43rd Annual Meeting

Montana Chapter of the American Fisheries Society

LINKAGES ACROSS LANDSCAPES: THE ECOLOGICAL ROLE OF FISH IN MONTANA

Program and Abstracts

February 9–12, 2010
Best Western GranTree Inn
Bozeman, Montana

About the American Fisheries Society and the Montana Chapter

The American Fisheries Society (AFS), founded in 1970, is the oldest and largest professional society representing fisheries scientists. Our Mission is to improve the conservation and sustainability of fishery resources and aquatic ecosystems by advancing fisheries and aquatic sciences and promoting the development of fisheries professionals. AFS promotes scientific research and enlightened management of resources for optimum use and enjoyment by the public. We also encourage a comprehensive education for fisheries scientists and continuing on-the-job training. The AFS publishes some of the world's leading fisheries journals and organizes scientific meetings where new results are reported and discussed. In addition to these primary functions, the Society has many other programs in areas such as professional certification, international affairs, public affairs, and public information.

The Montana Chapter of the AFS (MTAFS) was formed in 1967 and our membership is currently comprised of approximately 300 fisheries professionals affiliated with state and federal agencies, universities, and private industry across the state. The meeting, which is the 43rd annual meeting of the MTAFS, is the major gathering of the year for fisheries and other aquatic resource professionals of all affiliations across the state. Our annual meeting is a great opportunity for us to learn about what is happening in the management and conservation of fisheries resources across the state and explore timely issues.

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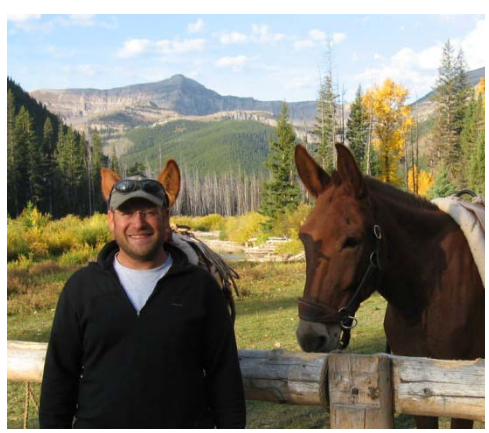

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Contents

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Agenda

Schedule at a Glance

Mon Feb. 8	**Event**	**Location**
1:00 – 3:00	Executive Committee Meeting	Atrium

Tues Feb. 9	**Event**	**Location**
8:00 – 10:00	Workshop Session II, Structured Decision Making	Hyalite Room
9:30 – 10:00	Workshop Session I, Montana Prairie Fishes	Madison Room
10:00	**Coffee Break**	
10:00 – 12:00	Workshop Session I, Montana Prairie Fishes	Madison Room
10:00 – 12:00	Workshop Session II, Structured Decision Making	Hyalite Room
10:00 – 12:00	Piscicide Certification Workgroup Meeting	Ponderosa/Tamarac
12:00 – 1:00	**Buffett Lunch**	**Atrium**
1:00 – 3:00	Workshop Session I, Montana Prairie Fishes	Madison Room
1:00 – 3:00	Workshop Session II, Structured Decision Making	Hyalite Room
1:00 – 3:00	Piscicide Certification Workgroup Meeting	Ponderosa/Tamarac
3:00	**Coffee Break**	
3:00 – 5:00	Workshop Session I, Montana Prairie Fishes	Madison Room
3:00 – 5:00	Workshop Session II, Structured Decision Making	Hyalite Room
3:00 – 5:00	Piscicide Certification Workgroup Meeting	Ponderosa/Tamarac
5:30 – 8:00	Lake Trout Working Group Meeting	Ponderosa/Tamarac

Dinner on Your Own

Wed Feb. 10	**Event**	**Location**
8:40 – 10:00	Plenary Speakers Session	Ballroom
10:00	**Coffee Break**	
10:30 – 12:00	Plenary Speakers Session	Ballroom
12:00 – 1:30	**Buffett Lunch**	**Atrium**
1:30 – 4:00	Plenary Speakers Session	Ballroom
4:00	**Coffee Break**	
4:30 – 5:30	Excom Subcommittee Meetings	Several
6:00 – 8:00	**Plenary Speaker Appreciation Social**	**Atrium**

Dinner on Your Own

Thu Feb. 11	**Event**	**Location**
8:00 – 9:40	Contributed Papers Session	Ballroom
9:40 – 10:00	**Formal Poster Session**	**Atrium**
10:20 – 12:00	Contributed Papers Session	Ballroom
12:00 – 2:00	**Business Luncheon (Buffett)**	**Atrium**
2:00 – 3:00	Contributed Papers Session	Ballroom
3:00	**Coffee Break**	
3:20 – 5:00	Contributed Papers Session	Ballroom
5:00 – 6:00	Student Mentoring Session	Aspen Room
5:00 – 6:00	MT Association of Fish & Wildlife Biologists	Tamarack Room
6:00 – 7:00	**Evening Social with Drinks and Hors d'Oeuvres**	**Atrium**
7:00 – 9:00	**Awards Banquet**	**Ballroom**

Fri Feb. 12	**Event**	**Location**
8:00 – 10:00	Contributed Papers Session	Ballroom
10:00	**Coffee Break**	
10:20 – 11:40	Contributed Papers Session	Ballroom
11:40	**End of Conference**	

Plenary Day Agenda

Wednesday February 10th
(8:40AM – 5:30PM; Social at 6:00PM)

Grand Ballroom

Plenary Session Welcome (8:40AM – 9:00AM)
8:40 Welcome – Scott Barndt, President MT AFS
8:50 Plenary Speaker Introductions – Todd Koel, Program Chair

Plenary Session I (9:00AM - 10:00AM)
Moderator: Todd Koel, Yellowstone National Park

9:00 Paul Schullery (p. 14)
Fish Culture and Human Culture: Historic Contexts of Modern Research and Management

9:30 Daniel Schindler - University of Washington (p. 14)
The Importance of Landscape- and Population Diversity for Ecosystem Services Associated with Fishes

10:00 Break for Coffee (10:00AM – 10:30AM)

Plenary Session II (10:30AM - 12:00PM)
Moderator: Carter Kruse, Turner Enterprises, Inc.

10:30 Wyatt Cross - Montana State University (p. 15)
Relationships Between Fish and Benthic Communities: A Call for More Experiments in the Context of Adaptive Management

11:00 Merav Ben-David - University of Wyoming (p. 15)
Aquatic-Terrestrial Linkages: Formation, Importance, and Disruption

11:30 Charles Schwartz – U.S. Geological Survey (p. 16)
Ecological Importance of Cutthroat Trout to the Yellowstone Grizzly Bear

12:00 Break for Buffett Lunch (12:00PM – 1:30PM)

Atrium

Buffet Lunch (12:00PM – 1:30PM)

Grand Ballroom

Plenary Session III (1:30PM – 4:00PM)
Moderator: Bob Gresswell, U.S. Geological Survey

1:30 Jonathon Klein – Beaverhead-Deerlodge National Forest (p. 16)
Stocking Wilderness Lakes – There's Something Fishy Going On?

