2002, and one in the winter while the trap was not fishing. Continued use of these methods will provide insight into the interrelated factors that influence out-migration dynamics of juvenile Bull Trout and will be used to maximize the efficiency of the trap and transport program.

Total Project Cost		$ 118,004.00
Beginning Balance – January 2020		7,694.52
Additional Funding -- 2020		49,802.00
Expenditures – January 2020 - December 2020		
Salaries and Benefits	21,274.22	
Contracted Services	0	
Supplies	275.37	
Communications	0	
Travel	2,493.91	
Tuition	3,890.92	
IDCs @ 20%	5,586.86	
Total Spent		33,521.28
Balance		23,975.24
Waived IDCs		6,704.26

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.

Duration
July 2018 – June 2022
Continuing

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

Funding
Wyoming Game and Fish
MSU index 4W7263

Mountain Whitefish are coldwater sportfish native to rivers and lakes throughout the western United States and Canada. In the last two decades, Mountain Whitefish population declines have been reported in many waterbodies in the southern part of the species range. Problems with recruitment are suspected, but little research has been conducted to describe the spawning characteristics and early-life history of Mountain Whitefish. The most thorough investigation of Mountain Whitefish movement and early-life history in the southern portion of the species range was conducted in the Madison River, Montana — a population that has experienced recruitment problems. Conversely, the Mountain Whitefish population in the upper Green River, Wyoming, has consistent recruitment and a stable age structure. In this study in the Green River, we will use identical methods to those in the Madison River study, which will allow for direct comparisons between populations. Comparing the movement and early-life history characteristics between populations will provide a better understanding of the factors that may be limiting recruitment and produce additional knowledge on Mountain Whitefish. The research questions are: 1) what is the age structure, age at maturity,

fecundity, and spawning periodicity, 2) what are the large-scale movement patterns through the spawning period, and what influence do abiotic factors have on movement, 3) what is the spatial distribution and habitat preference of age-0 Mountain Whitefish in the spring, and 4) what are the similarities and differences between the Green River and Madison River populations?

One-hundred twenty-seven Mountain Whitefish were collected in the autumn of 2019 to assess the age structure, age at maturity, fecundity, and spawning periodicity in the upper Green River. We found that the Green River population has an older age structure than that in the Madison. Age at maturity was similar between the populations with 50% reaching maturity at ages of 2 to 2.6 years. Both populations were highly fecund with a mean of 16,442 eggs/kg for fish in the Green River and a mean of 18,454 eggs/kg for fish in the Madison River. Both populations exhibited annual spawning.

In the spring and summer of 2019 and 2020, we implanted 96 radio transmitters in sexually mature Mountain Whitefish and tracked fish from 1 September to the end of the spawning period. The spawning season was determined by assessing the spawning stage (i.e., reproductive, spawning, spent) of Mountain Whitefish sampled by angling and embryos collected on egg mats. We located four general spawning areas in the study area, and most tagged Mountain Whitefish only moved a short distance to spawn. The upper Green River population mostly spawned from mid to late October, which is about one week earlier than the spawning period in the Madison River. Water temperature was much cooler during the spawning and early embryo development period in the Green River than in the Madison. Water temperature in the Madison River was often above the upper critical water temperature for embryo development and may be contributing to reduced recruitment. The research conducted here has increased our knowledge on the reproductive ecology of Mountain Whitefish and has helped identify mechanisms that could be contributing to the population decline in the Madison River.

Total Project Cost		$ 227,809.00
Beginning Balance – January 2020		103,350.17
Additional Funding -- 2020		59,486.00
Expenditures – January 2020 - December 2020		
Salaries and Benefits	25,682.00	
Contracted Services	31.55	
Supplies	10,769.93	
Communications	7.75	
Travel	6,927.74	
Rent	1,000.00	
Repair & Maintenance	0	
Tuition	4,153.05	
IDCs @ 20%	9,714.45	
Total Spent		58,286.47
Balance		104,549.70
Waived IDCs		11,657.29

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.

Total Project Cost		$ 58,004.00
Beginning Balance – July 2020		58,004.00
Additional Funding -- 2020		56,132.00
Expenditures – January 2020 - December 2020		
Salaries and Benefits	24,175.18	
Contracted Services	67.61	
Supplies	6,904.30	
Communications	0	
Travel	2,975.56	
Rent	0	
Repair & Maintenance	0	
Tuition	4,089.42	
IDCs @ 20%	7,642.41	
Total Spent		45,854.48
Balance		68,281.52
Waived IDCs		9,170.90

Spawning readiness, spawning locations and habitat use of Pallid Sturgeon in the Missouri River above Fort Peck

Investigators
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Assistant Unit Leader
Molly Webb
U.S. Fish and Wildlife Service

Graduate Student
Tanner Cox, M.S.

