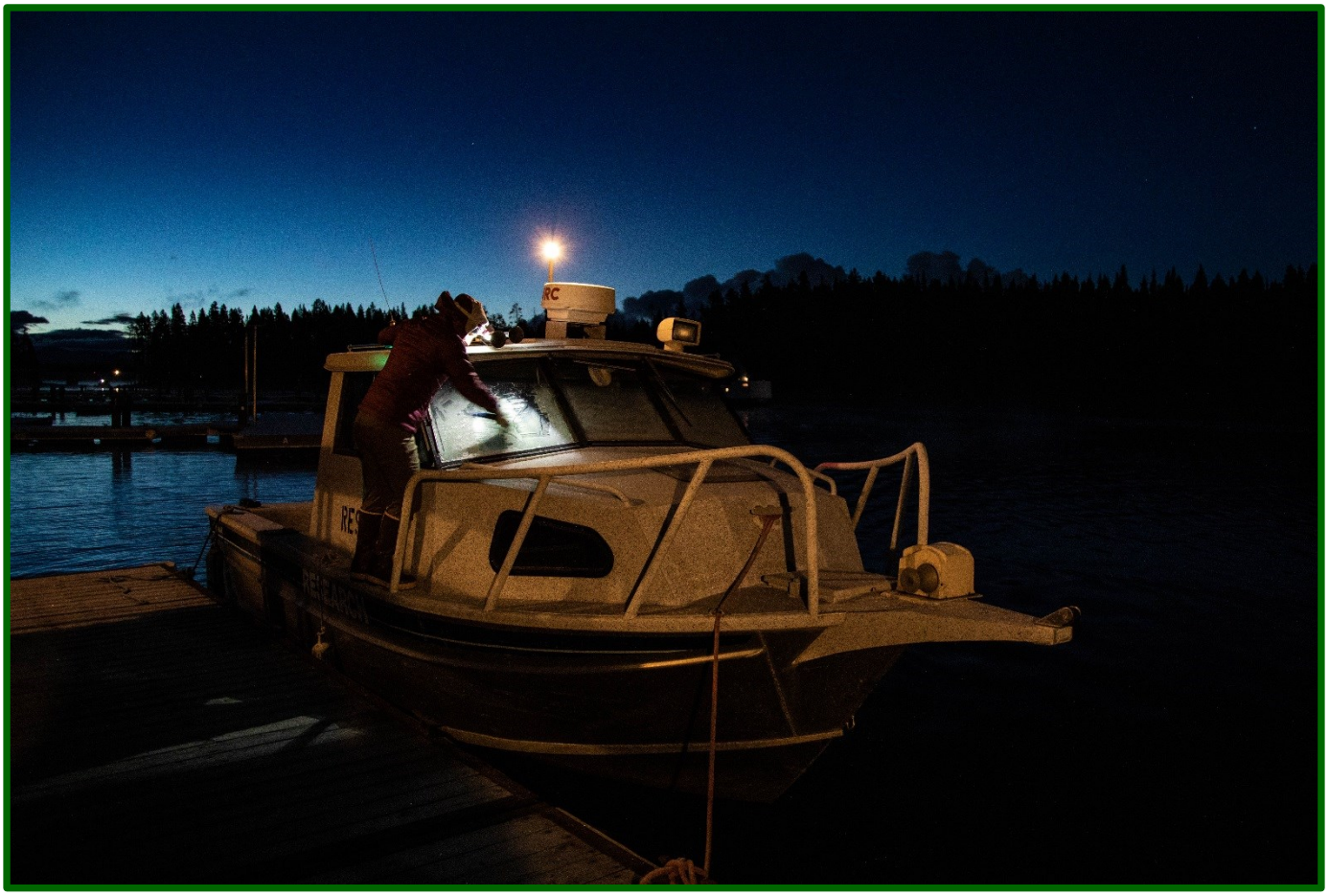
Montana Cooperative Fishery Research Unit

2019 Briefing Booklet



MONTANA COOPERATIVE
FISHERY RESEARCH UNIT

Coordinating Committee Meeting
Helena, Montana
14 May 2019

Personnel and Cooperators

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Daniel Kaus	M.S.
Michael Lance	M.S.
Jason Marsh	M.S.
Paige Maskill	M.S.
Lauren McGarvey	M.S.
Alex Poole	M.S.
Andriana Puchany	M.S.
Allison Stringer	M.S.
Nicholas Voss	M.S.
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Graduate Students Advised by Cooperating Faculty

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Shannon Hilty	M.S.
Megan Milligan	Ph.D.
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Skyler Vold	M.S.

Graduate Students Receiving Degrees

Daniel Kaus graduated with a M.S. in Fish and Wildlife Management and is working for U. S. Fish and Wildlife Service as a Fish Biologist.

Lauren McGarvey graduated with a M.S. in Fish and Wildlife Management and is working for the National Park Service as a Data Manager.

Alex Poole graduated with a M.S. in Fish and Wildlife Management and is working as a technician for Montana Fish, Wildlife & Parks in Region 1.

Allison Stringer graduated with a M.S. in Fish and Wildlife Management and is working for the USFS Custer Gallatin National Forest as a Fisheries Biologist.

Jacob Williams graduated with a M.S. in Fish and Wildlife Management and is working for Wyoming Game and Fish as a Fisheries Biologist.

Research Technicians

E J Ehrlich
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Trenton Heisel
Julianne Herrick
Will Mans
Ben Scott
Keith Wellstone
Jarod White
Matthew Williams

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.

Status of Northern Pearl Dace and chrosomid dace in prairie streams of Montana

Investigators
Robert Bramblett
Assistant Research Professor
Alexander Zale
Unit Leader

Graduate Student
Allison Stringer

Collaborators
Jake Chaffin
Bureau of Land Management
Steve Leathe
NorthWestern Energy

Duration
July 2014 – June 2018
Completed

Funding
Bureau of Land Management, CESU MSU index 4W5002
NorthWestern Energy
MSU index 433295

Non-native Northern Pike *Esox lucius* are predators that negatively affect native fish assemblages, possibly including those in Montana prairie streams, where their effects had not been investigated heretofore. We compared fish assemblages of prairie streams with and without Northern Pike and other non-native predators, with a focus on three species of concern that are probably particularly susceptible to predation (Northern Pearl Dace *Margariscus nachtriebi* (hereafter pearl dace), Northern Redbelly Dace *Chrosomus eos*, and Northern Redbelly Dace × Finescale Dace hybrids *C. eos* × *C. neogaeus* [hereafter hybrid dace]). We documented fish assemblages at 140 sites across the historical distribution of Northern Redbelly Dace and hybrid dace (hereafter collectively referred to as chrosomid dace), including 88 sites in the historical distribution of pearl dace. We estimated percent declines in distribution by comparing the number of currently occupied historical streams with the total number of historical streams and then determined if co-occurrence of pearl dace or chrosomid dace with non-native predators was different than predicted by chance. We augmented our dataset with fish collections from 5 additional sources and evaluated whether sites with and without Northern Pike differed in native species richness (with a Poisson regression) or assemblage composition (with a discriminant function analysis). Pearl dace distribution declined 63.3 to 83.3%, and chrosomid dace distribution declined 32.0% to 67.2%, depending on how declines were calculated. Pearl dace almost never co-occurred with Northern Pike or non-native trout and chrosomid dace rarely co-occurred with them. Native minnow species richness was 52% lower at sites with Northern Pike than at sites without Northern Pike. Predation probably caused the observed changes. Pearl dace are at extreme risk and chrosomid dace are at moderate risk of extirpation from Montana, and non-native predators appear to be the biggest threat to their continued persistence. Exclusion of Northern Pike from drainages where they have not yet invaded will afford fisheries managers the best chance of conserving native minnows in Montana prairie streams.

Total Project Cost		$ 172,500.00
Beginning Balance – January 2018		9,025.12
Expenditures – January 2018 - June 2018		
Salaries and Benefits	6,605.90	
Contracted Services	0	
Supplies	100.00	
Communications	0	
Travel	430.79	
Rent	0	
Repairs and Maintenance	0	
Tuition	543.30	
IDCs @ 17.5%	1,345.13	
Total Spent		9,025.12
Balance		0
Waived IDCs		2,035.20

Effect of water chemistry and pressure on lake trout embryos

Investigators
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Unit Leader
Molly Webb
Bozeman Fish Technology Center
U.S. Fish and Wildlife Service

Graduate Student
Alex Poole, M.S.

Collaborator
Todd Koel
Yellowstone National Park

Funding
National Park Service, CESU
MSU index 4W5648

Duration
September 2015 – January 2019
Completed

Introduced Lake Trout *Salvelinus namaycush* threaten native Yellowstone Cutthroat Trout *Oncorhynchus clarkii bouvieri* in Yellowstone Lake, Yellowstone National Park. Gill nets have been used to suppress subadult and adult Lake Trout since 1995. Because survival of embryonic and larval life history stages can have profound effects on population dynamics of Lake Trout, suppression at those stages, especially if used in concert with intensive gill netting of older fish, could enhance suppression efforts. Therefore, we conducted controlled laboratory and field experiments to systematically evaluate the effects of a variety of candidate chemical (sodium chloride, calcium carbonate, gelatin, and liquid and powdered rotenone), biological (carcass and carcass analog), and physical (sediment) suppression methods on different developmental stages of Lake Trout embryos and larvae. Liquid and powdered rotenone applications, fish carcass and carcass analog exposures, and sediment deposition significantly increased embryo mortality in laboratory experiments. Sodium chloride, calcium carbonate, and gelatin applications were not effective. In-situ exposure to ground carcass material in Yellowstone Lake resulted in 100% embryo mortality in 14 and 28 kg/m^2 biomass treatments; sediment deposition caused 97% embryo mortality among overwintering incubators. Embryo mortality was probably caused by hypoxic conditions within substrates. Embryo suppression methods differed in their effectiveness, rate at which mortality was achieved, and ease of application. These differences, as well as Lake Trout spawning site characteristics such as depth, contour, fetch, substrate size, interstitial depth, isolation, and presence of non-target organisms ultimately determine which embryo suppression method will be most applicable in a given situation. Nevertheless, implementation of successful embryo suppression techniques evaluated in this study could be used to increase mortality of Lake Trout in Yellowstone Lake. Incorporating effective embryo suppression in an Integrated Pest Management approach has the potential to provide more effective Lake Trout suppression in the long term.