2:00 Tom Reed – Trout Unlimited (p. 17)
Working together: Senator Jon Tester's Forest Jobs and Recreation Act

2:30 Wayne Hubert – University of Wyoming (p. 18)
Changes in Aquatic Species Introductions with Evolution from MSY to Ecosystem-Based Fisheries Management

3:00 Robert Gresswell – U.S. Geological Survey (p. 18)
Plenary Presentations Summary

3:20 Plenary Speaker Panel Session – Question/Answer with Audience

4:00 End of Plenary

Ballroom and Atrium Areas

4:30 Concurrent EXCOM Sub-Committee Meetings

Continuing Education – Ballroom, Madison
Public Outreach – Ballroom, Lewis
Legislation – Ballroom, Clark
Raffle – Ballroom, Hyalite
Resource Management Concerns – Atrium, Ponderosa
Species of Special Concern – Atrium, Tamarack
Web Site – Atrium, Aspen

5:30 End of EXCOM Sub-Committee Meetings

Atrium

6:00 Plenary Speaker Appreciation Social (6:00PM – 8:00PM)

Dinner on Your Own

Contributed Papers Agenda

Thursday February 11th
(8:00AM – 6:00PM; Banquet at 7:00PM)

Grand Ballroom

Contributed Papers I (8:00AM – 9:40AM)
Moderator: Mark Novak, USDA, Natural Resources Conservation Service

Time	Title/Presenter
8:00	*A Modular In-stream Barrier Structure to Limit Upstream Fish Passage* Miller, Dale (p. 19)
8:20	*Effectiveness of flow management and rainbow trout harvest on long term viability of native Yellowstone cutthroat trout in the South Fork Snake River* Battle, Laurie (p. 19)
8:40	*Movements of spawning and non-spawning shovelnose sturgeon in the Missouri River above Fort Peck Reservoir* Richards, Ryan (p. 20)
9:00	*Spatial Drift Dynamics of Shovelnose Sturgeon and Pallid Sturgeon Prelarvae in the Transition Zone of Ft. Peck Reservoir* Ranney, Steven (p. 20)
9:20	*Distribution & Population Status of Mussels in Eastern Montana: New Findings and Updates on Five Species East of the Divide* Stagliano, David (p. 21)

Break for Formal Poster Session

Atrium

Formal Poster Session (9:40AM – 10:20AM)

9:40	Presenters in Attendance (p. 35–38) Coffee

Grand Ballroom

Contributed Papers II (10:20AM – 12:00PM)
Moderator: Lisa Eby, University of Montana

Time	Title/Presenter
10:20	*O’Dell Creek Headwaters – Five Years of Stream and Wetland Restoration* Muhlfeld, John (p. 22)

10:40 *Effects of Fish Restoration Practices on Amphibians in Yellowstone National Park, WY*
Billman, Hilary (p. 22)

11:00 *Thermal Adaptation of Westslope Cutthroat Trout Oncorhynchus clarkii lewisi*
Drinan, Daniel (p. 23)

11:20 *Observing the Effects of Inbreeding and Local Adaptation on Fitness in Westslope Cutthroat Trout Populations in a Common Garden*
Andrews, Tessa (p. 23)

11:40 *Performance of westslope cutthroat trout (Oncorhynchus clarkii lewisi) released into the upper Cherry Creek drainage using remote stream incubators*
Shepard, Bradley (p. 24)

12:00 Break for AFS Business Lunch (12:00PM – 1:50PM)

Atrium

AFS Business Lunch (12:00PM – 1:50PM)

Grand Ballroom

Contributed Papers III (2:00PM – 3:00PM)
Moderator: Chris Guy, USGS Montana Cooperative Fishery Research Unit

Time Title/Presenter

2:00 *Western Lake Trout – Just Say Whoa!*
Fredenberg, Wade (p. 25)

2:20 *An Evaluation of Lake Trout Suppression in Yellowstone Lake, Yellowstone National Park*
Syslo, John (p. 25)

2:40 *Trends in Characteristics of Yellowstone Lake Cutthroat Trout, Associated Factors, and Evidence of a Population Shift*
Kaeding, Lynn (p. 26)

3:00 Break for Coffee

Contributed Papers IV (3:20PM – 5:00PM)
Moderator: Don Skaar, Montana Department of Fish, Wildlife, & Parks

Time Title/Presenter

3:20 *A Model of a Storied, Lacustrine-Adfluvial Cutthroat Trout Population of Yellowstone Lake: Development, Parameter Estimation, and Population Prediction*
Kaeding, Lynn (p. 26)

3:40 *Is Habitat Type a Useful Predictor of the Outcome of Interactions Between Tubifex tubifex and Myxobolus cerebralis, the Causative Agent of Salmonid Whirling Disease?*
Alexander, Julie (p. 27)

4:00 *A conceptual model for predicting areas with high potential for lake trout spawning habitat in Yellowstone Lake*
Bigelow, Patricia (p. 27)

4:20 *Montana's Crucial Areas and Connectivity Assessment: An update and demonstration of the Crucial Areas Mapping Service*
Daigle, Bill (p. 28)

4:40 *Effects of Topology, Number and Location of Nodes, Population Density, and Stocking Duration on Hybrids' Dispersal across a Network*
Della Croce, Patrick (p. 28)

5:00 End of Thursday's Contributed Papers Sessions

Atrium Area

5:00 Concurrent Sessions
Student Mentoring Session – Atrium, Aspen Room
MT Association of Fish & Wildlife Biologists – Atrium, Tamarack Room

6:00 Social Hour

Grand Ballroom

7:00 Awards Banquet

8:00 Raffle

9:00 End of Thursday's Events

Contributed Papers Agenda

Friday February 12th
(8:00AM – 12:00PM)

Grand Ballroom

Contributed Papers V (8:00AM – 10:00AM)
Moderator: Amber Steed, Montana Department of Fish, Wildlife, & Parks

Time	Title/Presenter
8:00	*Meeting Resource Needs for Whitewater Recreation and Stream Fisheries at the Mystic Lake Hydro Project* Pickett, Frank (p. 29)
8:20	*The Science of Felt* Wiltshire, Robert (p. 29)
8:40	*Clean, Drain, and Dry! What About the Biologists?* Hanson, Erik (p. 30)
9:00	*Efficacy of Terramycin® 200 for Fish (Oxytetracycline Dihydrate) for the Skeletal Marking of Rainbow Trout Oncorhynchus mykiss* Carty, Dan (p. 30)
9:20	*Quantifying temporal variability in stream habitat data: implications for restoration and monitoring* Archer, Eric (p. 31)
9:40	*Montana DEQ's approach to a standardized sediment assessment protocol: A biological consideration in the 303(d) listing process* Kusnierz, Paul (p. 31)
10:00	Break for Coffee (10:00AM – 10:20AM)

Contributed Papers VI (10:20AM – 11:40AM)
Moderator: Tom McMahon, Montana State University

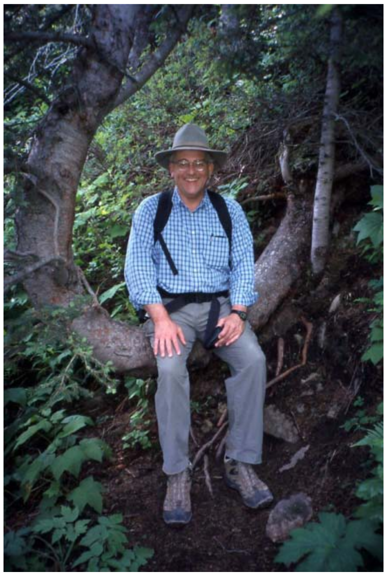
Time	Title/Presenter
10:20	*Evaluating watershed condition: bottom up vs. top down approaches?* Heitke, Jeremiah (p. 32)
10:40	*Bias associated with electrofishing estimates for mountain whitefish (Prosopium williamsoni) in rivers: four different ways we killed whitefish this summer* Schmettlering, David (p. 32)
11:00	*Investigation into bias and variability in estimates of population size and biomass when catches of individuals are large relative to the total population* Shepard, Bradley (p. 33)

11:20 *Using fixed and portable half-duplex PIT tag antennas to evaluate fish movement in a stream network: a case study in the upper Big Hole River basin*
Vatland, Shane (p. 34)

11:40 End of Friday's Contributed Papers Sessions – Conference Ends

Abstracts

Plenary Presentations



Fish Culture and Human Culture: Historic Contexts of Modern Research and Management

Paul Schullery

The intellectual and social foundations of three overlapping enterprises—fisheries science, fisheries management, and sport fishing—are incredibly complex. Practitioners of each of the three confront vexing yet stimulating instances of this complexity as they attempt to interact with practitioners of the other two. Historically, comparatively little scholarly attention has been paid to coming to terms with the character of these essential interactions. This paper will reinforce the urgency of advancing such scholarly attention. The paper will invoke C.P. Snow's provocative "two cultures" lecture (1959) on the persistence and power of such "incomprehensibility gaps" as now often exist among the "three cultures" of science, management, and sport fishers. The paper will also critique H. Jones' contemporaneous and controversial Maxim on Field Research (1957) as a way of proposing at least some means for a better understanding among the three cultures—and countless subcultures—of human/fish endeavors. Results will include a fast-and-loose overview of random but helpful if not inspiring cases that indicate possible directions for improvement of this difficult situation. The talk's tone will not be anything like this abstract.