Collaborator
Luke Holmquist
Montana Fish, Wildlife and Parks

Funding
Montana Fish, Wildlife and Parks
MSU index 4W6930

Duration
September 2017 – June 2020
Completed

Conservation propagation of Pallid Sturgeon above Fort Peck Reservoir has successfully recruited a new generation of spawning-capable Pallid Sturgeon to a location that would otherwise have fewer than 30 individuals remaining. Successful recovery of Pallid Sturgeon will now rely on spawning in locations that provide adequate drift distance for larvae to recruit. Prior to this study, all reproductively active female Pallid Sturgeon underwent ovarian follicular atresia. The reasons for and prevalence of ovarian follicular atresia were unclear, spawning periodicity of females remained undescribed, and status of remaining prepubescent fish indicated that age- and size-at-first maturity would vary more than currently described. Furthermore, spawning location, spawning-related interactions among conspecifics, and substrate composition at spawning locations remained undescribed. We used data on reproductive status and location to describe age- and size-at-first maturity, the prevalence of ovarian follicular atresia during first gametogenic cycles, spawning periodicity of female and male Pallid Sturgeon where spawning occurs, if spawning locations are related to discharge, if substrate characteristics at the spawning locations were similar to other river reaches, and if female, male, and atretic female Pallid Sturgeon use the river similarly. Pallid Sturgeon matured at older ages and larger sizes than described for other populations with females maturing at 18 years old and males at 15; however, prepubescent Pallid Sturgeon as old as 20 years were documented. During the presumed-first gametogenic cycle, 62.5% of female Pallid Sturgeon underwent follicular atresia. Females had biennial reproductive cycles, and males had annual and biennial reproductive cycles. Reproductively active male and female Pallid Sturgeon were found in similar locations, while locations of atretic female Pallid Sturgeon varied. The farthest upstream locations of Pallid Sturgeon including locations in the Marias River occurred during 2018 when discharge was at an unprecedented high. Spawning occurred in locations less than 131 km from the river-reservoir transition zone, which does not provide adequate drift-distance for larvae. Altering discharge and water temperature at Tiber Dam to mimic observed values in 2018 may increase use of the Marias River by Pallid Sturgeon during spawning, which would provide adequate drift distance to larvae.

Total Project Cost		$ 150,075.00
Beginning Balance – January 2020		33,842.49
Expenditures – January 2020 - December 2020		
Salaries and Benefits	24,284.53	
Contracted Services	730.00	
Supplies	6,234.69	
Communications	0	
Travel	1,486.90	
Rent	0	
Repair and Maintenance	0	
Tuition	1,082.66	
Total Spent		33,818.78
Balance		23.71
Waived IDCs		14,880.27

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

Investigators
Christopher Guy
Assistant Unit Leader
Molly Webb
U.S. Fish and Wildlife Service

Research Associate
Hilary Treanor

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 also 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 2020, we completed a trial 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). However, we observed considerable variability between families, with Family 2 exhibiting reduced survival compared to Family 1 across diet treatments. Despite the variability, 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, even for lower-quality genetic lots. Our individual length data further demonstrated a protective benefit against the genetic effect. Individuals in Family 1 were longer than individuals in Family 2 in all diet treatments except those fed *Artemia*. Individual lengths at the end of the trial were similar in both families for larvae fed solely *Artemia.* A similar pattern was observed for individual weight at the end of the trial, with the *Artemia* diet treatment providing a protective benefit to the lower-quality genetic lot.

Total Project Cost		104,451.00
Beginning Balance – January 2020		9,893.22
Additional Funding -- 2020		51,938.00
Expenditures – January 2020 - December 2020		
Salaries and Benefits	24,357.38	
Contracted Services	7,567.50	
Supplies	2,869.97	
Travel	0	
IDCs @ 15%	5,219.25	
Total Spent		40,014.10
Balance		21,817.12
Waived IDCs		10,090.51

Reproductive indices of hatchery-origin White Sturgeon in the lower Columbia River, Canada

Investigator
Molly Webb
U.S. Fish and Wildlife Service
Christopher Guy
Assistant Unit Leader

Graduate Student
Paige Maskill, M.S.

Collaborators
James Crossman
BC Hydro

Funding
U.S. Fish and Wildlife Service
MSU index 4W6791

Duration
August 2017 – June 2020
Completed

Conservation aquaculture has been successful in preventing extirpation of endangered White Sturgeon *Acipenser transmontanus* in the lower Columbia River (LCR), Canada. The goals of this project were to 1) determine if the hatchery-origin (HO) population has reached puberty as many fish are of an age and body size to begin contributing to spawning and 2) assess the size, absolute growth rate (AGR), and relative condition factor (K_n) of the population. The reproductive structure (sex and stage of maturity) of the HO population was assessed using multiple tools (gonadal biopsy analyzed histologically, ultrasound, endoscopy, and plasma sex steroids). The accuracy of each tool was determined by comparing the assigned sex to the true sex determined by histological analysis of a gonadal biopsy. A subobjective was to determine whether gonadal development was homogenous (assessed in fish captured in LCR and Lake Roosevelt, Washington, USA). All fish assessed were pre-meiotic males (n = 158) or pre-vitellogenic females (n = 174) and had yet to reach puberty. Endoscopy and gonadal biopsy analyzed histologically were the most accurate tools with accuracies $\geq$ 97%. Gonadal development was homogenous in females but 38% of the males exhibited non-homogenous testicular development, with a few precocious cysts that contained germ cells in an advanced stage of development compared to the predominant phase seen throughout the biopsy. The size, AGR, and K_n were compared among sex, age, and river zone. Whereas the mean K_n indicated that the HO White Sturgeon were in average condition relative to all HO fish within the LCR, they were lower in condition compared to the full transboundary population (Canada and USA). This disparity reflects a difference between the environmental or physiological conditions of the fish in the LCR and those captured throughout the transboundary reach. These findings will allow determination of the reproductive dynamics of the hatchery-origin population over time (e.g., age and size at puberty, sex ratio) and specifically when fish will begin spawning in the wild. Additionally, our results will help to develop other standardized monitoring programs, which can track the reproductive structure of a population over time using tools with known accuracy rates.