Total Project Cost		$ 90,017.00
Beginning Balance – January 2018		27,166.35
Expenditures – January 2018 - January 2019		
Salaries and Benefits	19,101.63	
Contracted Services	0	
Supplies	0	
Communications	0	
Travel	211.75	
Rent	0	
Repairs and Maintenance	0	
Tuition	3,873.47	
IDCs @ 17.5%	3,979.50	
Total Spent		27,166.35
Balance		0
Waived IDCs		6,144.52

Seasonal movements of rainbow trout, brown trout, and mountain whitefish in the Smith River, Montana

Investigator
Alexander Zale
Unit Leader

Graduate Student
Michael Lance, M.S.

Collaborators
Jason Mullen, Montana Fish, Wildlife and Parks
Tom McMahon, MSU
Robert Al-Chokhachy, USGS
Grant Grisak, Northwestern Energy

Duration
January 2015 – December 2018
Continuing

Funding
Montana Fish, Wildlife and Parks
MSU index 4W5241

The life history patterns and vital rates of stream dwelling fish can differ across biological, spatial, and temporal scales. We determined the movement patterns and vital rates of three abundant salmonids—brown trout (*Salmo trutta*), mountain whitefish (*Prosopium williamsoni*), and rainbow trout (*Oncorhynchus mykiss*)—in the Smith River watershed of central Montana, a system with three distinct geomorphic regions: the headwaters, semi-wilderness canyon, and prairie. We marked 7,172 fish with half-duplex passive integrated transponder (PIT) tags, monitored their watershed-scale movements past 15 stationary PIT arrays over four years, and relocated fish between arrays by conducting mobile surveys along the Smith River and major tributaries. Fish movement patterns and survival rates varied seasonally, among species, and among locations within the watershed. Volume of movement and diversity of movers were both greatest in the canyon geomorphic region and in lower portions of tributaries. Fish rarely left the canyon, but movement into the canyon from other regions was common among some groups of fish. Mountain whitefish were most likely to move and brown trout were least likely to move. The stream lengths traversed by fish followed a leptokurtic distribution with most fish travelling < 10 km and decreasing numbers of fish travelling farther. Distinct life history patterns were not evident as judged by the stream lengths traversed by tagged fish; rather, a continuous spectrum of distances was apparent. Species-specific spawning periods were associated with increased frequency of movement by mountain whitefish and rainbow trout. Increases in the frequency of watershed-scale movements of all three species were associated mean daily water temperatures of 11.7–15.3°C, compared to periods when water temperatures were cooler or warmer. Annual rates of survival were highest among mountain whitefish (0.38–0.54) and lower among brown trout (0.16–0.38) and rainbow trout (0.08–0.39). Survival of rainbow trout was highest in the canyon as was survival of mountain whitefish. Survival of mountain whitefish was also high in the headwaters and lowest in the prairie. Movements of stream-dwelling fish in the Smith River watershed were diverse, allowed movement among habitats with different rates of survival, and probably contributed to meta-population function, population resiliency, and species diversity.

Total Project Cost		$ 150,922.00
Beginning Balance – January 2018		19,589.13
Expenditures – January 2018 - December 2018		
Salaries and Benefits	9,572.79	
Contracted Services	0	
Supplies	299.98	
Communications	0	
Travel	396.06	
Rent	0	
Repairs and Maintenance	0	
Tuition	4,187.45	
Total Spent		14,456.28
Balance		5,132.85
Waived IDCs		6,360.76

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 – September 2018
Continuing

Funding
U.S. Fish and Wildlife Service
(no MSU involvement)

Habitat fragmentation can have significant effects on migratory fish populations. Arctic Grayling (*Thymallus arcticus*) spawned in 11 tributaries of Upper Red Rock Lake in southwest Montana in the early 1900s but now persist in only Red Rock Creek. Elk Springs Creek, a spring-fed tributary to Upper Red Rock Lake, historically had a large Arctic Grayling spawning presence. Arctic Grayling were so abundant that the U.S. Bureau of Fisheries operated a spawning station near the springheads from 1898 to 1910 for the collection of gametes. However, operation ceased after an unsuccessful egg take in 1910 that coincided with the diversion of water from Elk Springs Creek into low-gradient marsh habitat (Swan Lake) by duck hunters. Managers attempted to restore a spawning run using remote site incubators (RSIs) with little to no success. Juvenile Arctic Grayling were occasionally detected in Elk Springs and Picnic creeks after RSI use began in 1999; however, no adults returned to Elk Springs Creek to spawn. Managers responsible for managing the Upper Red Rock Lake Arctic Grayling population hypothesized that Swan Lake was inhospitable to upstream-migrating Arctic Grayling spawning adults and downstream-migrating juveniles. Managers rerouted Elk Springs Creek into its historical channel, which bypassed Swan Lake in autumn 2016. We investigated the effects of habitat restoration on fish assemblages and water quality in Elk Springs and Picnic creeks. Movements of Arctic Grayling, White Suckers, and Brook Trout between Upper Red Rock Lake and Elk Springs Creek increased after habitat restoration. Four adult Arctic Grayling were observed in Elk Springs Creek after Swan Lake was bypassed. Twenty-two naturally produced juvenile Arctic Grayling were observed in Elk Springs and Picnic creeks after restoration. The abundance, biomass, and distribution of White Suckers and Brook Trout also increased in Elk Springs and Picnic creeks after restoration. Mean temperature at 1900 hours during summer decreased from 22 °C in 2016 to 17 °C in 2018. Mean dissolved oxygen concentration at 0600 hours increased from 2 mg/L during summer 2016 to 7 mg/L during summer 2018. Increases in fish abundance, biomass, and movement after restoration suggests that habitat restoration improved aquatic conditions and access to spawning habitats in Elk Springs and Picnic creeks.

Environmental DNA as a means to estimate relative abundance of Yellowstone cutthroat trout spawning in tributaries to Yellowstone Lake

Investigator
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Unit Leader

Graduate Student
Colleen Detjens, M.S.

Collaborators
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Yellowstone National Park
Andrea Litt
Assistant Professor MSU
Mike Schwartz
U.S. Forest Service

Duration
January 2016 – December 2020
Continuing

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

The population of Yellowstone cutthroat trout in Yellowstone Lake is one of the largest genetically pure populations within the species' native range and is therefore a conservation priority. The population has been stressed by several factors over the years, including whirling disease and drought. However, the most serious threat is illegally introduced lake trout. First detected in 1994, lake trout have continued to pose a threat to native cutthroat trout through competition and predation. As a result of these threats, particularly in response to the introduction of lake trout, fisheries managers in Yellowstone National Park have invested a sizable amount of effort and funds in the recovery of the Yellowstone cutthroat trout population. In addition to the efforts aimed at removing lake trout, park biologists are also concerned with assessing the recovery of Yellowstone cutthroat trout based on a series of metrics that define desired conditions for Yellowstone Lake. One such metric is the assessment of cutthroat trout spawning in tributary streams.

Environmental DNA (eDNA) has recently garnered significant attention for its potential in assisting fisheries monitoring programs. The method, which involves collecting a water sample and testing for specific species presence or absence, has proven successful in many instances. Furthermore, several studies have suggested that relative abundance may be inferred from eDNA concentrations. We aim to provide a better understanding of the relationship between eDNA concentrations and fish abundance, specifically as it relates to spawning Yellowstone Cutthroat Trout in Yellowstone Lake tributaries. Samples were collected from six tributaries in 2016, five in 2017, and three in 2018. Sample results are currently being analyzed.

Identifying the threats of smallmouth bass to Yellowstone cutthroat trout in the Yellowstone River

Investigators

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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

Duration

April 2016 – May 2019
Continuing

Non-native smallmouth bass (*Micropterus dolomieu*) introductions have negatively affected salmonids and other resident fishes in streams and rivers across the West. In the Yellowstone River, non-native smallmouth bass have demonstrated considerable range expansion from their initial stocking locations in the lower river (river km 293 – 474), and adults are now sympatric with wild and native trout near Livingston, Montana (river km 797), and potentially as far upstream as Emigrant, Montana (river km 844). Information about their current and potential distribution, habitat associations, and ecological interactions is therefore needed to assess the threat that smallmouth bass pose to other fishes in the Yellowstone River.

We set trap nets in side channels to determine the upstream extent of age-0 smallmouth bass in 2016, 2017, and 2018, as the presence of this life stage is indicative of habitats that are suitable for establishment by the species. We documented age-0 smallmouth bass as far upstream as Big Timber (river km 732) in 2016 and Reed Point (river km 700) in 2017 and 2018, indicating a discrepancy between the upstream extent of adult distribution and that of successful reproduction.

We hypothesized that increasingly cold upstream habitat was unsuitable for reproduction because low age-0 growth potential would lead to high size-selective overwinter mortality. We tested this hypothesis in 2018 by determining age-0 size at the onset of winter, hatch date, growth rate, thermal experience, and diet across 200 river km of their upstream distribution. Surprisingly, median age-0 size at the onset of winter was not significantly different across our study area. Estimates of hatch dates and growth rates were also counter to our predictions. Our results suggest that age-0 overwinter mortality is occurring, but is not currently preventing upstream establishment in the Yellowstone River.

Next steps include using these results to inform a bioenergetics model that will estimate age-0 growth potential and resulting overwinter mortality based on temperature data. This tool will allow us to evaluate the current and future potential for further upstream establishment in the Yellowstone River.

Total Project Cost		$ 74,258.00
Beginning Balance – January 2018		46,533.63
Expenditures – January 2018 - December 2018		
Salaries and Benefits	18,612.01	
Contracted Services	157.65	
Supplies	0	
Communications	0	
Travel	244.54	
Rent	250.00	
Repairs and Maintenance	114.00	
Tuition	4,643.05	
IDCs @ 15%	3,603.19	
Total Spent		27,624.44
Balance		18,909.19
Waived IDCs		6,966.16

Linkages between unpaved road sediment production and instream sediment and the interactions between habitat, native trout eDNA, and abundance.

Investigators
Alexander Zale
Unit Leader
Robert Al-Chokhachy
USGS NOROCK

Graduate Student
Kyle Crapster, M.S.