The Importance of Landscape- and Population Diversity for Ecosystem Services Associated with Fishes

Daniel Schindler, University of Washington

One of the most pervasive themes in ecology is that biological diversity stabilizes ecosystem processes and the services they provide to society; a concept that has become a common argument for biodiversity conservation. In particular, species-rich communities are thought to produce more temporally stable ecosystem services because of the complementary or independent dynamics among species that perform similar ecosystem functions. These arguments have focused on the effects of species diversity on ecosystem stability but have generally not considered the importance of biologically relevant diversity within individual species. Current rates of population extirpation are probably at least three orders of magnitude higher than species extinction rates so there is pressing need to clarify how population and life history diversity affect the performance of individual species in providing important ecosystem services. Furthermore, heterogeneity in habitat conditions buffers the effects of regional scale climate change on aquatic organisms because of complementary filtering of climate by different habitat types. Taken together, habitat heterogeneity and the associated diversity of populations that inhabit aquatic landscapes, enhance resilience in ecosystems and the human economies that rely on these ecosystems.

Relationships between fish and benthic communities: a call for more experiments in the context of adaptive management

Wyatt Cross, Montana State University

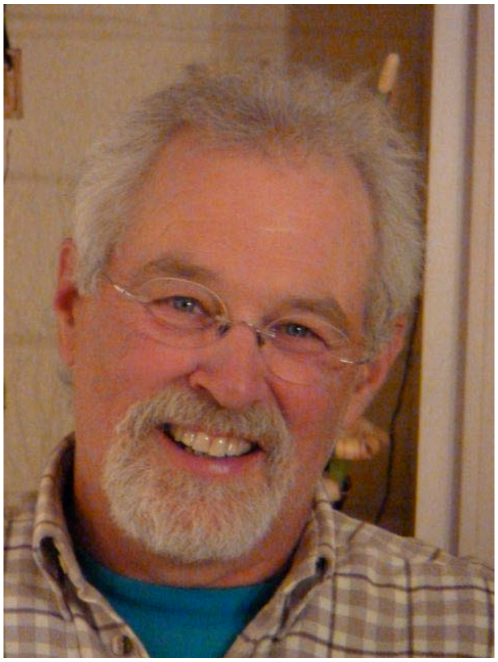
Fish are important components of most freshwater ecosystems and can interact strongly with their prey, potentially driving changes in system structure and function. Less appreciated, however, is the reciprocal role of prey availability and quality in limiting and/or structuring fish communities. Understanding both sides of these interactions is critical for predicting changes to aquatic ecosystems as a result of species invasions, extinctions, and well-intentioned management practices.

In this talk, I will focus on fish-benthos relationships in streams and rivers, with emphasis on salmonid-invertebrate interactions. First, I will argue that despite a large literature in this area, generalizations remain elusive because of broad differences in scale and study design. Next, I will present a food web approach (and case study from the Grand Canyon) that can help elucidate key pathways of interaction between fishes and their prey. Finally, I will discuss the critical role of ecosystem experiments in management, and argue that exciting opportunities abound in Montana for leading the way in science-based adaptive management of streams and rivers.

Aquatic-Terrestrial Linkages: Formation, Importance, and Disruption

Merav Ben-David, University of Wyoming

We can no longer regard ecosystems as discrete entities in space. Similar to human societies, the natural environment is a product of a wide range of transport, propagation and communication processes. Spatial coupling of ecosystems through cross-habitat fluxes of energy and matter may modify food web interactions, change ecosystem function, and alter community diversity. Lateral fluxes of matter and energy between discrete ecosystems have been shown to elicit variable responses in the recipient ones depending on trophic position, ecological process, biotic and abiotic conditions, and the ratio between the subsidy and local resources. In some cases, cross ecosystem nutrient fluxes can be as important as transfers within individual ecosystems. Some of the best documented ecosystem linkages occur in aquatic-terrestrial systems. For example, terrestrial animals feeding in freshwater and marine habitats transfer nutrients from these aquatic to adjacent terrestrial ecosystems leading to increases in primary production in the latter. Such increases in production are comparable in magnitude to positive effects of moderately elevated local herbivory observed in some systems or nitrogen fixation by alder. Nonetheless, recent human-induced ecosystem alterations result in disruption of the spatial continuity of ecosystem linkages. Here I evaluate the current knowledge on the formation and importance of aquatic-terrestrial linkages and provide examples of the consequences of discontinuity in these transport processes.



Ecological Importance of Cutthroat Trout to the Yellowstone Grizzly Bear

Chuck Schwartz, USGS Interagency Grizzly Bear Study Team

The importance of cutthroat trout (*Oncorhynchus clarkii*) to the Yellowstone grizzly bear (*Ursus arctos*) has changed over the decades. Early records from the 1930s suggested bears were foraging on cutthroat trout, but studies from the 1950s and 1960s found no evidence of fish use. Bears at that time likely did not use fish because their diets were composed primarily of garbage from park dumps. Following dump closure in the early 1970s, bear use of fish increased and likely peaked in the late-1980s, coinciding with a peak in the cutthroat population in Yellowstone Lake. Researchers estimated that about 44 grizzly bears fished on 61% of the 124 tributary streams. Female bears consumed most of the fish but females consuming fish had lower reproductive rates when compared to females not consuming fish. Bear use of fish began to decline as the cutthroat trout population declined as a result of predation from introduced lake trout (*Salvelinus namaycush*). Bear use of cutthroat trout was very low in the late 1990s and most fish were consumed by male bears. DNA capture mark recapture studies estimated that 68 individual bears used the area around Yellowstone Lake. Results from a recent study (2007-2009) suggest the number of bears using the area has not changed, but fish are no longer available or consumed by bears. They have shifted their diet to other natural foods including elk calves (*Cervus elaphus*) in habitat created by the 1988 fires. Demographic studies of the Yellowstone grizzly bear during the decades of the 1980s-2000s suggests this dynamic flux in fish availability and use by grizzly bears did not abate population growth and range expansion.

Stocking Wilderness Lakes – There's Something Fishy Going On?

Jonathan Klein, USDA Forest Service - Madison Ranger District

The Wilderness Act of 1964 set aside lands to be managed and protected so as to preserve their natural conditions. Yet, many historically fishless lakes within designated wilderness continue to be stocked with native and non-native fish by state fish and game agencies in order to provide recreational fishing opportunities. This practice is controversial because stocking programs can compromise ecological and social values of Wilderness. Stocking is commonly accomplished without adequate cooperation and consultation between state and federal agencies. A better understanding of wilderness impacts from fish stocking, as well as improved cooperation between agencies may help to balance opportunities for recreational fishing with wilderness values.

Sportsmen and the world we live in

Tom Reed, Trout Unlimited

It's no secret to the historian that sportsmen and women have long had a role in public lands policy. Certainly, the public lands legacy that has been left to us in this country is a legacy of sportsmen before us; Roosevelt was a hunter, Pinchot was a fisherman. But in recent years, sportsmen have again stepped into the lead, particularly on public lands issues that challenge our society to balance our growing country and our need to have places to get away, places of retreat.

Trout Unlimited has been instrumental in guiding and driving much of the good public lands decisions that have been made in the recent past. In particular, the Wyoming Range Legacy Act, sponsored by Sen. John Barrasso-R, Wyoming, is case in point. Located just south of Jackson, Wyoming, and running approximately 125 miles north-south to near the town of Kemmerer, the range is home to three subspecies of cutthroat trout including the Colorado River, the Snake River and the Bonneville. The Bridger-Teton National Forest cloaks some 1.2 million acres of the range.

A group led by TU called Sportsmen for the Wyoming Range pushed for withdrawal legislation; legislation that would allow one use of the public's land—mineral extraction—to be taken off the table. While some of the range was previously leased for oil and gas exploration, much of the range was not. The Act did two things: it provided for no new leasing on unleased land, and it allowed for private buy-out of existing leases while not preventing drilling of valid existing leases.

The Act passed as part of the Omnibus Public Lands bill that was signed by the President in March 2009. Today, some 1.2 million acres of public land will never see a drill rig while about 60-70,000 acres is targeted for buy-out or light development.

Senator Jon Tester-D, Montana, introduced a bill last summer that TU is very supportive of and has some similarities to the Wyoming Range Legacy Act. The Forest Jobs and Recreation Act seeks to mandate logging on 100,000 acres of federal U.S. Forest Service land, create some 670,000 acres of designated big 'W' wilderness, and 330,000 some acres of motorized recreation area. For TU, the bill fits our mission perfectly: Protect, Reconnect, Restore and Sustain.