Total Project Cost		$ 82,154.00
Beginning Balance – January 2020		11,782.75
Expenditures – January 2020 - December 2020		
Salaries and Benefits	1,832.49	
Contracted Services	140.94	
Supplies	3,032.98	
Communications	0	
Travel	610.45	
Rent	0	
Tuition	1,036.90	
IDCs @ 17.5%	982.94	
Total Spent		7,636.70
Balance		4,146.05
Waived IDCs		1,763.25

Determining causes, costs, and benefits of triploidization to improve sturgeon caviar production

Investigators
Christopher Guy
Assistant Unit Leader
Molly Webb
U.S. Fish and Wildlife Service

Collaborators
Joel Van Eenennaam, Andrea Schreier, Anne Todgham, UC Davis
Shawn Young, Kootenai Tribe of Idaho

Research Associate
Hilary Treanor

Funding
University of California Davis
MSU index 4W7205, 4W7795
4W8355

Duration
September 2017 – August 2020
Completed

Few studies have examined the relative performance of triploid and diploid finfishes from the perspective of aquaculture production. Because all sturgeon are naturally polyploid (4N, 8N, 12N), they may be more tolerant of genome size manipulation than other fishes. Although the utility of triploidization has yet to be explored in the sturgeon industry, unintentional induction of genetic triploidy (diploid 2x = 8N to triploid 3x = 12N) has been discovered in two White Sturgeon culture facilities. Our long-term objective is to evaluate the influence of spontaneous (unintentional) 12N sturgeon production on the caviar industry. We will determine whether 12N sturgeon represent a new avenue of improvement for sturgeon farming while simultaneously determining whether spontaneous triploid sturgeon negatively affect the industry. Specifically, the Bozeman Fish Technology Center will participate in evaluating non-reproductive females and their ploidy levels. To date, we have found that plasma T and E2 concentrations did not differ among ploidy levels in females. Plasma T concentrations were lower in females undergoing follicular atresia compared to females with ripe ovarian follicles (T: $p < 0.001$, $F = 27.624$, $df = 1$). Plasma T and E2 concentrations did

not differ between ploidy levels for immature females in Stage 1 and 2 (T: $p = 0.063$, $F = 3.56$, $df = 1$; E2: $p = 0.146$, $F = 2.156$, $df = 1$). Immature females (8N) that were vitellogenic (Stages 3 and 4) had low T and E2 concentrations compared to female White Sturgeon with normal gonadal development and few adipocytes present in the gonadal tissue. One possible explanation for the low steroid concentrations in Stage 3 and 4 females may be that because steroids are produced by the developing ovarian follicles, females with few ovarian follicles and considerable adipocytes may have low circulating steroid concentrations compared to females with many ovarian follicles and few adipocytes.

Total Project Cost		$ 34,417.00
Beginning Balance – January 2020		11,457.00
Expenditures – January 2020 - December 2020		
Salaries and Benefits	11,431.62	
Contracted Services	0	
Supplies	25.38	
Communications	0	
Travel	0	
Total Spent		11,457.00
Balance		0
Waived IDCs		5,041.08

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 – June 2021
Continuing

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. Reference ranges for hatchery-reared juvenile Pallid Sturgeon blood biochemistry were determined. We also plan to compare 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 2020		89,010.18
Expenditures – January 2020 - December 2020		
Salaries and Benefits	43,659.74	
Contracted Services	16,681.03	
Supplies	2,015.76	
Communications	0	
Travel	1,076.00	
Tuition	2,513.32	
Total Spent		65,945.85
Balance		23,064.33
Waived IDCs		29,016.18

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 2021
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. Three field seasons of monitoring non-lethal physiological measurements on wild-captured adult Pallid Sturgeon within the Central Lowlands Management Unit have been completed and an additional field season is currently underway. These data will be compared with data from the hatchery study to infer health status of wild-captured fish. To investigate environmental contaminants as a mechanism underlying emaciated adult Pallid Sturgeon, we are working toward collecting tissue biopsies from wild-captured Pallid Sturgeon for quantification of known contaminants of concern. To secure permits from the U. S. Fish and Wildlife Service for these collections, a hatchery study tested for effects of biopsy collection on hatchery adult Pallid Sturgeon; data analysis is in progress. 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 2020		102,608.52
Expenditures – January 2020 - December 2020		
Salaries and Benefits	29,746.39	
Contracted Services	27.75	
Supplies	3,506.62	
Communications	186.40	
Travel	<8.28>	
Awards	2,244.72	
IDCs @ 15%	5,355.54	
Total Spent		41,059.14
Balance		61,549.38
Waived IDCs		10,353.47

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.