Duration
August 2016 – September 2019
Continuing

Collaborators
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Ladd Knotek, MTFWP
Tom Black, Charles Luce, Shane Hendrickson, Michael Young
USDA Forest Service

Funding
USDA Forest Service , CESU
MSU index 4W6280
RWO 73 4W6610

Native trout populations are becoming increasingly vulnerable to interactions between large-scale natural and anthropogenic disturbances. To focus conservation efforts on mitigating these emergent threats, we must understanding the implications of climate and land management on aquatic habitats and the linkage of habitat to populations at multiple scales. One such anthropogenic disturbance tied to land management is road networks. For example, the U.S. Forest Service road network exceeds over 600,000 kilometers and serves as a primary sediment contributor to streams. However, road sediment contributions and subsequent habitat degradation are dependent on the extent of an unpaved road network and its context within the landscape. Mechanistic models for estimating road sediment production are currently being refined but lack validation from in-stream sediment monitoring.

To address this need, we initiated a field study to improve our understanding of linkages between roads and instream sediment. We focused on three watersheds (12-digit Hydrologic Unit Code; Cold Creek, Finley Creek, and Poorman Creek) within the Southwest Crown of the Continent in Montana. We selected these watersheds to capitalize on previous field and modeling studies of road-stream sediment delivery points, spatially explicit sediment production estimates, and stream connection points. Within each basin we focused on three road-stream connection points to evaluate road-stream sediment patterns as these typically represent primary sources of sediment and direct pathways for road sediment contributions to streams. We sampled suspended sediment and streambed sediment above and below each road-stream connection point to quantify the difference as a measure of the sediment contributed from the roads. Instream fine sediment above road sediment delivery points serve as a baseline and the difference in above and below measures (delta; Δ) isolates sediment contributions from that individual road sediment. Measures of instream fine sediment below the road-stream connection point will be used to represent the total fine sediment transport or retention within the stream segment. In addition, we deployed stream stage loggers to

quantify the hydrologic regime and control for differences in suspended sediment that arise from changes in hydrology. Next steps are to analyze the field data to specifically quantify the variability in road-stream sediment linkages, provide insights into the importance of restoring roads in the study area, and provide insights into the most effective approach for monitoring road-stream sediment linkages.

An additional challenge in understanding biological effects of large scale disturbances such as road networks is monitoring fish populations at corresponding scales. Rapid and cost-effective tools that allow managers to effectively scale up population abundance estimates are therefore needed. Whereas environmental DNA (eDNA) has the potential to assess fish abundances, considerable variability exists in the relationship between eDNA concentration and fish abundance. To address this limitation, we collected water samples to assess eDNA copy numbers (i.e., concentrations) and quantified the abundances of westslope cutthroat (*Onchorhynchus clarkii lewisi*) and bull trout (*Salvelinus confluentus*) at 20 streams across western Montana. In addition, we collected local habitat data at each sampling site to quantify how habitat conditions may account for the variability in the relationships between eDNA concentrations and fish abundance. Examining the relationship between relative abundance and eDNA concentrations, we found considerably different linear relationship between eDNA concentrations and abundance of the two species. Bull trout relative abundance showed a strong positive linear relationship with eDNA concentrations (r^2 = 0.74), but no relationship was apparent for westslope cutthroat trout (r^2 = -0.05). The different relationships illustrate the challenges of using and interpreting eDNA results across species. Next steps will be to incorporate the habitat data in attempts to reduce the variability in these relationships.

Total Project Cost 4W6280		$ 65,009.74
Beginning Balance – January 2018		33,603.04
Additional Funding – 2018		10,000.00
Expenditures – January 2018 - December 2018		
Salaries and Benefits	23,159.52	
Contracted Services	0	
Supplies	520.82	
Communications	0	
Travel	6,710.09	
Tuition	3,677.10	
Repairs and Maintenance	0	
IDCs @ 17.5%	5,961.75	
Total Spent		40,029.28
Balance		3,573.76
Waived IDCs		9,027.90

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

Investigator
Alexander Zale
Unit Leader

Graduate Student
Andriana Puchany, M.S.

Collaborators
Todd Koel
Yellowstone National Park
Bradley Shepard
B. B. Shepard and Associates

Duration
August 2016 – September 2019
Continuing

Funding
National Park Service
MSU index 4W6811

Native populations of Westslope Cutthroat Trout *Oncorhynchus clarkii lewisi* and Arctic Grayling *Thymallus articus* in Yellowstone National Park were reduced or eliminated through competition, predation, and hybridization with nonnative fishes that were historically stocked by managers, ostensibly to enhance sportfishing. National Park Service (NPS) fisheries managers carried out conservation actions aimed at restoring Westslope Cutthroat Trout (WCT) and Arctic Grayling populations in two watersheds in Yellowstone National Park, including East Fork Specimen Creek in the Gallatin River drainage and Grayling Creek in the Madison River drainage. Conservation actions included 1) building barriers impassable to upstream fish movement to isolate watersheds; 2) applying rotenone, a lethal fish toxicant, to eliminate all fish from the watersheds above the barriers; and 3) reintroducing native fish to the isolated watersheds.

NPS fisheries managers plan to continue restoration efforts of WCT and Arctic Grayling in additional park watersheds, but first want to understand how past conservation efforts performed to guide future restoration actions. Therefore, the goal of this research project is to assess the recovery and status of the reintroduced populations of WCT and Arctic Grayling in East Fork Specimen and Grayling creeks. Our specific objectives are to 1) assess population abundance, size structure, condition, individual growth, and reproductive success of WCT and Arctic Grayling; 2) determine the spatial distributions of restored WCT and Arctic Grayling in relation to the reintroduction sites; 3) determine how population size structure and condition of recovering WCT in East Fork Specimen Creek compare to those of the hybridized WCT population they replaced; and 4) estimate the genetic population structure of recovering Westslope Cutthroat Trout relative to the contributions of the various WCT donor sources (Last Chance, Geode, and Muskrat creeks, and Sun Ranch Hatchery). Attainment of these objectives will provide NPS fisheries managers with information needed to better manage these populations and to guide future restoration efforts elsewhere in the Park.

High Lake and Grayling Creek were sampled in 2018; however, fire activity prevented sampling in East Fork Specimen Creek. Only 12 WCT were captured with gill nets in High Lake. A total of 370 WCT (359 PIT-tagged) and 19 Arctic Grayling (all PIT-tagged)

were captured by jonboat electrofishing during two sample occasions on the main stem of Grayling Creek. We recaptured 25 WCT and two Arctic Grayling. Additionally, a total of 79 WCT and three Arctic Grayling were captured by backpack electrofishing in 18 pass-depletion sites on tributaries to Grayling Creek. Analyses are currently underway for these 2018 data and we plan to collect additional data in 2019 at all study sites.

Total Project Cost		$ 125,357.00
Beginning Balance – January 2018		125,357.00
Expenditures – January 2018 - December 2018		
Salaries and Benefits	27,678.16	
Contracted Services	195.66	
Supplies	5,004.76	
Communications	0	
Travel	5,006.48	
Rent	0	
Repairs and Maintenance	0	
Tuition	5,139.24	
IDCs @ 17.5%	6,629.84	
Total Spent		49,654.14
Balance		75,702.86
Waived IDCs		12,477.05

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

Investigator
Alexander Zale
Unit Leader

Graduate Student
Ian Anderson, M.S.

Collaborators
Mike Ruggles, Montana Fish, Wildlife and Parks
Kathryn Plymesser, Matt Blank, Joel Cahoon, Montana State University

Duration
September 2018 – March 2022
New, approved

Funding
Montana Natural Resource Damage Program, MT DOJ
MSU index 4W7278

The Huntley Diversion Dam was constructed in 1934 at river km 566 on the Yellowstone River 15 km downstream of Billings, Montana, to supply irrigation and municipal water. Following flooding in 1996 and 1997, repairs were made to the dam and a nature-like fish bypass channel was concurrently constructed around the dam; in 2015 the bypass channel was lengthened and reconfigured to a more appropriate design. Unlike traditional fish ladders, nature-like fish bypass channels are designed to facilitate the passage of a wide range of species due to their lower water velocities, reduced gradient, and sinuosity. The efficacy of a fish bypass is characterized by the ability of fishes to first locate (attraction) and then navigate the channel in its entirety (passage), with hydraulic conditions often dictating the success or failure of individual fish. The nature-like bypass channel around Huntley Diversion Dam has yet to be evaluated for its fish passage or hydraulic characteristics.

We will implant various sizes and species of fish with passive integrated transponder (PIT) tags and use stationary PIT tag antennas to continuously monitor fish movement both in and near the bypass channel. We will also electrofish, construct temporary weirs, and translocate fish into the channel to assess channel residency, movement of untagged fish, and locations of hydraulic bottlenecks, respectively. Together, these techniques will allow us to determine 1) approach, attraction, and passage efficiencies (%) of fish species through the bypass, 2) the locations of any passage bottlenecks, 3) fish passage durations, and 4) the seasonal and daily timing of fish passage. By coupling passage information with topography, bathymetry, and hydraulic surveys of the bypass, we will be able to predict the overall passability of the nature-like bypass channel at different hydrologic conditions.

Total Project Cost		$ 157,429.00
Beginning Balance – September 2018		157,429.00
Expenditures – September 2018 - December 2018		
Salaries and Benefits	0	
Contracted Services	0	
Supplies	12,697.03	
Communications	0	
Travel	0	
Total Spent		12,697.03
Balance		144,731.97
Waived IDCs		5,586.69

Reproductive events and timing of western pearlshells in Montana

Investigator
Alexander Zale
Unit Leader

Graduate Student
Kristen Cook, M.S.

Duration
May 2019 – May 2021
New, not yet approved

Collaborators
David Stagliano, Montana Biological Survey
Michelle Anderson, University of Montana – Western

Funding
State Wildlife Grants Program
U.S Fish and Wildlife Service

Western pearlshells are the only native freshwater mussel found in western Montana. Pearlshells have experienced significant range-wide reductions in Montana. Most of the populations left are at risk for extirpation and considered nonviable because of small population abundances and lack of recruitment. Future conservation efforts will probably involve propagation of pearlshells for augmentation or reintroduction, or the stocking of pearlshell-infected host fish. Any attempts to propagate pearlshells or infect host fish will require knowledge of reproductive timing and suitable fish host species for this mussel in Montana. However, very little is known about the reproductive biology of western pearlshells in Montana. Furthermore, it is unclear at which life stage nonviable populations of pearlshells are being limited. The objectives of this study are to (1) determine the timing of reproductive events of Montana pearlshell populations, specifically fertilization and glochidial release, in relation to temperature, (2) determine which fish host species are being used by pearlshells in Montana, and (3) determine if nonviable pearlshell populations are being limited at reproductive, larval, or juvenile life-stages.