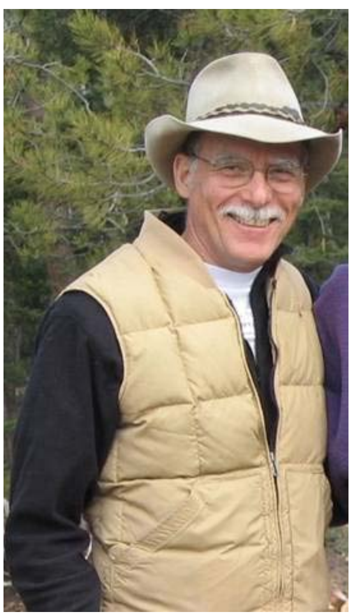
> *Protect*: Wilderness and recreation designation would set aside the headwaters of some of Montana's most fabled trout streams.
> *Reconnect*: Stewardship logging would pay for much-needed culvert removal for fish passage.
> Restore: Stewardship logging would pay for road removal or realignment where interfering with fisheries habitat.
> *Sustain*: The Act would maintain Montana lifestyles for those who like to fish and do other activities outside.

TU is fully supportive of the bill for not only the mission fit, but also because of its grassroots nature, its collaborative process, its bipartisan nature, and its Montana-based common-sense solution.

Changes in Aquatic Species Introductions with Evolution from MSY to Ecosystem-based Fisheries Management

Wayne A. Hubert, Professor Emeritus, University of Wyoming

The American Fisheries Society was formed in 1870 to promote the development of fish culture in North America, and inland fisheries management was focused on stocking to maintain populations and introductions to create new fisheries. The primary philosophy for inland fisheries management evolved during the 20th century to maximum sustained yield (MSY) and was then tweaked to the notion of optimum sustained yield (OSY) with little change in attitude toward aquatic species introductions. Late in the 20th century, fisheries managers began to recognize the consequences of habitat alterations and aquatic species introductions on aquatic ecosystems, as well as the need to maintain the components and processes of ecosystems. Over the last decade there has been increasing focus by fisheries managers on preservation and restoration of ecosystems, management goals confounded by intended and unintended species introductions. Preservation of rare species, control of undesired exotic species, and prevention of further introductions of aquatic species, including fish, invertebrates, pathogens, and aquatic plants, are becoming dominant goals in fisheries management programs. Many questions can be asked about the future of inland fisheries management as we begin to recognize the linkages across landscapes. This talk delves into questions pertinent to the education and practices of fisheries managers as maintenance and restoration of linkages across landscapes become a larger focus into the 21st century.



Plenary Presentations Summary and Moderator, Panel Discussion

Bob Gresswell, USGS Northern Rocky Mountain Science Center

Contributed Papers

A Modular In-stream Barrier Structure to Limit Upstream Fish Passage

Dale E. Miller*, CPESC, Mainstream Restoration, Inc., 321 E. Main St., Suite 401, Bozeman, MT 59715, dmiller@mainstreamrestoration.com

Paul Sanford, P.E., Allied Engineering Services, Inc., 32 Discovery Drive, Bozeman, MT 59715, paul@alliedengineering.com

Fisheries management objectives that include segregation of native and introduced fish species often depend upon installation of a physical in-stream barrier with a long functional design life. Fish barrier sites are typically located in remote locations and reflect varied topographic and hydrologic conditions. A modular fish barrier, consisting of commercially available pre-cast concrete box culverts and slabs, was developed for relatively low-cost, permanent installations at multiple locations around the State. The barrier is comprised of upright culverts connected to form a weir and abutments and slabs to form splash pads. Structural design elements include: weir width; abutment height; and structure stability against overturning. Passage impedance design elements include: weir height; preventing pool formation at the structure base; and restrictive velocity when leap constraints are exceeded. Topographic design elements include: channel-to-weir transitions and grading between the abutments and adjacent ground. This barrier has recently been installed on Whites Gulch near Canyon Ferry; barriers on Seepay and Magpie Creeks near Dixon and Cottonwood Creek near Wolf Creek are in various design phases. This paper presents the basis for the structural, passage impedance and topographic design elements as well as design lessons learned from the installed barrier.

Effectiveness of flow management and rainbow trout harvest on long-term viability of native Yellowstone cutthroat trout in the South Fork Snake River

Laurie Battle*, Department of Mathematical Sciences, Montana Tech, 1300 W. Park St., Butte, MT 59701, lbattle@mtech.edu

Rob Van Kirk, Department of Mathematics, Humboldt State University

Bill Schrader, Idaho Department of Fish and Game

The South Fork Snake River supports one of the last remaining large-river populations of Yellowstone cutthroat trout (YCT). Rainbow and rainbow x cutthroat hybrid trout (collectively, RHT) established a self-sustaining population in the upper South Fork in the mid-1980s. In 2003, density of each species was 1,400 fish per mile. In 2004, U.S. Bureau of Reclamation began delivering a spring “freshet” from Palisades Dam, and Idaho Department of Fish and Game removed harvest limits on RHT. We evaluated current and future effectiveness of these management actions with a stochastic simulation model parameterized with observed data. Total RHT + YCT recruitment is positively correlated with winter flow, and RHT recruitment is negatively correlated with maximum freshet flow. There is little temporal overlap in spawning, and hybridization alone does not explain the observed RHT invasion rate. Nonetheless, continued removal of RHT from spawning tributaries is necessary to prevent long-term loss of YCT. A model of juvenile competition between the two species based on experimental results of Seiler and Keeley explains observed invasion rates. Current densities of 1,700 YCT per mile and 925 RHT per mile indicate reversal in population trends since 2004, and our analysis suggests that this is due primarily to harvest of RHT, which increased from 7% in 2003 to 20% in 2005. About 15% exploitation on RHT is required to prevent YCT extinction. We considered a likely future scenario to include mean winter flow of 1,600 cfs (72% of 1987-2007 mean but necessary to enable the freshet operation), maximum freshet flow averaging 20,000 cfs, and RHT harvest at 20%. Assuming environmental variance as observed since

1987, the 25-year population projection is about 1,100 fish per mile of each species. Increased percentage of YCT requires higher RHT harvest and/or higher maximum flows, and increased abundance requires higher winter flows.

Movements of spawning and non-spawning shovelnose sturgeon in the Missouri River above Fort Peck Reservoir

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During the last 40 years there has been a lack of pallid sturgeon *Scaphirhynchus albus* recruitment in the upper Missouri River (UMR). However, shovelnose sturgeon *Scaphirhynchus platorynchus* continue to exhibit recruitment in the UMR. Understanding the recruitment dichotomy between the species is receiving much attention throughout their range. The objectives of this study were to identify the effects of varying discharge on spawning locations and spawning movements for pallid and shovelnose sturgeon. Two female pallid sturgeon, 32 gravid female shovelnose sturgeon, and 32 non-reproductively active female shovelnose sturgeon were radio tagged at three locations and tracked from 1 May to 5 July 2009. Unfortunately, no data is available for spawning pallid sturgeon movements because fish were not reproductively active. Upstream movement by gravid shovelnose sturgeon varied from 20% of the fish tagged at Judith Landing to 56% of the fish tagged at Coal Banks Recreation Area (CBRA). Mean maximum upstream movement of gravid shovelnose sturgeon varied from 35.7 km at CBRA to 87.9 km at Fred Robinson Bridge (FRB), mean maximum downstream movement varied from 24.9 km at FRB to 80.3 km at CBRA. Reproductively inactive shovelnose sturgeon exhibited lower mean maximum movements than reproductively active fish (mean maximum distance 5.7 km). Shovelnose sturgeon in the UMR exhibit both upstream and downstream movements prior to spawning and are using several spawning areas. Thus, maintaining spawning habitat throughout a regulated river is important with regard to shovelnose sturgeon conservation.