Collaborator

Alexander Zale
Unit Leader

Funding

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

Duration

September 2019 – March 2021
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 (MFWP), the Montana Department of Natural Resources and Conservation (DNRC), the Natural Resources Conservation Service (NRCS), the United States Fish and Wildlife Service (USFWS), 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. These trials are expected to be completed in summer of 2021.

Total Project Cost		$ 99,955.00
Beginning Balance – December 2020		45,549.72
Additional Funding -- 2020		51,211.00
Expenditures – January 2020 - December 2020		
Salaries and Benefits	30,897.07	
Contracted Services	18,000.00	
Supplies	2,554.78	
Communications	0	
Tuition	7,771.10	
IDCs @ 15%	7,717.81	
Total Spent		66,940.76
Balance		29,819.96
Waived IDCs		17,174.66

Carnivore management and elk recruitment in western Montana

Investigators

Robert Garrott, Jay Rotella, MSU Department of Ecology
Terrill Paterson, Postdoctoral Research Associate

Graduate Student

Michael Forzley, M.S.

Collaborator

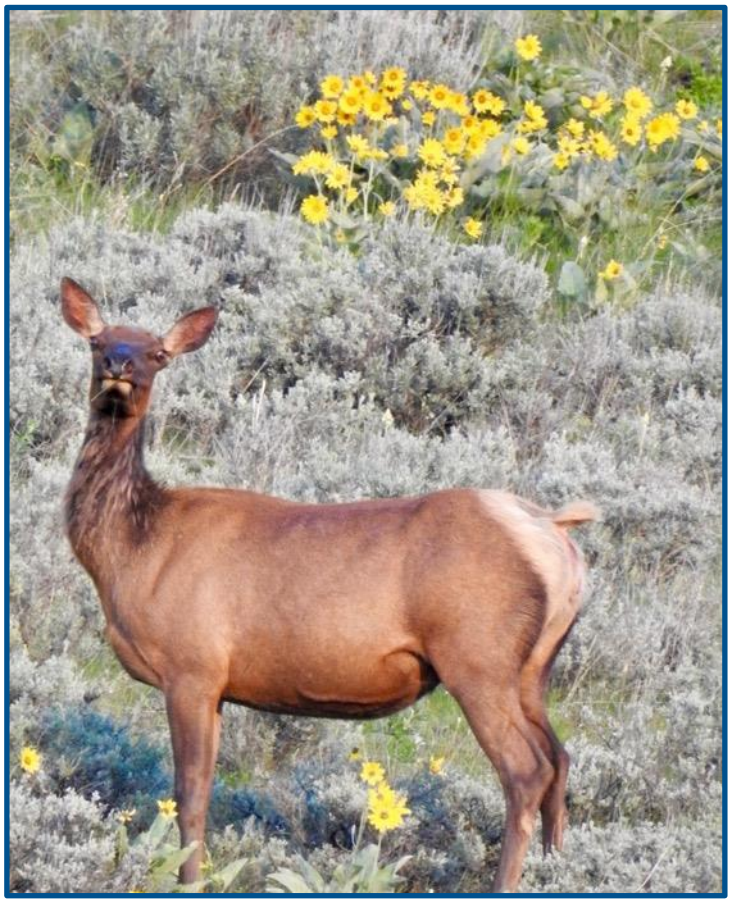
Kelly Proffitt
Montana Fish, Wildlife and Parks

Funding

Montana Fish, Wildlife and Parks
MSU index 4W5906

Duration

February 2016 – February 2021
Completed



Montana Fish, Wildlife and Parks Region 2 experienced long periods of uninterrupted increases in elk abundance in the mid-20th century followed by increases in large carnivore abundance starting in the late 20th century. These increases in large carnivore abundance coincided with decreases in elk calf recruitment and changes in elk abundance. To reduce predation on elk, wildlife managers applied integrated carnivore-ungulate management strategies. We determined the efficacy of increasing the harvest quotas for large carnivores to increase elk recruitment and elk populations, and evaluated potential variation in calf recruitment due to shifts in the age structure of female elk incurred through heavy harvests. First, we assessed the effects of mountain lion harvest management on their abundance by comparing their abundances in a watershed managed for carnivore reductions (i.e., treatment area) to abundances in a watershed that was managed for stable carnivore populations (i.e., control area) before after the harvest quota was increased. The increased mountain lion harvest quotas coincided with slight increases in mountain lion abundance in the control area and decreases in the treatment area. Second, we evaluated the effects of increased carnivore harvest quotas on elk calf