Assessing landscape connectivity of Denil fishways for Arctic Grayling in the upper Big Hole River

Investigators
Thomas McMahon
MSU
Kevin Kappenman
U.S. Fish and Wildlife Service

Collaborators
Matt Blank, Kathryn Plymesser,
Joel Cahoon, Nolan Platt
MSU Engineering and Western
Transportation Institute

Graduate Student
Benjamin Triano, M.S.

Funding
U.S. Geological Survey RWO 74
MSU index 4W6821

Duration
August 2017 – March 2019
Continuing

The upper Big Hole River basin supports the only indigenous, self-sustaining, and confirmed fluvial population of Arctic grayling in the lower 48 states. Movement is an integral component of the life history of Big Hole grayling, but the Big Hole and its tributaries are fragmented by irrigation diversions that support agricultural practices in the valley. A Candidate Conservation Agreement with Assurances (CCAA) was established in 2006 to secure and enhance this population, and one of many CCAA conservation actions was the installation of Denil fish ladders at 63 irrigation diversions to improve aquatic connectivity. A thorough evaluation of these fishways is necessary to ensure proper function and provide adaptive management strategies to improve their efficiency. Our objectives are to (1) characterize site-specific hydraulic conditions throughout the water year through hydraulic modeling, (2) quantify fishway efficiencies for grayling and other species over a range of conditions through passage experiments, and (3) combine the results from hydraulic models and passage experiments to develop “passage windows” characterizing fishway efficiencies over annual flow patterns.

Hydraulic models have been built from physical and hydrologic data collected in 2017 to predict site-specific fishway conditions from stream discharge. In 2018, we quantified fishway efficiencies (attraction, entrance, and passage) over a range of physical (fishway slope) and hydraulic conditions (e.g., flow, attraction flow, entrance depth, exit depth) using Passive Integrated Transponder antenna arrays. Attraction and entrance limited overall efficiency, but passage of fish that entered fishways was greater than 90% across all taxa. We are currently modelling fishway efficiencies and will combine efficiency models with hydraulic model predictions to address our third objective. This research will provide stakeholders with design criteria and adaptive management strategies to improve the efficiency of Denil fish ladders in the Big Hole River basin.

Total Project Cost		$ 47,675.00
Beginning Balance – January 2018		39,572.82
Additional Funding – 2018		49,975.00
Expenditures – January 2018 - December 2018		
Salaries and Benefits	23,248.00	
Contracted Services	537.80	
Supplies	14,381.85	
Communications	13.65	
Travel	6,359.20	
Rent	1,817.43	
Repairs and Maintenance	22.99	
Tuition	4,472.10	
IDCs @ 15%	7,627.90	
Total Spent		58,480.92
Balance		31,066.90
Waived IDCs		14,747.61

Annual evaluation and development of benchmarks for Lake Trout suppression in Yellowstone Lake

Investigators
Christopher Guy
Assistant Unit Leader
John Syslo, Post Doc
Travis Brenden Research Associate

Collaborator
Todd Koel
Yellowstone National Park

Funding
National Park Service, CESU
MSU index 7263

Duration
July 2013 – May 2018
Completed

Introduced Lake Trout threaten to extirpate native Yellowstone Cutthroat Trout, an important species in the Yellowstone Lake ecosystem of Yellowstone National Park. A National Park Service (NPS) Lake Trout suppression program has been on-going since 1994; however, the effort has not resulted in a Lake Trout population decline. Consequently, recovery of the Yellowstone Cutthroat Trout is lacking. In August 2008, a panel of 15 independent scientists convened and evaluated the program. It was determined that because of the lack of an adequate monitoring design, existing data and analyses are insufficient for guiding the program. A top recommendation was that NPS address this issue and ultimately determine the level of harvest required to reduce Lake Trout abundance and set quantifiable benchmarks for the number of Lake Trout to be removed annually. Statistical catch-at-age and matrix-population models are used to assess the efficacy of the Lake Trout suppression program and quantify targets for exploitation and fishing effort. The level of Lake Trout suppression effort in 2017 again exceeded primary goals (70,000 100-m net nights). Continuing suppression at this level of effort for another seven years (for a total of 10 years) should yield clear evidence of population control. Statistical models indicate no further increase in overall Lake Trout abundance. Abundance of older Lake Trout continues to decline, reflecting the effect of the high levels of gillnetting effort and associated fishing mortality. In 2017, decline in the abundance of older Lake Trout was offset by an increase in recruitment of younger (age 2) fish. This is not an unusual phenomenon for a fish population in the early stages of decline. The number of Lake Trout removed annually remains high (≈300,000 in 2012-2015 and > 366,000 in 2017).

Total Project Cost		$ 85,165.00
Beginning Balance – January 2018		20,617.76
Expenditures – January 2018 - May 2018		
Salaries and Benefits	17,542.79	
Contracted Services	0	
Supplies	0	
Communications	0	
Travel	0	
Rent	0	
Repairs and Maintenance	0	
Tuition	0	
IDCs @ 15%	3,074.97	
Total Spent		20,617.76
Balance		0
Waived IDCs		5,087.41

Mobile tracking of Lake Trout in Yellowstone Lake

Investigator
Christopher Guy
Assistant Unit Leader

Collaborator
Todd Koel, Pat Bigelow
Yellowstone National Park

Graduate Student
Jacob Williams, M.S.

Funding
National Park Service, CESU
MSU index 4W5738

Duration
September 2015 – January 2019
Completed

Conserving Yellowstone Cutthroat Trout by suppressing invasive Lake Trout in Yellowstone Lake is a high priority for Yellowstone National Park natural-resource managers. Insight into the spatial structure of Lake Trout throughout the lake will help increase the efficacy of the Lake Trout suppression program. Lake Trout (N = 578) were surgically implanted with dual acoustic and radio transmitters from 2015 through 2017. Mobile acoustic (boat) and radio (fixed-wing aircraft) telemetry surveys were performed to identify aggregations of Lake Trout. Telemetry surveys occurred during the spawning period (autumn) in 2016 and during the summer and spawning period in 2017. Lake Trout exhibited distinct aggregations during the summer and spawning period. Lake Trout aggregated at nine locations during the summer 2017 and were most frequently located in the West Thumb. Lake Trout aggregated at 22 locations during the spawning period including 12 previously undocumented putative spawning locations. Two aggregations in the West Thumb, Carrington Island and Anglers Bluff, had the highest relative densities of Lake Trout. Aggregations during the summer were generally farther from shore, greater in depth, and more dispersed than aggregations during the spawning period. Targeting locations of Lake Trout, as identified through telemetry, with gill nets was an effective strategy for increasing catch-per-unit-effort. The Lake Trout suppression program is probably altering the behavior of Lake Trout in Yellowstone Lake, which explains the high number of spawning locations and low spawning site fidelity relative to other research studies on Lake Trout spawning behavior. This study provided valuable insight into the spatial structure of Lake Trout in Yellowstone Lake. The areas Lake Trout aggregated will continue to be targeted by gillnetting and novel embryo suppression methods.

Total Project Cost		$ 90,017.00
Beginning Balance – January 2018		31,114.71
Expenditures – January 2018 - January 2019		
Salaries and Benefits	20,395.83	
Contracted Services	0	
Supplies	100.00	
Communications	0	
Travel	2,267.05	
Rent	0	
Repairs and Maintenance	0	
Tuition	3,717.80	
IDCs @ 17.5%	4,634.03	
Total Spent		31,114.71
Balance		0
Waived IDCs		7,017.38

Lake trout telemetry, Swan Lake, Montana

Investigators
Christopher Guy
Assistant Unit Leader

Graduate Student
Mike Siemiantkowski, M.S.

Collaborators
Carter Fredenberg, Creston Fish And Wildlife Center

Funding
US Fish Wildlife Service
CESU MSU index 4W7111

Duration
February 2018 – October 2022
New, approved

The establishment of Lake Trout in Swan Lake, Montana threatens one of the last remaining robust populations of Bull Trout in Montana. An experimental gillnetting program was conducted between 2009 and 2016 with the goal of suppressing the Lake Trout population. Unfortunately, the Lake Trout suppression program in Swan Lake ended because of monetary constraints and the concern of excessive Bull Trout bycatch. However, there is renewed interest in Lake Trout suppression in Swan Lake given the advent of novel embryo suppression methods. For embryo suppression to be successful, the precise spawning locations of Lake Trout need to be determined. Therefore, this project was initiated in 2018 to build on previous telemetry projects to clearly define Lake Trout spawning locations. The specific objectives of this study are to identify Lake Trout spawning locations and quantify the area of those locations. In 2018, 48 Lake Trout were surgically implanted with acoustic tags. Nightly tracking efforts during the autumn of 2018 produced 759 individual locations for 29 Lake Trout. Kernel-density analysis was used to evaluate Lake Trout locations and corroborated previous studies; for example, spawning continues to occur in the littoral zone where debris from the Highway 83 roadcut occurs on the east shore of Swan Lake. Interestingly, the highest concentration of spawning Lake Trout occurred near the confluence of the Swan River, which was not considered a "hot spot" from previous research. Spawning was confirmed at four areas by observing embryos. In 2019, tracking will be repeated in the autumn; in addition, divers and side-scan imaging will be used to describe the total area of confirmed spawning sites to assess the feasibility of implementing embryo suppression in Swan Lake.

Total Project Cost		$ 57,479.00
Beginning Balance – February 2018		57,479.00
Expenditures – February 2018 - December 2018		
Salaries and Benefits	16,104.28	
Contracted Services	58.60	
Supplies	6,467.34	
Communications	0	
Travel	4,596.48	
Rent	2,250.00	
Repair and Maintenance	1,623.83	
Tuition	1,097.90	
IDCs @ 17.5%	5,390.13	
Total Spent		37,588.56
Balance		19,890.44
Waived IDCs		8,532.58

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
New, approved

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. Understanding the interrelationships among factors influencing out-migration dynamics will assist in making more informed decisions about the management of the juvenile transport program.