Spatial Drift Dynamics of Shovelnose Sturgeon and Pallid Sturgeon Prelarvae in the Transition Zone of Ft. Peck Reservoir

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Habitats in reservoir headwaters may cause high mortality of sturgeon prelarvae. Short inter-reservoir reaches export drifting prelarvae from hatch locations into reservoirs. However, flooded vegetation could entrain prelarvae. We used 2 day post hatch (dph) shovelnose sturgeon and 1-dph pallid sturgeon to determine the spatial dynamics of drifting prelarvae. We released 220,000 2-dph shovelnose sturgeon 4 km upstream of Ft. Peck Reservoir and 135,000 1-dph pallid sturgeon 2.5 km upstream of the reservoir the following day. We recaptured shovelnose sturgeon prelarvae with nets deployed along three transects of the transition zone and within the headwaters of the reservoir. We sampled 5,148.2 m3 of water and recaptured 323 prelarval shovelnose sturgeon for a recapture rate of 0.14%. Fifty-nine percent of recaptured prelarvae were recaptured from the thalweg, 12% from the flooded vegetation-main channel interface, 9% from the channel border, and 19% from the zero-velocity area of Ft. Peck Reservoir. We recaptured pallid sturgeon prelarvae with nets deployed along one transect of the transition zone and within the headwaters of the reservoir. We sampled 6,608.5 m3 of water and recaptured 397 pallid sturgeon prelarvae for a recapture rate of 0.29%. Twenty-one percent of prelarvae were recaptured within the thalweg, 0.25% were recaptured along the channel margins, and 79% from the zero-velocity area of Ft. Peck Reservoir. Although recapture rates were low, the majority of prelarvae were captured in the thalweg and transported to the headwaters of Ft. Peck Reservoir. The drift dynamics observed in this study provide a springboard for further research.

Distribution & Population Status of Mussels in Eastern Montana: New Findings and Updates on Five Species East of the Divide

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The first two years of the SWG state-wide mussel surveys focused on the western pearlshell, but we've also collected distributional and population data on five other mussel species occurring in the state, two native (fatmucket, *Lampsilis siliquoidaea* & giant floater, *Pyganodon grandis*) and three introduced species (black sandshell, mapleleaf and creek heelsplitter). Eastern Mussel Surveys in 2008 & 2009 focused on the Missouri, Milk, Marias and Yellowstone River Watersheds. Survey reaches were chosen opportunistically based on accessibility, previous mussel sightings and suitable mussel habitat (depositional areas and gravel run/glides). Aquascopes were used for shallow water transects, while SCUBA was utilized for deeper water (>1m). Mussel data recorded during transects were standardized by time (CPUE, man-hour) and distance (mussels per 50m). Rivers with excellent populations of native mussels include the Missouri River between Fort Benton and Fort Peck, the Marias River above Lake Elwell & within 10 miles of the confluence. In the Yellowstone River Watershed, the Tongue and Bighorn Rivers reported viable fatmucket populations, while catch rates of the fatmucket on the Yellowstone mainstem were low (avg. ~1/hr compared to ~7 /hr in the Missouri). We documented the first records of the giant floater in the Yellowstone Basin at 3 tributary sites (O'Fallon, Little Porcupine, Tongue River), but no evidence of this species in the mainstem. The introduced mapleleaf (*Quadrula quadrula*) has high densities in the Tongue River, but was not found live in the mainstem Yellowstone. Further population analysis and state conservation rank status will also be presented.

O'Dell Creek Headwaters – Five Years of Stream and Wetland Restoration

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Since 2005, River Design Group, Inc. has collaborated with resource agencies and landowners to develop and implement comprehensive stream and wetland restoration strategies in the O'Dell Creek Headwaters Wetland Complex southeast of Ennis, Montana. An important spring creek tributary to the Madison River, historical land management practices resulted in the degradation and loss of wetland habitats and physical changes to O'Dell Creek including channel downcutting and incision, bank erosion, and simplification of instream aquatic habitat.

Projects have included reclaiming over 3.0 miles of irrigation and diversion ditches, reconstructing over 6.7 miles of spring creek, restoring 254 acres of prior converted wetlands, and improving the function of an additional 256 acres of wetland habitat in the project area. These activities have significantly improved habitat conditions for target fish species including brown trout and rainbow trout. Aquatic habitat improvements included modifying the channel geometry to a lower width-to-depth ratio configuration with riffle, run, pool and glide features. Coarse wood habitat structures and large roughness elements included roughened riffles were incorporated to diversity channel habitats. Wildlife habitat improvements enhanced existing and created additional palustrine emergent and scrub shrub wetlands throughout the project area, with emphasis on breeding, migration and stop-over habitats for neo-tropical migrant birds.

In summary, this multi-year restoration effort has improved aquatic habitat complexity, reduced the supply of sediment loading to O'Dell Creek and the Madison River, re-established functional wetlands, and increased the quality and availability of habitat for a variety of migratory bird species.

Effects of Fish Restoration Practices on Amphibians in Yellowstone National Park, WY

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Throughout the Western United States, fisheries managers are attempting to restore native cutthroat trout (*Onchorynchus clarkii*) populations by removing nonnative fish species. A new formulation of the EPA approved piscicide rotenone (CFT Legumine) is increasingly being used as a method to accomplish this removal. Because fish restoration projects bring about an abrupt change to aquatic environments, it is important to consider their immediate and long-term effects on non-target species, such as amphibians. We assessed the effects of fish removal on amphibians in Yellowstone National Park (YNP) by investigating the toxicity of rotenone to and the long-term impacts of removing fish on local amphibian populations. CFT Legumine (5% rotenone) was applied to High Lake in YNP (2006) to remove stocked Yellowstone cutthroat trout (O. c. bouvieri). To determine toxicity, amphibian surveys were conducted immediately prior to the treatment to obtain pre-treatment tadpole population estimates. Post-treatment surveys were conducted both immediately, for assessing treatment-related mortality (during and after application), and 1, 2, and 3 years following to obtain tadpole abundance estimates in the years after application and to address the long-term effects of fish removal and reintroduction. The results of the toxicity trials revealed that in the 24 hours following application, rotenone was lethal to gill-breathing amphibian tadpoles and non-lethal to non-gill breathing metamorphs, juveniles, and adults. In the years following, tadpole repopulation occurred at levels above the pre-treatment abundance estimate, though both tadpole abundance and distribution appeared correlated with fish presence.

Thermal Adaptation of Westslope Cutthroat Trout Oncorhynchus clarkii lewisi

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Populations of westslope cutthroat trout *Oncorhynchus clarkii lewisi*, a State species of special concern, have declined throughout their native range. Genetic introgressions, mainly from rainbow trout *O. mykiss*, but also from Yellowstone cutthroat trout *O. c. bouvieri*, and habitat loss are believed to be the leading causes of this decline. Populations that remain are often small and isolated, thereby increasing their risk of inbreeding depression and extinction. Translocation projects may offer a solution by infusing new genetic material into populations and potentially increasing their probability of persistence. However, local adaptations must be considered when selecting a donor population. We investigated thermal adaptations of four wild populations of westslope cutthroat trout from the Missouri River drainage and one hatchery population from the Washoe Park Trout Hatchery, Anaconda, Montana. Two wild populations were deemed to be from warm streams and two from cold streams. Fish were spawned streamside and at the hatchery. The resulting embryos were placed in experimental systems at 8°, 10°, and 14°C. Survival was monitored throughout incubation. Post-embryonic growth was measured 90 days after hatching. Relationships between population performance and natal stream thermal characteristics were examined for adaptive differences.

Observing the Effects of Inbreeding and Local Adaptation on Fitness in Westslope Cutthroat Trout Populations in a Common Garden

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Montana Westslope cutthroat trout (WCT) populations, particularly those east of the continental divide, are predominantly small and isolated from one other. Small population size inevitably leads to a more inbred population and can lead to lowered fitness (inbreeding depression). Isolated populations may experience local adaptation, which increases the fitness of a population within its native habitat. If inbreeding is the greatest threat to a population, introducing individuals from another population might be the best management decision. However, if local adaptation has also occured, introducing new individuals might lower the fitness of the population. Our goal was to evaluate the relative importance of inbreeding

and local adaptation on fitness in several WCT populations. This study combines eggs from several populations of WCT into several different natural habitats. Remote-site incubators were used to introduce eggs to six sites over four years in the Cherry Creek drainage. Each year a colder and warmer site was selected to test for the potential of local adaptation to stream temperature. Electrofishing was used to sample above and below introduction sites one, two, and three years after eggs were introduced. DNA sequencing of microsatellite loci in parents and offspring were then used to determine the population of origin of 511 offspring sampled in Cherry Creek in 2008 and will ultimately be used for over 750 offspring sampled in 2007 and 2009. Preliminary results suggest that a colder common habitat produces larger differences in relative fitness than a warmer habitat.