survival in the East Fork and West Fork watersheds of the Bitterroot River. Average rates of survival of female elk calves were lowest before the carnivore harvest treatment, highest during the carnivore harvest treatment, and intermediate 4-5 years after the carnivore harvest treatment. Increased rates of elk calf survival during the period of increased carnivore harvest quotas coincided with moderate evidence for decreased rates of mountain lion predation and no overall changes to the probabilities of black bear and wolf predation. Increased harvest of mountain lions may increase short-term elk calf survival and may increase calf recruitment. Third, to understand sources of variation in elk calf recruitment at the regional scale, we developed a population model that incorporated survey data and harvest numbers; per capita recruitment rates were negatively associated with cold, wet springs and severe winters and were positively associated with summer precipitation. Fourth, we evaluated the evidence for any long-term effects on population-level recruitment due to potential shifts in the age structure resulting from hunting harvest. Median age-specific pregnancy rates increased with age from yearlings to a plateau among prime ages, followed by a decline for the oldest ages. Annual survival rates were highest for yearlings, plateaued among prime ages, and declined for the oldest ages. Simulated population trajectories indicated that additional mortality due to harvest resulted in a shift in the age structure towards younger animals with lower probabilities of pregnancy. Populations with a low mean value of calf survival) and no additional mortality due to harvest had marginal demographic performance and could sustain no additional mortality from harvest and still increase. In contrast, productive populations with a high mean value of calf survival required high harvests to abate population growth. Effect of harvest on age structure was temporally lagged such that a shift towards younger animals could affect recruitment for multiple years following a reduction in harvest. Our work highlights the importance of considering the effect of varying age-structure on population dynamics, and provides the framework required for future management-specific recommendations using stochastic population projection matrices.

Total Project Cost		$ 909,000.00
Beginning Balance – January 2020		101,958.65
Expenditures – January 2020 - February 2021		
Salaries and Benefits	92,166.04	
Contracted Services	2,334.16	
Supplies	7,460.75	
Communications	0	
Travel	<2.36>	
Rent	0	
Repairs and Maintenance	0	
Tuition	0	
Total Spent		101,958.59
Balance		.06
Waived IDCs		44,861.78

Delineating and mapping ungulate seasonal ranges and movement corridors in Montana

Investigators
Jay Rotella, Robert Garrott
MSU Department of Ecology

Collaborator
Kelly Proffitt
Montana Fish, Wildlife and Parks

Research Associate
Blake Lowrey, MSU

Duration
May 2019 – June 2021
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). To delineate migration corridors, we first classified animals as migratory or non-migratory and delineated the start and end dates of each migration period. We then delineated individual migration corridors, which were then merged together to create a single migration footprint representing areas traversed by ≥ 1 collared individual during

migration period. We plan to repeat these analyses in 2021 for eight pronghorn populations. We will also work with FWP to provide the required data layers to populate a web page that will serve as an internal resource where FWP staff can download herd-specific maps as well as an online tool for the general public to learn about FWP research projects.

Total Project Cost 4W8069		$ 136,000.00
Beginning Balance – January 2020		136,000.00
Expenditures – January 2020 - December 2020		
Salaries and Benefits	66,992.18	
Contracted Services	0	
Supplies	234.99	
Travel	0	
Total Spent		67,227.17
Balance		68,772.83
Waived IDCs		29,579.96

Total Project Cost 4W8304		$ 38,640.00
Beginning Balance – March 2020		38,640.00
Expenditures – March 2020 - December 2020		
Salaries and Benefits	0	
Travel	0	
IDCs @ 15%	0	
Total Spent		0
Balance		38,640.00
Waived IDCs		0

Elk habitat management in Montana

Investigators
Jay Rotella, Robert Garrott
MSU Department of Ecology

Collaborator
Kelly Proffitt
Montana Fish, Wildlife and Parks

Research Associate
Terrill Paterson, MSU

Funding
Montana Fish, Wildlife and Parks
MSU index 4W8829

Duration
November 2020 – June 2025
New, approved

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. We will continue to collect and assess elk movement data as part of an initiative by Montana Fish, Wildlife and Parks (MFWP) to identify elk migration corridors and winter ranges and work cooperatively with partners to conserve these important habitats. Seasonal range and movement information is lacking for many elk populations in Montana, particularly in the central and eastern portion of the State. The project will build from previous security habitat studies in Montana and provide 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.

Total Project Cost		$ 144,275.00
Beginning Balance – November 2020		144,275.00
Expenditures – November 2020 - December 2020		
Salaries and Benefits	0	
Contracted Services	0	
Supplies	83,900.00	
Travel	0	
Tuition	0	
Total Spent		83,900.00
Balance		60,375.00
Waived IDCs		36,916.00

Characterizing foraging areas and maternity roost sites of bat species and evaluating the effects of forest disturbance

Investigator
Andrea Litt
MSU Department of Ecology

Collaborator
Claire Gower
Montana Fish, Wildlife and Parks

Graduate Student
Shannon Hilty, M.S.