Total Project Cost		$ 20,800.00
Beginning Balance – May 2018		20,800.00
Expenditures – May 2018 - December 2018		
Salaries and Benefits	6,125.72	
Contracted Services	0	
Supplies	2,477.18	
Communications	0	
Travel	0	
Tuition	0	
IDCs @ 20%	1,720.58	
Total Spent		10,323.48
Balance		10,476.52
Waived IDCs		2,064.70

Spawning characteristics and juvenile sampling for mountain whitefish in the Green River, Wyoming

Investigator
Christopher Guy
Assistant Unit Leader

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

Graduate Student
Colter Brown, M.S.

Funding
Wyoming Game and Fish
MSU index 4W7263

Duration
July 2018 – June 2019
New, approved

Mountain Whitefish are a coldwater sport fish 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 done 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. This study will occur in the Green River and will use identical methods to those in the Madison River study, which will allow for direct comparison 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 this understudied species. The specific objectives of the study are: 1) identify large-scale movement patterns during the spawning period; 2) describe the age structure, age at maturity, fecundity, and spawning periodicity; 3) identify the drift distance of age-0 Mountain Whitefish; 4) identify which river reaches in the upper Green River have high age-0 Mountain Whitefish density; and 5) compare results between studies.

Total Project Cost		$ 112,854.00
Beginning Balance – July 2018		112,854.00
Expenditures – July 2018 - December 2018		
Salaries and Benefits	0	
Contracted Services	0	
Supplies	0	
Communications	0	
Travel	0	
Tuition	0	
IDCs @ 20%	0	
Total Spent		0
Balance		112,854.00
Waived IDCs		0

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

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 fishes in Yellowstone Lake and tissue from 359 individual fish during the 2018 field season. 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		$ 183,300.00
Beginning Balance – January 2018		183,300.00
Expenditures – January 2018 - December 2018		
Salaries and Benefits	23,830.05	
Contracted Services	1,420.42	
Supplies	6,913.81	
Communications	13.65	
Travel	4,094.78	
Rent	10,050.00	
Repairs and Maintenance	922.02	
Tuition	1,023.30	
IDCs @ 17.5%	8,446.91	
Total Spent		56,714.94
Balance		126,585.06
Waived IDCs		12,791.03

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

Investigators
Christopher Guy
Assistant Unit Leader
Molly Webb
US 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
Continuing

All reproductively-active female Pallid Sturgeon monitored from 2014 through 2016 in the Missouri River above Fort Peck Reservoir, Montana underwent follicular atresia. Hatchery-origin Pallid Sturgeon that underwent follicular atresia may have experienced a spawning “dummy run” that would affect first-time reproductively-active female Pallid Sturgeon. Successful recruitment of Pallid Sturgeon is hindered by inadequate drift distance resulting in mortality of larval Pallid Sturgeon that settle in anoxic conditions found in the transition zone of Fort Peck Reservoir. Recruitment failure continues to prevent Pallid Sturgeon recovery in the upper Missouri River. Thus, knowledge of spawning site selection and reproductive status of Pallid Sturgeon is important to conservation of the species. The objectives of this study are: 1) describe age at first maturity; 2) describe spawning periodicity; 3) compare movement rates of reproductively-active Pallid Sturgeon to non-reproductively-active Pallid Sturgeon, atretic Pallid Sturgeon, and Pallid Sturgeon in other studies; 4) identify Pallid Sturgeon spawning locations; 5) describe habitat characteristics at aggregation and spawning locations; and 6) determine if a spawning “dummy run” contributes to follicular atresia. Six reproductively-active hatchery-origin female Pallid Sturgeon were tracked during the 2018 putative spawning season. Three of the six hatchery-origin female Pallid Sturgeon that were tracked spawned in the Missouri River between river kilometers 3100 and 3127—this is the first record of spawning in the Missouri River above Fort Peck Reservoir. Furthermore, reproductively-active female Pallid Sturgeon were documented in the Marias River for the first time and were located up to 52-km upstream from the confluence with the Missouri River; however, these fish did not spawn in the Marias River. Three hatchery-origin female Pallid Sturgeon underwent follicular atresia similar to previous years. Tracking and reproductive assessments of the 1997 year-class Pallid Sturgeon will be continued from May through July in 2019 to identify additional aggregation and spawning sites, evaluate reproductive health, and evaluate reproductive indices of hatchery-origin Pallid Sturgeon in the Missouri River above Fort Peck Reservoir.

Total Project Cost		$ 27,984.00
Beginning Balance – January 2018		21,153.65
Additional Funding – 2018		59,701.00
Expenditures – January 2018 - December 2018		
Salaries and Benefits	28,692.32	
Contracted Services	172.18	
Supplies	8,190.54	
Communications	0	
Travel	7,270.76	
Rent	2,850.00	
Tuition	3,207.00	
Repair and Maintenance	1,509.99	
Total Spent		51,892.79
Balance		28,961.86
Waived IDCs		22,832.83

Survival and abundance of paddlefish in the Missouri River above Ft. Peck Reservoir

Investigator
Christopher Guy
Assistant Unit Leader

Graduate Student
Hayley Glassic Ph.D.

Collaborators
Steve Dalbey, Cody Nagel
David Schmetterling, Montana Fish, Wildlife and Parks
Jay Rotella, Montana State University

Duration
June 2018 – June 2019
New, approved

Funding
Montana Fish, Wildlife and Parks
MSU index 4W7278

Paddlefish fisheries in Montana are highly valued. Given their life-history characteristics and their susceptibility to overharvest, sustainably managing Paddlefish requires precise and accurate population-dynamics information. Here, we describe the survival and abundance of the Paddlefish population in the Missouri River upstream of Ft. Peck Reservoir. We combined a 25-year Montana Fish, Wildlife & Parks (MFWP) mark-recapture dataset of 8,518 tagged Paddlefish to determine the feasibility of estimating survival and abundance using capture-histories. We used a suite of Cormack-Jolly-Seber (CJS) models to estimate survival and recapture rates. Additionally, we used a modified Jolly-Seber (POPAN) model to estimate spawning paddlefish abundance. The best-supported CJS model estimated a maximum female recapture rate of 0.02 and male recapture rate of 0.08. Female survival was estimated at a constant rate of 0.92 (CI 0.89 – 0.94), while male survival averaged 0.82 (0.53 – 0.94). Our best supported POPAN model estimated abundance of spawning females between 5745 (3045 – 10839) and 9982 (7183 – 13827) and abundance of spawning males between 4333 (3119 – 6020) and 12208 (8485 – 17564) individuals over the 25-year period. Our results will provide more precise information about the fishery and guide future sustainable management of the population.

Total Project Cost		$ 25,000.00
Beginning Balance – June 2018		25,000.00
Expenditures – June 2018 - December 2018		
Salaries and Benefits	8,273.10	
Contracted Services	0	
Supplies	0	
Communications	0	
Travel	0	
Total Spent		8,273.10
Balance		16,726.90
Waived IDCs		3,640.16

Walleye suppression in Buffalo Bill Reservoir

Investigator
Christopher Guy
Assistant Unit Leader

Graduate Student
Daniel Kaus, M.S.

Duration
July 2015 – December 2018
Completed

Collaborators
Mark Smith, Jason Burckhardt, Travis Neebling
Wyoming Game and Fish Department

Funding
Wyoming Game and Fish Department
MSU index 4W5474

Buffalo Bill Reservoir, Wyoming, is managed as a wild Rainbow Trout and Cutthroat Trout fishery. Nonnative Walleyes were discovered in 2008, and subsequent sampling of Walleye indicate natural recruitment and a rapidly expanding population. Walleyes pose a predation threat to the wild trout populations in Buffalo Bill Reservoir. The Wyoming Game and Fish Department (WGFD) is interested in suppressing the Walleye population using mechanical removal with electrofishing and gillnetting during the Walleye spawning period. The purpose of this study was to evaluate the population demographics of Walleyes in Buffalo Bill Reservoir. Age-structured population models were used to estimate the Walleye population growth rate for scenarios with and without Walleye removal. To inform the population models, age-specific fecundity, probability of maturity, natural mortality, and fishing mortality were estimated. Mean asymptotic population growth rate for the five scenarios were estimated as 1.22 (95% CI of 1.05 to 1.37) for no suppression, 1.18 (95% CI of 1.04 to 1.32) for electrofish exploitation, 1.04 (95% CI of 0.88 to 1.19) for gill-net exploitation, 0.91 (95% CI of 0.61 to 1.36) for angler exploitation, and 0.81 (95% CI of 0.66 to 0.96) for angler and gill-net exploitation combined. Results from the age-structured population models suggest that long-term population suppression is a feasible goal, and additional gill-net effort and angler harvest incentives should be pursued. As of this study, the density of mature Walleyes was low, indicating that the population had not yet reached carrying capacity. Analysis of population inertia indicates that the projected abundance of the initial population vector results in a lower population size compared to projected abundance of a population with stable-age distribution. Results from this study will be used to inform cost-effective management decisions regarding the future of the recreational fishery in Buffalo Bill Reservoir. The cost per mature female removed in 2017 was $490.91 and $80.08 for electrofish and gill net removal respectively. Future suppression efforts should be monitored using population indices of age diversity for female Walleyes.

Beginning Balance – January 2018		31,944.57
Expenditures – January 2018 - December 2018		
Salaries and Benefits	12,489.61	
Contracted Services	0	
Supplies	1,959.85	
Communications	0	
Travel	3,409.07	
Rent	0	
Repairs and Maintenance	0	
Tuition	7,301.15	
IDCs @ 20%	5,031.94	
Total Spent		30,191.62
Balance return to sponsor		1,752.95
Waived IDCs		6,038.32

Lake Roosevelt Burbot maturation study

Investigators
Christopher Guy
Assistant Unit Leader

Graduate Student
Lauren McGarvey, M.S.