Performance of westslope cutthroat trout (Oncorhynchus clarkii lewisi) released into the upper Cherry Creek drainage using remote stream incubators

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A major effort to conserve westslope cutthroat (*Oncorhynchus clarkii lewisi*; WCT) is underway throughout Montana. One of the larger WCT conservation projects is occurring in the Cherry Creek drainage of the Madison River. About 105 km of stream and a mountain lake are being treated with piscicides to remove nonnative trout, and WCT are being introduced into the drainage using remote stream incubators (RSIs). We are evaluating the relative success of different wild and hatchery stocks of WCT released into Cherry Creek. Here, we report on survival, abundance, growth, condition, and dispersal of WCT in the upper Cherry Creek drainage during the first three years of releases. Two streams of similar size, upper Cherry Creek and Cherry Lake Creek, meet to form main Cherry Creek. Cherry Lake Creek is colder than upper Cherry Creek (average August temperature about 3˚C colder). Known numbers of WCT embryos were placed into RSIs at two sites in upper Cherry Creek during 2006 and 2007, one site in Cherry Lake Creek during 2006 and 2007, one site in Pika Creek (a tributary to Cherry Lake Creek) during 2008, and in an un-named spring-fed tributary to main Cherry Creek just below the mouth of Cherry Lake Creek during 2008. Fry that hatched in each RSI were captured and counted prior to release. Population abundances were estimated by single and multiple-pass electrofishing in 100-m sample sections located systematically throughout the upper reaches of the drainage. Estimated survivals from egg to fry, fry to age-1, age-1 to age-2, and age-2 to age-3 ranged from 13 to 80%, 7 to 80%, 21 to 100%, and 100%, respectively. Survivals in the colder stream, Cherry Lake Creek, were lower than in the warmer stream. Over 3,500 WCT occupied the upper Cherry Creek drainage by 2009. Fish dispersed short distances upstream and long distances downstream, but downstream dispersal appeared relatively discrete, with WCT filling available habitat near RSIs before occupying reaches further downstream. Early growth of WCT was much slower in colder streams, but by age-3 little difference existed among streams. Conversely, condition factors of WCT were slightly lower in upper Cherry Creek (averaging 0.88 to 0.95) than in Cherry Lake Creek (0.92 to 1.11). The introduction of WCT in upper Cherry Creek has been successful to date; however, natural reproduction by introduced WCT has not yet occurred, but is expected to occur next year.

Western Lake Trout – Just Say Whoa!

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In Montana, lake trout are a self-sustaining introduced species in approximately 20 lakes west of the Continental Divide. Less than half those lakes were intentionally stocked and lake trout naturally invaded the others through connected waterways. Lake trout populations are a detriment to native fish recovery in the majority of waters where they occur, including large lakes in Glacier National Park as well as Flathead, Swan, Whitefish, and others. In lakes with threatened native bull trout, lake trout management runs headlong into the Endangered Species Act. In addition, ongoing lake trout expansion ranks high amongst future threats to bull trout in the Clearwater lakes (Salmon, Seeley, Alva, Inez, etc.), Lindbergh Lake, Holland Lake, Lake Koocanusa, and others. In oligotrophic lakes of the Columbia Basin, introduced lake trout are well adapted and reproduce liberally, preying upon and competing with other native and sport fishes. Lake trout preference for deepwater habitat and in-lake spawning limits their exposure to land-based and avian predators. Lake trout are long-lived, hardy and resistant to starvation. In systems where Mysis relicta are added to the mix, a tipping point has often been exceeded for maintaining a diverse native ecosystem. Historically, lake trout management strategies were often designed to produce both maximum yield and trophy specimens. A recent review of seven western states revealed agencies are increasingly implementing strategies to reduce lake trout populations in attempts to minimize their impacts. However, management action to deter proliferation of lake trout has often been too little, with too few viable options, too costly, and sometimes too late. In addition, marginal support for lake trout suppression from an unhappy and divided angling public is also an issue.

An Evaluation of Lake Trout Suppression in Yellowstone Lake, Yellowstone National Park

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Introduced lake trout *Salvelinus namaycush* threaten to extirpate native Yellowstone cutthroat trout *Oncorhynchus clarkii bouvieri* from Yellowstone Lake, Yellowstone National Park. A National Park Service gill netting program has removed nearly 400,000 lake trout from Yellowstone Lake since 1995. Lake trout population size has not been estimated; therefore, it is difficult to determine the proportion that has been removed. Our objectives were to (1) examine catch as a function of effort to determine if the suppression program has caused lake trout abundance to decline, (2) determine if certain population metrics have changed over time as a function of harvest, and (3) develop age-structured models to determine the level of mortality required to cause population growth rate to decline below 1.0 (replacement). Catch has continued to increase as a function of effort, indicating lake trout abundance is increasing. Population metrics were not clearly indicative of a response to harvest, but were comparable to North American lake trout populations where harvest has occurred. Results from an age-structured matrix model determined the rate of population growth was 1.1 given the current rate of fishing mortality and that population growth rate would be 1.3 in the absence of fishing mortality. The current rate of population growth is positive; however, it is slower than it would be in the absence of lake trout suppression. Fishing mortality needs to increase by at least 10% to reduce population growth rate below 1.0 in the future.

Trends in characteristics of Yellowstone lake cutthroat trout, associated factors, and evidence of a population shift

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Comprehensive time-series data for Yellowstone cutthroat trout *Oncorhynchus clarkii bouvieri* (YCT) based on samples taken between 1977 and 2007 from the spawning run (spring; n = 29 years) of a tributary (Clear Creek) of Yellowstone Lake or caught in gill nets set (fall; n = 30 years) at established locations in the lake were examined to identify (1) associations between population characteristics within and between capture methods, as well as temporal trends in those characteristics, (2) evidence of informative shifts in population characteristics, and (3) factors that may have importantly affected the dynamics of the lacustrine-adfluvial YCT population of the tributary. Temporal increases in mean TL of YCT in the spawning run and of prespawners (i.e., YCT whose gonads indicated the fish would have spawned the next year) in the gillnet catch and concurrent declines in run size and prespawner catch were suggestive of an effect of YCT population density on the somatic growth of the fish. Similarly, a concurrent increase in mean TL of gillnetted YCT 100–199 mm long was indicated by the polynomial regression results, which also suggested statistical change points in the temporal trends for each of those variables. Contrasting those trends was that for mean TL of gillnetted YCT 200–299 mm long, whose general decline during the past two decades was attributed to predation by nonnative lake trout *Salvelinus namaycush*. Collectively, these trends provided evidence of a YCT population shift. Correlation results indicated YCT in the spawning run could not be unequivocally assigned to any particular lake region. Multiple regression analyses showed that Clear Creek run size was strongly affected by parental run size five years earlier and a measure of climate six years earlier.

A model of a storied, Lacustrine-adfluvial cutthroat trout population of Yellowstone lake: development, parameter estimation, and population prediction

Lynn R. Kaeding

A dynamic, age-structured model of the lacustrine-adfluvial Yellowstone cutthroat trout *Oncorhynchus clarkii bouvieri* population of Clear Creek, a tributary of Yellowstone Lake in Yellowstone National Park, Wyoming, was developed and its key parameters estimated on the basis of data taken from fish in the spawning run during each of two periods, "pre-lake trout" (1977–1993) and "lake trout" (1994–2007). The illegally introduced, reproducing, nonnative lake trout *Salvelinus namaycush* were discovered in the lake in 1994. Separate fitting of the model to data from each period allowed assessment of the robustness of the procedures employed and the rigor of conclusions. The model – of the time-variant, nonlinear linear, Leslie form – explained 72% of the variation in observed annual run size during the lake trout period when fitted to data from the pre-lake trout period. Conversely, the model explained 70% of the variation in observed annual run size during the pre-lake trout period when fitted to data from the lake trout period. The models each explained 85% of variation in observed run size when the two periods were combined. Results strongly suggested that climate (as indexed by total-annual atmospheric degree-days measured on the lake's north shore) had an important effect on recruitment of age-0 Yellowstone cutthroat trout to subsequent spawning runs. Characteristics of climate that individually or collectively affected first-year survival of YCT are unknown. Results also suggested that the effect of lake trout predation on the YCT population was small. Ongoing efforts to control lake trout in Yellowstone Lake may be importantly limiting lake trout predation on YCT.