Funding
Montana Fish, Wildlife and Parks
MSU index 4W6331

Duration
September 2016 – June 2020
Completed

Although bat roosts have been well-studied in the eastern United States, we know less about roosts in the west. Western bats may make use of trees and snags, as in the eastern US, but the Rocky Mountains provide more exposed rock, which could contribute to western bat species using different roosting features. Additionally, roost studies often focus on maternity colonies, and information on roosts used by male bats is limited. Given that roosting sites may be limiting, we aimed to quantify structural features of roosts used by male little brown myotis (*Myotis lucifugus*) in forests dominated by lodgepole pine (*Pinus contorta*) during the summer and determine whether bats are selecting roosts with particular features disproportionately to what is available on the landscape. We mist-netted for bats during the summers of 2017 and 2018 and attached transmitters to 34 male little brown myotis. We located at least 1

roost for 20 individuals (average = 2.85 roosts/bat, range = 1-6). Although snags were available, most bats roosted in rock features (86% in rocks, 14% in snags); rock roosts were mainly in vertically oriented crevices with (85%) instead of rock cavities (15%). Male bats were more likely to select roosts with less canopy closure (mean for used locations = 14.1%, SE = 2.3) that were closer to water (1063.1 m, SE = 136.2). They also selected roosts with more overall rock cover (77%, SE = 3), wider entrances (3.1 cm, SE = 0.3), and access to a skyward-facing crevice, creating warmer microclimates. Our work indicates that rock features provide essential summer habitat for male little brown myotis and that lodgepole pine in this landscape may not provide appropriate roosting features. Understanding how other bat species may be using rock features during summer and other seasons remains a sizeable information gap. Learning more about hibernacula is of great importance due to the spread of white-nose syndrome and rock features may be essential autumn transitional roosts and winter hibernacula at higher elevations. Roosts that provide variation in microclimate, including the potential for passive warming, could be very beneficial for bats recovering from white-nose syndrome.

Total Project Cost		$ 74,100.00
Beginning Balance – January 2020		3,325.45
Expenditures – January 2020 - July 2020		
Salaries and Benefits	1,674.26	
Contracted Services	99.02	
Supplies	130.07	
Communications	0	
Travel	345.20	
Tuition	1,076.90	
Repairs and Maintenance	0	
Total Spent		3,325.45
Balance		0
Waived IDCs		1,463.20

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
Continuing

Funding

Montana Fish, Wildlife and Parks
MSU index 4W5907

Rangelands used for domestic cattle grazing consist of the largest remaining tracts of native grassland that have not otherwise been fragmented by agricultural use or other human development. Grazing is the predominant land use across western North America and livestock grazing directly affects the structure, composition, and productivity of native grasslands. Grazing management within these rangelands therefore has a significant effect on the quality and extent of wildlife habitat. This project aims to evaluate the effects of various grazing systems on the ecology of sharp-tailed grouse (*Tympanuchus phasianellus*), grassland birds, and their predators by examining the effects of rangeland management practices prescribed by the Montana Upland Game Bird Enhancement Program on private lands in relation to the management systems employed on surrounding lands not enrolled in conservation easements. Specifically, we are looking at the effects of different grazing systems on sharp-tailed grouse nesting ecology, survival, and space use to determine if the management guidelines recommended by Montana Fish, Wildlife and Parks (FWP) are having an effect on grouse populations. We are also assessing the ecological effects of various grazing treatments by examining abundance and space use of the grassland bird and meso-predator assemblages within the study site. Our results suggest that the various grazing systems were not important predictors of grouse nest site selection, nest survival, adult survival, or space use and that, overall, the rest-rotation grazing system did not contribute to vegetation heterogeneity at a spatial scale that is relevant to breeding grouse. Further, no noticeable benefit of rest-rotation grazing on the abundance or species diversity of grassland birds existed relative to season-long and summer rotation grazing systems. Species-specific responses to livestock grazing systems occurred among three obligate grassland birds, but support for interactions between grazing system and local rangeland production potential limits the ability to

recommend general livestock management practices for the benefit of grassland bird populations. Occupancy of meso-carnivores was highest in rest-rotation grazing systems followed by season-long and summer rotation systems, respectively. Taken together, our results suggest that the rest-rotation grazing system recommended by Montana FWP did not have the greatest benefit for either sharp-tailed grouse or grassland birds.

Total Project Cost		$ 591,335.00
Beginning Balance – January 2020		159,813.21
Additional Funding -- 2020		57,360.00
Expenditures – January 2020 - December 2020		
Salaries and Benefits	64,826.10	
Contracted Services	1,305.42	
Supplies	12,817.86	
Communications	40.85	
Travel	1,840.79	
Rent	82.00	
Repairs and Maintenance	1,617.00	
Total Spent		82,530.02
Balance		134,643.19
Waived IDCs		36,313.21

Environmental Libby amphibole asbestos: potential risk of injury to U.S. Fish and Wildlife Service's trust resources and their habitat