Duration
December 2016 – December 2018
Completed

Collaborators
Confederated Tribes of the Colville Reservation

Funding
Confederated Tribes of the Colville Reservation
Bonneville Power Administration
US Fish Wildlife Service, CESU
MSU index 4W6449, 4W7209

Non-lethal tools (plasma sex steroid concentrations and ultrasound) were assessed to assign sex, stage of maturity, and reproductive condition (non-reproductive and reproductive) in Burbot from Lake Roosevelt, Washington. Gonadal tissue, plasma samples, and gonadal sonograms were collected from Burbot. Gonadal tissue was processed for histological analysis to describe gametogenesis and confirm sex, stage of maturity, and reproductive condition. Plasma testosterone (T) and estradiol-17β (E2) concentrations were measured by radioimmunoassay. Plasma 11-ketotestosterone (11-KT) concentrations were measured by liquid chromatography-mass spectrometry. Gametogenesis was described by gonadal histology during the entire reproductive cycle. Plasma sex-steroid profiles, gonadosomatic index, and ovarian follicle diameter were also described during the entire reproductive cycle. Plasma 11-KT concentrations were used to assign sex with 81% accuracy during the entire reproductive cycle, and plasma 11-KT and E2 concentrations were used to assign sex with 98% accuracy during the reproductive phase (i.e., November to March in Lake Roosevelt). In females, plasma T concentration, plasma E2 concentration, and month were used to assign stage of maturity with 87% accuracy, and plasma T concentration and plasma E2 concentration were used to assign reproductive condition with 98% accuracy. In males, plasma 11-KT concentration, girth at the urogenital pore, and month were used to assign stage of maturity with 73% accuracy, and plasma T concentration were used to assign reproductive condition with 90% accuracy. Ultrasound was used to assign sex with 97% accuracy, and ultrasound measurements of gonad size were a promising tool to assign stage of maturity and reproductive condition. Non-lethal tools (plasma sex steroid concentrations, gonad size measured by ultrasound, and ovarian follicle diameter) were also assessed to identify mass ovarian follicular atresia in female Burbot. Plasma T concentrations and ovarian follicle diameter were promising tools to identify mass ovarian follicular atresia. Nonlethal tools to assign sex, stage of maturity, and reproductive condition will enable fisheries biologists to assess indices of reproductive potential for the Burbot population in Lake Roosevelt. Indices of reproductive potential can be used characterize and monitor population demographics, improve models of population growth, establish sustainable harvest regulations, monitor the effects of management actions, and monitor the effects of environmental stressors.

Total Project Cost 4W6449		$ 45,579.00
Beginning Balance – December 2018		15,451.58
Expenditures – January 2018 - December 2018		
Salaries and Benefits	9,183.60	
Contracted Services	63.28	
Supplies	0	
Communications	0	
Travel	30.00	
Tuition	3,873.43	
IDCs @ 17.5%	2,301.27	
Total Spent		15,451.58
Balance		0
Waived IDCs		3,484.83

Total Project Cost 4W7209		$ 26,230.00
Beginning Balance – January 2018		26,230.00
Expenditures – January 2018 - December 2018		
Salaries and Benefits	11,571.04	
Contracted Services	6,960.00	
Supplies	1,118.74	
Communications	0	
Travel	0	
Tuition	3,141.56	
IDCs @ 17.5%	3,438.66	
Total Spent		26,230.00
Balance		0
Waived IDCs		6,039.71

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
Continuing

Conservation aquaculture has been the main recovery measure since 2001 for endangered White Sturgeon in the lower Columbia River, Canada. Survival of hatchery-origin fish has been high, with certain year classes estimated to be in higher abundance than the wild population. Furthermore, disproportionate survival among maternal family groups has led to lower than expected genetic diversity in the hatchery-origin population. It is important to determine the proportion of the hatchery-origin population that could be sexually mature and contributing to natural spawning. Therefore, the reproductive structure will need to be determined for the hatchery-origin population. There are tools available which can be used to assign sex and stage of maturity to fish that are not sexually dimorphic, such as sturgeons. However, all of these tools have error rates associated with them. The objectives of this research are: 1) determine the accuracy of multiple tools, ultrasound, blood plasma sex steroids, endoscopy, and gonadal biopsy to assign sex and stage of maturity in hatchery-origin and wild populations, 2) determine if gametogenesis occurs homogenously across the gonadal tissue in male and female hatchery-origin White Sturgeon, and 3) determine how biological (i.e., age, sex, and size) and environmental characteristics (i.e., discharge rate and water temperature) could influence the stage of maturity in hatchery-origin White Sturgeon in the lower Columbia River, Canada. Sampling will occur during the spring and fall of 2017 and 2018. To date, it has been determined that the hatchery-origin population has sexually differentiated but are not yet sexually mature. Additionally, it has been determined that an otoscope can be used to assign sex in the field across a variety of sizes and ages within the hatchery-origin population (97% accuracy). Plasma sex steroids can be used as a less invasive tool to determine whether the fish are reproductive or non-reproductive (100% accuracy), based on previously determined sex steroid concentrations.

Total Project Cost		$ 22,653.00
Beginning Balance – January 2018		13,262.95
Additional Funding – 2018		41,001.00
Expenditures – January 2018 - December 2018		
Salaries and Benefits	19,101.63	
Contracted Services	342.60	
Supplies	115.23	
Communications	0	
Travel	5,229.55	
Rent	<234.00>	
Tuition	2,282.70	
IDCs @ 17.5%	4,696.56	
Total Spent		31,534.27
Balance		22,729.68
Waived IDCs		7,111.99

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

Investigators

Christopher Guy
Assistant Unit Leader
Molly Webb
US 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

Duration

September 2017 – August 2020
Continuing

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.

Total Project Cost		$ 11,503.00
Beginning Balance – January 2018		11,503.00
Expenditures – January 2018 - December 2018		
Salaries and Benefits	11,320.98	
Contracted Services	0	
Supplies	182.02	
Communications	0	
Travel	0	
Total Spent		11,503.00
Balance		0
Waived IDCs		5,061.32

Carnivore management and elk recruitment in western Montana

Investigators
Robert Garrott, Jay Rotella
Professors, MSU
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 – June 2020
Continuing

Montana Fish, Wildlife Parks Region 2 in west-central Montana 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 in some areas. To reduce predation on elk, wildlife managers have applied integrated carnivore-ungulate management strategies over the past 5 years. In particular, carnivore harvest quotas have been increased in an attempt to reduce wolf, black bear, and mountain lion populations. Our goals were threefold and designed to determine the efficacy of increasing the harvest quotas for large carnivores to increase elk recruitment and overall elk populations.

First, we assessed the effects of mountain lion harvest management on mountain lion population abundance by comparing their abundances in a study area located within a watershed managed for carnivore reductions (i.e., treatment area) to abundances in a study area located within a watershed that was managed for stable carnivore populations (i.e., control area) before and 4 years after increased harvest quotas in the treatment area. We used DNA-based spatially-explicit capture-recapture models, in conjunction with telemetry information from collared individuals, to estimate mountain lion abundances. The increased mountain lion harvest quotas coincided with (1) slight increases in mountain lion abundance in the control area from 57 (90% CI = 37-85) to 72 (90% CI = 47-105) after and (2) decreases in the treatment area from 161 (90% CI = 104-233) to 115 (90% CI = 69-173).

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. We used ear-tag radio transmitters to monitor the survival and mortality of elk calves for the first year of their life, over five years (2011-2014, 2016-2018). We radio-tagged 534 elk calves, and used time to event survival and mortality analyses to 1) estimate potential changes in elk calf survival and cause-specific mortality before, during, and after increased carnivore harvest quotas, and 2) understand the relative effects of spatiotemporal covariates and individual characteristics on elk calf survival in the area.

Average rates of survival of female elk calves were lowest before the carnivore harvest treatment (0.38, 95% CI = 0.00-0.54), highest during the carnivore harvest treatment (0.65, 95% CI = 0.47-0.83), and intermediate 4-5 years after the carnivore harvest treatment (0.46, 95% CI = 0.31-0.61). Our analyses of cause-specific mortality indicated that 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. Our results suggest that increasing the harvest of mountain lions may be effective in allowing for short-term increases in elk calf survival and may be an effective management tool to increase calf recruitment. However, because a number of calves in each treatment era died due to unknown causes, we cannot rule out the possibility that changes in predation by carnivores other than mountain lions caused the changes we observed across the 3 treatment eras.

Third, to understand sources of variation in elk calf recruitment at the regional scale, we developed a population model that incorporated survey data (including counts and age ratios) and harvest numbers. This model had significantly higher statistical power than a model based on age ratios alone and provided additional information regarding variation in key vital rates. Our results suggest that per capita recruitment rates were negatively associated with cold, wet springs and severe winters and were positively associated with summer precipitation. This approach based on a population model provided estimates of the region-wide mean per capita recruitment rate (mean = 0.25, 90% CI = 0.21-0.29), temporal variation in hunting-district-specific recruitment rates (minimum = 0.09, 90% CI = 0.07-0.11; maximum = 0.43, 90% CI = 0.38-0.48), and annual population growth rates (minimum = 0.83, 90% CI = 0.78-0.87; maximum = 1.20, 90% CI = 1.11-1.29). We recommend using count data and a population modeling approach rather than interpreting estimated age ratios as a substantial improvement in understanding population dynamics.

Total Project Cost		$ 785,000.00
Beginning Balance – January 2018		272,047.71
Additional Funding – 2018		62,000.00
Expenditures – January 2018 - December 2018		
Salaries and Benefits	119,330.40	
Contracted Services	63,415.20	
Supplies	4,747.70	
Communications	4.78	
Travel	300.86	
Rent	2,161.18	
Repairs and Maintenance	0	
Tuition	4,761.28	
Total Spent		194,721.40
Balance		139,326.31
Waived IDCs		85,677.42

Elk response to pine beetle outbreak and management responses to that outbreak in the Elkhorn Mountains