Is habitat type a useful predictor of the outcome of interactions between Tubifex tubifex and Myxobolus cerebralis, the causative agent of salmonid whirling disease?

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The aquatic oligochaete *Tubifex tubifex* is the intermediate host for the parasite, *Myxobolus cerebralis*, which causes salmonid whirling disease (WD). Although the relationship between WD severity in salmonids and infection in *T. tubifex* is not well understood, previous research suggests that variation within local stream populations of *T. tubifex* may be an important determinant of parasite success. Our goals were to examine relationships among habitat features, abundance, infection prevalence, genetic diversity and susceptibility of *T. tubifex*, and WD risk in Yellowstone cutthroat trout spawning tributaries in Yellowstone National Park, where *M. cerebralis* was detected in 1998. Abundance of tubificids and *T. tubifex*, and infection prevalence in *T. tubifex* were higher in unconfined habitat types than in confined habitat types. *Tubifex tubifex* belonging to mtDNA lineages III, which are considered moderately susceptible to *M. cerebralis*, were also more abundant in unconfined habitats than confined habitats. We assessed the susceptibility of four genetically distinct strains of lineage III *T. tubifex* to *M. cerebralis* in the laboratory. Strains were established from field collected *T. tubifex*. All strains were susceptible to infection by *M. cerebralis* and strains from unconfined habitats amplified the parasite only slightly more than strains from confined habitats. These results suggest habitat type may influence variability in WD risk by affecting the outcome of interactions between *T. tubifex* and *M. cerebralis* in the field.

A conceptual model for predicting areas with high potential for lake trout spawning habitat in Yellowstone Lake

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The presence of non-native lake trout has become a serious threat to native salmonid populations in many lakes throughout the West. Costly and time consuming suppression efforts have been undertaken by agencies in several of these systems with concern regarding their efficacy expressed by fisheries managers. Frequently, mature lake trout are interspersed with the native fishes, hindering removal efforts because of bycatch of fishes meant to be the beneficiary of suppression efforts. One method of improving suppression efforts that could reduce negative impacts on other species is to target areas where sexually mature lake trout congregate for spawning activities. Using theory that water movements within lakes influence habitat formation, parameters describing lake trout spawning habitat in published literature, and the capability of a GIS to mesh spatially-explicit geographical datasets, a conceptual lake trout spawning habitat model was developed for Yellowstone Lake. Important inputs to this model include detailed bathymetry of Yellowstone Lake, a sedimentation model that predicts erosion and deposition of particles within lake systems, and data on primary wind direction over the lake. The model predicts that 4.4% of the surface area of Yellowstone Lake has excellent potential, 8.9% has some potential, and 86.7% has no potential to contain lake trout spawning habitat. Additional data layers can be easily incorporated as new information becomes available on lake trout requirements for successful spawning. This model can be used to identify suitable spawning areas for monitoring and control, and has potential to be applied on other lakes experiencing lake trout invasion.

Montana's Crucial Areas and Connectivity Assessment: An update and demonstration of the Crucial Areas Mapping Service

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Montana Fish, Wildlife and Parks (FWP) completed the Comprehensive Fish and Wildlife Conservation Strategy (CFWCS) in October 2005 as a landscape level plan to identify aquatic and terrestrial focus areas important to species and habitats of "Greatest Conservation Need". As implementation of the CFWCS began, FWP saw a need to refine the conservation scale and include terrestrial game and sport fish, FWP lands, and other recreational values into a Comprehensive Plan for Conservation. The "Crucial Areas and Connectivity Assessment" is an attempt to refine the conservation scale and identify important game and nongame fish and wildlife habitats, critical corridors, and valued recreational areas using a combination of empirical data, modeling based on these data, and expert opinion. The goal of this project is to identify and display critical and important habitats for fish and wildlife. Multiple benefits are perceived through achievement of this goal: increased efficiency in planning and commenting on development proposals, effective targeting and planning for the conservation of valued habitats, and increased opportunity for coordination with other agencies states. FWP spent the past year developing data layers, vetting the layers both internally and within the scientific community. Layers available to date include: game quality, game fish life history, watershed integrity, species of concern, aquatic connectivity, angler use, terrestrial species richness, and core area index. In parallel, FWP has developed an interactive Crucial Areas Mapping Service (CAMS) that depicts these resource values and allows users to relate each resource value to risk factors including energy development, urbanization, and subdivision. As the project develops and nears completion, best management practices and policy related to critical habitats will be produced. In mid-March, we plan to release CAMS to the public as a pre-planning tool and comprehensive decision support system.

Effects of Topology, Number and Location of Nodes, Population Density, and Stocking Duration on Hybrids' Dispersal across a Network

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Hybridization between native cutthroat trout (*Oncorhynchus clarki* sp.) and introduced rainbow trout (*O. mykiss*) has been a topic of fisheries research for decades in the northern Rocky Mountains, USA. Several studies suggest that the likelihood of introgression at any location in a stream network is influenced by the distance between that location and the source of non-native genes (e.g., stocking locations or areas dominated by non-native or introgressed fish). The relationship between "distance to non-native source"

and hybridization rates, however, is rarely quantified. Studies that attempt to quantify the relationship generally ignore the potential influence of stream network topology on gene movement. We have developed and applied an agent-based model that tracks the lineage and breeding location of individual fish over time, this simulating the movement of non-native genes among spawning locations within a stream network. The model considers both distances between spawning sites and network topology in determining non-natal spawning site selection by stocked and straying fish. Model results suggest that stream network topology has a strong influence on the relationship between "stream distance from genetic source" and "degree of hybridization" at spawning locations. However, the importance of topology varies depending on underlying model assumptions about, stocking duration, number and location of spawning grounds, population density, and spawning site fidelity (i.e., "straying rates") within the river system.

Meeting Resource Needs for Whitewater Recreation and Stream Fisheries at the Mystic Lake Hydro Project

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West Rosebud Creek is a valuable resource to both fishery and whitewater interests. It provides about 25 miles of trout habitat and several miles of late season, Class IV and Class V whitewater boating. Located approximately 90 miles from Billings and 150 miles from Bozeman, it is available to large populations of fishermen and boaters. Flow enhancement for whitewater recreation was identified as an issue early in the public relicensing process for the Mystic Lake Hydro Project. PPL Montana (PPLM) initiated a collaborative whitewater study and planning process with five stakeholder entities in 2004. In 2007, test flows and a paddler survey were used to identify desired flows, and in 2008 and 2009, test flows were used to develop the mechanics of providing the flows and investigate the effects of the whitewater flows on fish resources. In 2009, a flow protocol was developed that specifies the hydrologic conditions required for whitewater flow augmentation. PPLM plans to file the Final Whitewater Plan with the FERC in December 2009. A key to reaching agreement from all parties was the setting of a relatively high minimum flow to protect fish habitat. We will present the setting, constraints, methods, results, and initial experience of developing, testing, and implementing the whitewater flow plan.

The Science of Felt: A look at the research driving the move to eliminate felt soled waders

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One key to preventing new aquatic invasive species (AIS) introductions is to understand introduction pathways in order to implement prevention strategies. There is significant evidence that some AIS are being transported by wading anglers and many new introductions can be traced to this pathway. Research conducted in New Zealand and Montana has provided a better understanding of how AIS are likely spread by anglers and what might be required to reduce the risk of angler transport. The most significant finding is that the felt material glued to the soles of wading boots is a very problematic material and is far more likely to viably transport AIS than any other material used in waders. Based on this research, New Zealand instituted a national ban on the use of felt soles in October 2008. In the US, Alaska has announced a ban for parts of the state beginning in 2011 and New Mexico is considering a statewide ban. This presentation will provide an overview of the research into felt soles and will summarize how companies, agencies, policy makers and the public are reacting to the use of felt.

Clean, Drain and Dry! What about the biologists?

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One of the main ways invasive species are introduced to new habitats is through the movement of boats, field gear, and equipment from water body to water body. We ask the public to clean their gear and boats but are we leading by example? A field crew can enter multiple water bodies during a day without cleaning and disinfecting their gear. VHS, zebra mussels, chytrid fungus, New Zealand mudsnails, Eurasian watermilfoil and terrestrial weed seeds among others can be easily transported by field staff.