Investigator
Deborah Keil
MSU Department of Microbiology and Immunology

Collaborator
David Rouse
U.S. Fish and Wildlife Service

Duration
September 2019 – May 2020
Completed

Funding
U.S. Geological Survey RWO 79
MSU index 4W7970

Very little research has been done on effects of asbestos exposures in the ecological environment. Only a few studies were found that explored effects of asbestos on wild populations of fish, crustaceans, reptiles/amphibians, small mammals, and birds. However, all of the studies that were found, including the Site-Wide Baseline Ecological Risk Assessment (BERA), did suggest at least the potential for effects on individual members or entire communities. The BERA, while providing extensive and extremely valuable information, should not be considered due diligence in the evaluation of the potential ecologic effect of Libby Amphibole (LA). Rather, it can be used as a baseline and a tutorial to tailor future studies. Studies need to be done now to evaluate populations, immune effects, and other short-term outcomes in view of the BERA results, new knowledge about LA and disease latency, and continuing exposures in Libby. The situation is unique in the Libby Asbestos Superfund Site compared to many other spill sites in that massive amounts of LA-containing material remains on the mountain, continuously blowing in the wind and washing down into the watershed lands, renewing and extending the exposures. The environmental concentrations (and therefore potential exposures) need to be re-evaluated to determine how they change over time to fully understand the ecological effects of LA.

In addition, other species that the BERA was not able to evaluate including larger, longer-lived animals should be included in future studies. Genetic studies can reveal changes in allele frequencies, changes in DNA methylation, and other epigenetic modifications that can lead to abnormal gene expression, all of which occur with asbestos exposure. Such studies can be done with small, non-invasive samples. Perhaps a tiered and targeted approach is needed, where fiber measurements at key sites (reference compared to animal collection sites) are followed up with optimal methods. For example, polarized light microscopy (PLM) can be used as a soil screen, but it should be followed up with transmission electron microscopy (TEM) to provide more sensitive evaluation of concentrations. Population studies should follow up those done in the BERA, plus key large animal populations, and then studies could be performed to detect immunological and genomic effects, which are far more sensitive

measures of health effects than gross lesions and histology, occur within the normal life-span of animals in the wild, and do not require killing the animals.

Total Project Cost		$ 18,867.92
Beginning Balance – January 2020		17,046.85
Expenditures – January 2020 - December 2020		
Salaries and Benefits	7,160.16	
Travel	0	
IDCs @ 15%	1,074.77	
Total Spent		8,234.93
Balance returned to Sponsor		8,811.92
Waived IDCs		2,388.13

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 2020		$ 6,233.96
Additional Funding		0
Expenditures – January 2020 - December 2020		
Salaries and Benefits	463.00	
Contracted Services	0	
Supplies	0	
Communications	0	
Travel	59.89	
Rent	0	
Repairs and Maintenance	0	
Tuition	265.55	
Administrative Fee @ 6%	31.37	
Total Spent		819.81
Balance		5,414.15

MTCFRU service project account

Investigators
Alexander Zale
Unit Leader

Collaborators
Bradley B. Shepard
B. B. Shepard and Associates

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 2020		$ 2,426.92
Additional Funding –		0
Expenditures – January 2020 - December 2020		
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

MTCFRU Gift Account

Investigators

Alexander Zale
Unit Leader
Jason Marsh
Graduate Student M.S.

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 2020		787.56
Additional Funding – 2020		0
STIP Interest 2020		4.60
Expenditures – January 2020 - December 2020		
Salaries and Benefits	0	
Supplies	0	
Travel	0	
Repairs and Maintenance	0	
Tuition	780.00	
Total Spent		780.00
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 2020		$ 88,932.76
Expenditures – January 2020 - December 2020		
Repairs and Maintenance	2,418.75	
Fuel	4,883.60	
New 2020 Dodge Ram	28,078.00	
Administrative Assessment Fee @ 6%	2,122.81	
Total Spent		37,503.16
Total Revenue Reimbursed		16,524.92
Balance		67,954.52