Investigator
Robert Garrott
Professor MSU

Collaborators
Kelly Proffitt
Montana Fish Wildlife and Parks

Research Associates
Jesse DeVoe, Blake Lowrey MSU

Funding
Montana Fish, Wildlife and Parks
MSU index 4W6318

Duration
October 2016 – June 2019
Continuing

Western US forests have experienced a mountain pine beetle (MPB) epidemic unprecedented in the past 100 years in extent, severity, and duration. From 2000 to 2013, MPBs caused tree mortality in 17.5 million acres of pine forest across the western United States. The potential effects of MPB-caused tree mortality on ungulate populations and habitat are relatively unstudied, and the possibility exists for both beneficial effects (e.g., increased forage production through the opening of the forest canopy) and negative effects (e.g., reduced thermal or security cover). Recent concerns of changes in elk distributions and habitats in the Elkhorn Mountains of southwestern Montana, where about 1,655 km^2 of forests were affected by beetle infestation during 2005 – 2012, have highlighted the need to better understand the effects of MPB on elk in this area. In collaboration with the Elkhorn Working Group, Helena-Lewis and Clark National Forest, Montana State University, and Montana Department of Military Affairs, Montana Fish, Wildlife & Parks initiated the Elkhorn Mountains Elk Project in 2015 to evaluate the effect of MPB infestation on elk habitat and distributions in the Elkhorn Mountains. During summers 2016 and 2017, we sampled elk diet from 12 composite fecal samples and elk forage at 212 random vegetation sampling sites in a variety of landcover types that included MPB-infected and -uninfected forests to characterize the availability of and the effects of MPBs on elk nutritional resources. To gain insight into elk seasonal distributions, elk use of MPB-affected areas, and the effect of MPBs on elk security during the hunting seasons, we used GPS location data from 35 female and 25 male adult elk that we captured and radio-collared during winters 2015 and 2017. We also used VHF location data collected as part of a previous study conducted during 1982 – 1992. Overall, the most abundant and species-diverse herbaceous forage occurred in riparian areas followed by grasslands and shrublands, with forage graminoids making up the majority of the understory cover in all landcover classes. Forests had the lowest herbaceous forage abundance as compared to agricultural, grassland, shrubland, and riparian areas but higher levels of forage cover and forage species richness than agricultural areas. Generally, levels of herbaceous forage abundance, forage cover, forage species richness, and quality were greater in MPB-infected forests but generally within the range of observed levels in uninfected forests. Additionally, forage quality in both types exceeded levels considered adequate for

female elk to meet survival and reproductive requirements. Proportional elk use of infected forests decreased from pre- to post-MPB infestation across all seasons, but was most pronounced during the summer and archery hunting season for females and the archery and rifle hunting seasons for males. Our assessment of the influence of MPB on elk security during the hunting seasons and associated conclusions and management recommendations are forthcoming.

Beginning Balance – January 2018		35,762.55
Additional Funding -- 2018		67,404.00
Expenditures – January 2018 - December 2018		
Salaries and Benefits	27,098.22	
Contracted Services	0	
Supplies	0	
Communications	0	
Travel	341.70	
Tuition	1,907.00	
Repairs and Maintenance	0	
Total Spent		29,346.92
Balance		73,819.63
Waived IDCs		12,912.64

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

Investigator
Andrea Litt
Assistant Professor, MSU

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
Continuing

Mountain pine beetle (MPB, *Dendroctonus ponderosae*) outbreaks have resulted in large-scale changes in forest structure throughout the western United States. These changes can have large effects on wildlife but have not been studied in bats. Given that foraging and roosting sites may limit the distribution and abundance of bat populations, we aim to 1) quantify characteristics of these sites in forests during the summer, and 2) evaluate how the availability of these characteristics changes with different intensities of MPB disturbance.

To characterize roosting sites, we mist-netted for bats in forests dominated by lodgepole pine (*Pinus contorta*) that exhibited varying degrees of tree mortality due to MPB during the summers of 2017 and 2018 (total bats captured = 221). Two bat species comprised the majority of captures: little brown myotis (*Myotis lucifugus*) and silver-haired bat (*Lasionycteris noctivagans*). We attached radio-transmitters to 41 male bats (35 little brown myotis, 4 long-legged myotis [*Myotis volans*], and 2 long-eared myotis [*Myotis evotis*]) and located at least 1 roost for 25 individuals (total roosts = 74). Bats roosted in crevices and cavities within rock features as well as in snags of lodgepole pine and Douglas fir. We will analyze these data to understand roost selection by bats in lodgepole pine-dominated forests and how roost sites differ with MPB severity.

To characterize foraging by bats, we deployed 39 acoustic detectors in forest stands (16 in lodgepole pine, 12 in lodgepole pine and Douglas fir [*Pseudotsuga menziesii*] mixture, and 11 in ponderosa pine [*Pinus ponderosa*]) with varying degrees of MPB-caused tree mortality across the Helena Lewis and Clark National Forest between June and August 2017 and 2018. During summer 2017, these detectors recorded 902 GB of data resulting in 30,693 sound files, or bat passes. We are currently processing data from summer 2018. We will analyze data from both years to understand how bat foraging activity varies with MPB severity.

Beginning Balance – January 2018		27,793.70
Additional Funding -- 2018		10,000.00
Expenditures – January 2018 - December 2018		
Salaries and Benefits	26,880.84	
Contracted Services	0	
Supplies	739.10	
Communications	103.15	
Travel	2,512.99	
Tuition	2,195.10	
Repairs and Maintenance	5.17	
Total Spent		32,436.35
Balance		5,357.35
Waived IDCs		14,271.99

Bat population monitoring and disease surveillance analysis

Investigator
Andrea Litt
Associate Professor MSU

Research Associate
Wilson Wright, M.S.

Collaborators
Kathi Irvine
U.S. Geological Survey, NRMSC
Emily Almberg, Lauri Hanauska-Brown, Justin Gude
Montana Fish, Wildlife and Parks

Duration
October 2017 – May 2019
Completed

Funding
Montana Fish, Wildlife and Parks
MSU index 4W6943, 4W6958

The spread of white-nose syndrome (WNS) across the eastern United States has resulted in population declines of many bat species. WNS has not yet been detected in Montana, or any other western state besides Washington, and we have little information to predict severity of effects of this disease after arrival in this region. Understanding the effects of WNS in western states requires accurate baseline population assessments and continued monitoring after the disease arrives. This study aims to inform surveillance efforts to detect WNS and develop a bat monitoring plan to understand effects of the disease after it arrives in Montana. To assess current bat populations, we analyzed data previously collected by Montana Fish, Wildlife and Parks and its partners. Within an occupancy-model framework, we analyzed acoustic records and mist netting captures of eight bat species to estimate baseline distributions across Montana. For each species, patterns in the probability of occupancy were explained using covariates for forest cover (%), elevation, ruggedness, and average degree days. Estimates from this occupancy model were used to map distributions for each species individually and for species combinations of interest. Additional acoustic data were used to develop a model for overall bat activity. Even after accounting for nightly weather conditions, patterns in overall activity appear highly variable across years and detector locations. These estimates of baseline distribution and activity patterns can used in conjunction and compared to future analyses to better elucidate the effects of WNS when it arrives in Montana.

Based on these models, we will provide guidance on designing future sampling efforts with the goals of detecting arrival and monitoring effects of WNS on bat populations in the state. For early detection of WNS, surveillance efforts can focus on locations with high estimated probabilities of occupancy for susceptible species and consistent bat activity. The baseline estimates can be used to develop a monitoring plan with known power to detect possible changes in distribution or activity or both due to WNS.

Total Project Cost 4W6943		$ 74,815.00
Beginning Balance – January 2018		68,920.90
Expenditures – January 2018 - December 2018		
Salaries and Benefits	66,609.78	
Contracted Services	86.86	
Supplies	119.96	
Communications	0	
Travel	2,104.30	
Tuition	0	
Total Spent		68,920.90
Balance		0
Waived IDCs		30,325.20

Total Project Cost 4W6958		$ 5,185.00
Beginning Balance – January 2018		0
Expenditures – January 2018 - December 2018		
Salaries and Benefits	0	
Contracted Services	0	
Supplies	0	
Communications	0	
Total Spent		0
Balance		0
Waived IDCs		0

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

Investigator
Lance McNew
Assistant Professor

Collaborator
Lorelle Berkeley
Montana Fish, Wildlife and Parks

Graduate Students
Megan Milligan, Ph.D.
Skyler Vold, M.S.

Funding
Montana Fish, Wildlife and Parks
MSU index 4W5907

Duration
February 2016 – June 2020
Continuing

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. Thus, grazing management within these rangelands 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, this project will look 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. This project will also examine 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. We will thereby evaluate whether Montana FWP management guidelines are recommending the grazing system with the greatest benefit to grassland wildlife. Preliminary results suggest that the various grazing systems are not important predictors of grouse nest site selection, nest survival, adult survival, or space use and that, overall, the rest-rotation grazing system recommended by Montana FWP does not contribute to vegetation heterogeneity at a spatial scale that is relevant to breeding grouse. Furthermore, 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 system 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 mesocarnivores 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		$ 506,050.00
Beginning Balance – January 2018		181,175.38
Additional Funding – 2018		98,975.00
Expenditures – January 2018 - December 2018		
Salaries and Benefits	50,491.25	
Contracted Services	1,018.35	
Supplies	24,862.80	
Communications	124.79	
Travel	6,951.95	
Rent	7,200.00	
Repairs and Maintenance	5,668.76	
Total Spent		96,317.90
Balance		183,832.48
Waived IDCs		42,379.88

Grouse food insect, pollinator, and dung beetle ecology - grazing

Investigator
Hayes Goosey
Assistant Research Professor

Duration
May 2016 – September 2018
Completed

Collaborators
Lorelle Berkeley, John Ensign
Melissa Foster
Montana Fish, Wildlife and Parks
Marni Rolston, MSU Animal and Range Sciences

Funding
Montana Fish, Wildlife and Parks
MSU index 4W6068

One goal of the Natural Resource Conservation Service's Sage-Grouse Initiative was to reverse the western US trend of declining sage-grouse populations. The sage-grouse initiative aims to prevent 'sod-busting' activities (conversion of native habitats into cropland), which are considered the largest threat to stable sage-grouse populations and their habitats. Rest-rotation livestock grazing is implemented on sage-grouse 'core areas' to improve rangeland health on private lands and eliminate the need for listing sage-grouse on the threatened or endangered species list. We collected arthropods in central Montana in 2012-2014 from three habitat classes associated with the Sage-Grouse Initiative: 1) Grazed (actively grazed livestock pastures), 2) Deferred (ungrazed pastures), and 3) Idle (Lands of the Lake Mason National Wildlife Refuge lower unit). Total arthropod catches in pitfall traps were greatest in Idle pastures; however, greater numbers of those arthropods classified as sage-grouse food were caught in Deferred pastures. Differences in habitat class catches revolved primarily around the high levels of thatch found on the Lake Mason Wildlife Refuge, which altered the community composition and predator:prey ratios.

Total Project Cost		$ 219,249.97
Beginning Balance – January 2018		47,991.15
Subtracted Funding – 2018		57,966.03
Additional Funding – 2018		103,922.00
Expenditures – January 2018 - September 2018		
Salaries and Benefits	89,781.23	
Contracted Services	24.00	
Supplies	1,746.10	
Communications	0	
Travel	2,335.82	
Rent	0	
Repairs and Maintenance	0	
Total Spent		93,887.15
Balance back to sponsor		59.97
Waived IDCs		41,310.35

Wolverine connectivity in Wyoming, Idaho, and Washington

Investigator
Andrew Hansen
Professor

Graduate Student
Kathleen Carroll, Ph. D.