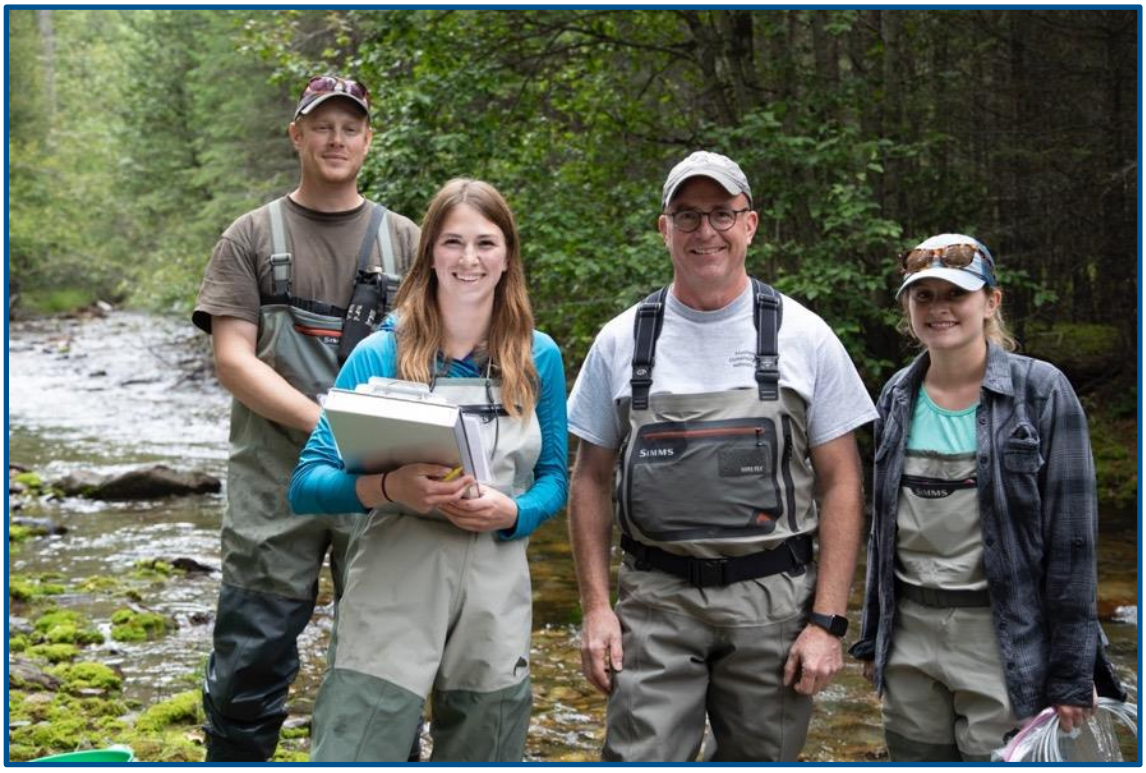
Montana Cooperative Fishery Research Unit Watercraft Account

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 2020		31,128.64
Expenditures – January 2020 - December 2020		
Repairs and Maintenance	2,032.22	
Fuel	3,873.29	
New	0	
Administrative Assessment Fee @ 6%	354.32	
Total Spent		6,259.83
Total Revenue Reimbursed		4,300.00
Balance		29,168.81



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 2020		$14,707.79
Expenditures – January 2020 - December 2020		
Maintenance	0	
Contracted Services	34.75	
Supplies	95.58	
Communications	717.00	
CCM	0	
Rent (storage unit)	8,440.00	
Parking expense	3,482.35	
Administrative Assessment Fee @ 6%	766.35	
Total Spent		13,536.03
Total Revenue from VPR		7,500.00
Balance		8,671.76

Monetary Equivalence for MSU Services and Facilities
January 2020 - December 2020

Program Manager salary and benefits	$ 62,054.00
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 ($1,010,054)	8,080.44
Utilities - General @ 12% of total expenditures ($1,010,054)	121,206.48
Unit Operations Account	7,500.00
Waived IDCs	318,187.31
Total	**541,501.69**

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 2020		$ 16,492.95
Additional Funding – 2020		40,000.00
Expenditures – January 2020 - December 2020		
Salaries and Benefits	259.46	
Contracted Services	955.24	
Supplies	9,506.56	
Communications	166.19	
Travel	4,221.41	
Rent	0	
Repairs and Maintenance	2,086.56	
Tuition	1,042.66	
Equipment	0	
Total Spent		18,238.08
Balance		38,254.87

Federal Budget
January 2020 - December 2020

Salaries and Benefits	$ 425,278.40
Equipment	144,546.00
Total	$ 569,824.40

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 45

2016 Chevrolet Silverado 2500, 4x4 crew cab (white)
Property No. 434174 – Serial No.1GC1KUE80GF252052
Acquisition value $35,644
Mileage 13,346

2011 Ford F250 4×4 crew cab (green)
Property No. 433429 – Serial No 1FT7W2BTOBEA70586
Acquisition value $31,697
Mileage 64,950

2005 Chevrolet Silverado 2500, 4×4 crew cab (green)
Property No. 430750 - Serial No. 1GCHK23G15F926039 (2005)
Acquisition value $22,948
Mileage 144,172

2002 Chevrolet 4×4 Suburban (white)
Property No. 261052 - Serial No. 3GNGK26U52G249012
Acquisition value $31,988
Mileage 146,906

1989 Chevrolet 4×4 Suburban (tan)
Property No. 261114 - Serial No. 1GNGV26K2KF176088
Acquisition value $15,766
Mileage 161,402

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 2,339

2017 Ford F150 Supercab (blue)
Serial No. 1FTFX1EF0HKD34442
Acquisition Value $26,826
Mileage 8,440

2014 Dodge Ram 2500 (white)
Property No. 135050
Serial No. 3C6TR5DT0EG281683
Acquisition Value $29,197
Mileage 51,806

2008 Ford Escape Hybrid 4WD (grey)
Property No. 132775
Serial No. 1FMCU59H78KA13346
Acquisition Value $26,554 (2007)
Mileage 45,146

2005 GMC Sierra 2500 crew cab truck (green)
Property No. 132353
Serial No. 1GTHK23G65F944780
Acquisition Value $24,463 (2005)
Mileage 176,459

2001 GMC 1/2 ton 4×4 extended cab truck (green)
Property No. 132228
Serial No. 2GTEK19T911227311

Acquisition Value $15,255 (2005)
Mileage 199,914

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)