Duration
November 2016 – June 2018
Completed

Collaborators
Justin Gude, Robert Inman
Montana Fish, Wildlife and Parks

Funding
Montana Fish, Wildlife and Parks
MSU index 4W6410

Wolverines (*Gulo gulo*) occupy semi-isolated patches of public lands at naturally low densities in the conterminous United States. Connectivity among this metapopulation is essential to the persistence of this species in the western U.S. However, maintaining habitat connectivity presents several challenges: 1) the scale that the wolverine metapopulation functions over is large, 2) connective habitat is often privately-owned land, 3) high-quality and connective wolverine habitats may shift in the future due to climate and land-use change, and 4) current models of wolverine connectivity do not account for these changes. Our goal was to provide land trusts, which work to secure conservation easements on private lands, with maps of priority connectivity areas so that they can consider these values in their decisions. To achieve this goal, we used a second-order resource selection function model to determine areas of high-quality wolverine habitat and prioritize connectivity zones. This included an analysis of how wolverine habitat may shift under various future climate change and land-use scenarios so that our results are as valuable as possible over the long-term. We predicted high-quality wolverine habitat and connectivity at three time intervals (2010, 2030, and 2050) and evaluated opportunities for conservation action across the four-state area that is currently occupied by breeding wolverines (ID, MT, WA, WY). We used agent-based model Circuitscape 4.0 and least-cost corridor model Linkage Mapper 2.0.0 at each time period along with dispersal data to determine areas valuable for connectivity but subject to development at this time (2010). Based on the land protections in place in 2010, we found areas of wolverine connectivity habitat in both 2030 and 2050 that would benefit from conservation action in order to remain useful for wolverines. This analysis provides specific guidance on areas that are most valuable for long-term conservation of wolverines in the lower 48 United States.

Total Project Cost		$ 112,984.00
Beginning Balance – January 2018		86,187.35
Expenditures – January 2018 - December 2018		
Salaries and Benefits	78,537.18	
Contracted Services	0	
Supplies	1,768.70	
Communications	0	
Travel	2,231.79	
Tuition	3,649.68	
Repairs and Maintenance	0	
Total Spent		86,187.35
Balance		0
Waived IDCs		37,922.43

Pallid sturgeon condition evaluation

Investigator
Christine Verhille
Professor, MSU

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
New, approved

Previous researchers have been successful in relating stream-side non-invasive physiological assessments of wild-captured salmonids to performance outcomes. 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 in 2018. Assessments will involve an extensive suite of health assessment variables for prediction of overall health of pallid sturgeon. Measurements making up the extensive suite of health assessment variables will include 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 tissue biochemistry measurements as well as for direct determination of whole-body energy concentration to confirm indirect, but non-invasive, microwave and bioelectrical impedance measurements of whole-body energy. Variables making up the field health assessment criterion will be determined through statistical analyses identifying the combination of variables with the greatest predictive power of growth and overall performance in a hatchery study as well as whole body energy concentration. The field health assessment criterion is also being developed for wild captured juvenile pallid sturgeon as the priority life stage identified by Upper Missouri River Basin biologists and managers.

Total Project Cost		$ 85,245.00
Beginning Balance – July 2018		85,245.00
Expenditures – July 2018 - December 2018		
Salaries and Benefits	11,344.88	
Contracted Services	0	
Supplies	3,480.46	
Communications	0	
Travel	674.08	
Total Spent		15,499.42
Balance		69,745.58
Waived IDCs		6,819.74

Taxonomic and ecological service project account

Investigator
Alexander Zale
Unit Leader

Funding
NorthWestern Energy
MSU Index 433295

Duration
Continuing

Unit personnel provide services and workshops periodically.

Beginning Balance – January 2018		19,091.15
Additional Funding –		0
Expenditures – January 2018 - December 2018		
Salaries and Benefits	12,648.29	
Contracted Services	0	
Supplies	0	
Communications	0	
Travel	0	
Rent	0	
Repairs and Maintenance	0	
Tuition	0	
Administrative Fee @ 6%	758.90	
Total Spent		13,407.19
Balance		5,683.96

MTCFRU service project account

Investigators

Alexander Zale
Unit Leader
Michael Lance
Graduate Student M.S.

Collaborators

Bradley B. Shepard
B. B. Shepard and Associates
Grant Grisak
Montana Fish, Wildlife and Parks

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 2018		$ 14,956.53
Additional Funding –		0
Expenditures – January 2018 - December 2018		
Salaries and Benefits	8,932.49	
Contracted Services	366.38	
Supplies	22.00	
Communications	0	
Travel	1,233.58	
Rent	0	
Repairs and Maintenance	1,265.91	
Tuition	0	
Administrative Fee @ 6%	709.25	
Total Spent		12,529.61
Balance		2,426.92

MTCFRU Gift Account

Investigators

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

Funding

Trout Unlimited
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 2018		2,791.60
Additional Funding – 2018		5,000.00
STIP Interest 2017		30.64
Expenditures – January 2018 - December 2018		
Salaries and Benefits	0	
Supplies	5,000.00	
Travel	160.39	
Repairs and Maintenance	0	
Tuition	1,887.00	
Total Spent		7,047.39
Balance		774.85

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 2018		$ 50,810.74
Expenditures – January 2018 - December 2018		
Repairs and Maintenance	2,333.27	
Fuel	11,709.38	
Insurance	0	
Administrative Assessment Fee @ 6%	842.56	
Total Spent		14,885.21
Total Revenue Reimbursed		34,375.07
Balance		70,300.60

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 2018		51,470.23
Expenditures – January 2018 - December 2018		
Repairs and Maintenance	6,253.63	
Supplies	4,665.75	
New 2017 Hewes Craft	34,434.25	
Administrative Assessment Fee @ 6%	2,721.22	
Total Spent		48,074.85
Total Revenue Reimbursed		10,300.00
Balance		13,695.38

Montana Cooperative Fishery Research Unit Operations Account

Administrator
Alexander Zale
Unit Leader

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

Beginning Balance – January 2018		$ <77.84>
Expenditures – January 2018 - December 2018		
Maintenance: Lab	177.00	
Contracted Services	150.00	
Supplies	412.96	
Communications	780.05	
CCM	0	
Rent (storage unit)	8,083.04	
Parking expense	2,580.00	
Administrative Assessment Fee @ 6%	731.02	
Total Spent		12,914.07
Total Revenue from VPR		10,285.71
Balance		<2,706.20>

Monetary Equivalence for MSU Services and Facilities
January 2016 - December 2016

Program Manager salary and benefits	$ 55,911.97
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 ($1,313,800)	10,510.40
Utilities - General @ 12% of total expenditures ($1,313,800)	157,656.00
Unit Operations Account	10,285.71
Waived IDCs	424,667.80
Total	**683,505.34**

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

Administrator	**Funding**
Alexander Zale	Montana Fish, Wildlife and Parks
Unit Leader	MSU index 4W5335

Beginning Balance – January 2017		$ 45,730.74
Additional Funding – 2018		30,000.00
Expenditures – January 2018 - December 2018		
Salaries and Benefits	1,351.41	
Contracted Services	4,836.46	
Supplies	7,185.28	
Communications	37.78	
Travel	1,266.20	
Rent	0	
Repairs and Maintenance	464.39	
Tuition	1,913.00	
Equipment	0	
Total Spent		17,054.52
Balance		58,676.22

Federal Budget
January 2015 - December 2015

Salaries and Benefits	$ 385,923.20
Supplies	0
Total	$ 385,923.20

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

USGS

2016 Chevrolet Silverado 2500, 4x4 crew cab (white)
Property No. 434174 – Serial No.1GC1KUE80GF252052
Acquisition value $35,644
Mileage 7855

2011 Ford F250 4×4 crew cab (green)
Property No. 433429 – Serial No 1FT7W2BTOBEA70586
Acquisition value $31,697
Mileage 59,740

2009 Chevrolet HHR (red)
Property No. 433291 – Serial No. 3GNBAADB4AS513678
Acquisition value $18,720
Mileage 34,824

2005 Chevrolet Silverado 2500, 4×4 crew cab (green)
Property No. 430750 - Serial No. 1GCHK23G15F926039 (2005)
Acquisition value $22,948
Mileage 127864

2002 Chevrolet 4×4 Suburban (white)
Property No. 261052 - Serial No. 3GNGK26U52G249012
Acquisition value $31,988
Mileage 129,462

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

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)

1990 23' Sea Ark Marine Boat and EZ-Load Trailer with a Zodiac life raft, Mobile Radio, Binoculars, Ross Depthfinder and Hummingbird Fish Finder.
Property No. Boat 632069 - Serial No. SAMA0093J989/FSC 1940
Property No. Trailer 632068 - Serial No. 12EIGN224LLW19678/FSC 2330
Property No. Mobile Radio 632015 - Serial No. 1391568/FSC 5820
Property No. Depthfinder 632014 - Serial No. 1975-201/FSC 6605
Property No. Life Raft 632007 - Serial No. 2845 or 2860/FSC 4220
Property No. Fish Finder 618216 - Serial No. 4765325
Property No. Binoculars 237807 - Serial No. 308594
Acquisition value $42,846 (Transferred from USFWS Creston Fish and Wildlife Center June 2006)

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

2017 Ford F150 Supercab (blue)
Serial No. 1FTFX1EF0HKD34442
Acquisition Value $26,826
Mileage 602

2014 Dodge Ram 2500 (white)
Property No. 135050
Serial No. 3C6TR5DT0EG281683
Acquisition Value $29,197
Mileage 44,004

2008 Ford Escape Hybrid 4WD (grey)
Property No. 132775
Serial No. 1FMCU59H78KA13346
Acquisition Value $26,554 (2007)
Mileage 42,238

2005 GMC Sierra 2500 crew cab truck (green)
Property No. 132353
Serial No. 1GTHK23G65F944780
Acquisition Value $24,463 (2005)
Mileage 159,976

2001 GMC 1/2 ton 4×4 extended cab truck (green)
Property No. 132228
Serial No. 2GTEK19T911227311
Acquisition Value $15,255 (2005)
Mileage 199,292

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)