How can we expect the public to be concerned about how their actions spread invasive species when natural resource agencies and workers aren't taking preventative steps? Agencies and biologists need to develop and follow guidelines to prevent the movement of invasive species. Contracts with private companies and consultants should contain clauses that require disinfection of gear.

The Montana Chapter of the American Fisheries Society has a role to play. As a society that represents aquatic resources and professionals, AFS can promote cleaning and disinfecting protocols and procedures and educate its members about the need. I suggest that the Montana Chapter of AFS develop a policy statement and guidelines to limit the spread of invasive species by field workers. Only by leading, will the public follow the necessary steps to prevent the introduction of new invasive species to Montana.

Efficacy of Terramycin® 200 for Fish (*Oxytetracycline Dihydrate*) for the Skeletal Marking of Rainbow Trout Oncorhynchus mykiss

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In 2009, we conducted a study to evaluate the efficacy of Terramycin® 200 for Fish (TM200; 44.1% active oxytetracycline dihydrate) administered in feed at a target dosage of 3.75 g/100 lbs fish/d for 10 d for the skeletal (fluorescent) marking of fingerling rainbow trout. The in-life phase of the study was conducted indoors at a mean water temperature of 10.3ºC and comprised a 1-d acclimation period (no feed administered), 10-d treatment period (TM200-treated feed fed to six treated tanks; nontreated control feed fed to three control tanks), and 22-d posttreatment period (control feed administered to all tanks). At the end of the posttreatment period, all fish were collected and individually frozen. One month later, all fish were thawed, and two vertebrae were extracted from each fish. Each vertebra extracted was cleaned and then evaluated under ultraviolet light and a dissecting scope for the presence and quality of a fluorescent mark. All vertebrae extracted from TM200-treated fish (N = 120) had clearly visible marks, whereas no vertebrae extracted from control fish (N = 60) were marked. Consequently, in this study, TM200 administered in feed at a target dosage of 3.75 g OTC/100 lbs fish/d for 10 d was effective for the skeletal (fluorescent) marking of fingerling rainbow trout. Results will be used to support a U.S. approval of an expanded skeletal marking claim for TM200.

Quantifying temporal variability in stream habitat data: implications for restoration and monitoring

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Quantifying natural and anthropogenic-induced levels of temporal variability is essential for robust trend analyses and for evaluating the effectiveness of restoration activities or changed management actions. Here, we used data collected as part of the Pacfish/Infish Biological Effectiveness Monitoring Project to evaluate the extent of temporal variability in instream habitat collected at the reach scale. We integrate habitat data collected yearly (2001 to 2009) at 50 sites experiencing a range of management activities into our analyses to better understand the consistency of temporal variability in watersheds with inherently different landscape characteristics and disturbance regimes. We initially decompose variance estimates to remove site-to-site variability, sampling error, and year effects and use the remaining variance as a measure of site-specific temporal variability. We then relate this temporal variability to landscape, management, and climate attributes at multiple scales to better understand which characteristics result in more or less variability in habitat attributes at specific sites. Our results suggest temporal variability differs significantly across individual sites and attributes within sites, indicating our ability to detect significant changes as a result of management changes and/or restoration efforts are context dependent. The spatial scale of landscape attributes (e.g., stream buffer vs. catchment) related to temporal variability also varied across individual attributes. Our efforts highlight the importance of considering site-specific measures of temporal variability as they relate to specific restoration and management goals.

Montana DEQ’s approach to a standardized sediment assessment protocol: A biological consideration in the 303(d) listing process

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The Montana Department of Environmental Quality (DEQ) has been delegated by the Environmental Protection Agency (EPA) to implement provisions of the Clean Water Act. This includes submitting a 305(b) report every two years to the EPA describing the condition of all waters within the state’s jurisdiction and creating a 303(d) list of impaired waters. This reporting process involves assessing water quality for various parameters including sediment, metals, and nutrients. DEQ is currently reforming the assessment process by addressing inconsistencies in the way assessments were performed in the past and writing standardized protocols that will lead to more consistent decisions regarding impairment determinations. Here we focus on the assessment protocol being developed for sediment; a pollutant that can cause harm to aquatic life and fisheries. DEQ has applied the “Sufficient Credible Data/Beneficial Use Determination” since 2000. This process is well suited for an initial (screening) assessment, but has been challenged on the grounds of rigor and reproducibility by stakeholders when a specific pollutant is identified as harming a beneficial use. Our approach to this reforming process has been to study the literature, what other states have developed for assessment protocol, and methods that have already been developed by DEQ. Current considerations for what may be included in the assessment protocol will be discussed. We would like this process to be in the open for the public to comment and contribute. DEQ welcomes input in the process via a wiki page found at http://montanastag.pbworks.com and/or contacting any of the contributing authors.

Evaluating watershed condition: bottom up vs. top down approaches?

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Habitat degradation has been identified as one of the major factors affecting the declines of fishes in the Columbia River Basin. The condition of physical habitat and the biotic integrity of stream systems are often directly correlated with substantial alterations to key landscape attributes. As such, numerous approaches to measure watershed condition have been developed. Here, we compare two separate measures of watershed condition: 1) a GIS-based measure of condition (i.e., top down); and 2) a ground based assessment of condition (i.e., bottom up) using field data collected across 1,200 sites in the Interior Columbia River Basin under the PIBO Effectiveness Monitoring Project. With our GIS approach, we integrate land management and natural disturbance from watershed upstream of sample reaches into an overall watershed condition score. With our bottom-up approach, we integrate stream temperature data, indices of macroinvertebrate health, and an index of physical habitat condition from reach-level field data into an overall condition score. Our results indicate significant differences in assessments of condition across the two methods, as the GIS approach ranked considerably more watersheds with management activities into a low condition category than found in the bottom-up approach. Conversely, the GIS approach also categorized most watersheds with no or minimal management activities (i.e., reference) as low risk, while the field-based, bottom up approach illustrated a wide range of condition of reference sites due to natural disturbances. Our results suggest GIS-based approaches tended to quantify the 'risk' rather than condition within watersheds. The bottom-up approach tended to quantify actual conditions within streams, without consideration of potential risks associated with land management activities. Here, we advocate the most beneficial approach would be some combination of the two to help guide and prioritize restoration activities to enhance habitat conditions and minimize risk of catastrophic disturbances.

Bias associated with electrofishing estimates for mountain whitefish (*Prosopium williamsoni*) in rivers: four different ways we killed whitefish this summer

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Habitat loss, competition from exotic species, and a warming environment clearly are changing cold-water aquatic communities in western North America. As a result, the need to accurately quantify and detect trends in many species, rather than just threatened and endangered salmonine stocks whose low densities often preclude statistical certainty, is critical. Conventional monitoring has ignored many sympatric species, like mountain whitefish (*Prosopium williamsoni*). One challenge to monitoring other species is a lack of information on how to accurately sample their densities and monitor population status. Despite their broad distribution and locally high densities across their range in western North America, anecdotal evidence suggests their densities are declining and their distributions are changing, similar to those of sympatric salmonines. However, other anecdotal evidence suggests they may be more sensitive to electrofishing than salmonines. Thus, conventional monitoring many lead to biased estimates. We evaluated effects of capture technique, handling, and density on the survival of caged mountain whitefish in four separate week-long simulated mark recapture estimate studies in three sections of the Bitterroot River, Montana. In each study mountain whitefish succumbed to a variety of stressors and mortality ranged from 46-87%. Mortality was significantly greater than compared to paired treatments with rainbow trout (*Oncorhynchus mykiss*), where none died. As a result of the effects of a variety of stressors on survival and condition, we caution against mark recapture estimates for mountain whitefish in rivers.

Investigation into bias and variability in estimates of population size and biomass when catches of individuals are large relative to the total population

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Biomass of fish populations has traditionally been estimated by multiplying the average weight of captured fish by the estimated number of fish, with its variance estimated as the product of two variances. We present a method for estimating fish biomass in small streams (< 5 m wetted width) that uses a finite population correction factor (hereafter FPC) to take advantage of the fact that a relatively high proportion of the total population is normally captured and can be weighed during removal estimates. For these captured fish, measurement error is related to scale accuracy and field conditions. For the portion of the population that is not captured, we used a randomly stopped sums estimator (hereafter RSS) to estimate the total weight and variance of this non-captured proportion of the population. We also evaluated FPC and RSS methods individually to determine which of the four methods--(1) combination of FPC and RSS (FPCRSS), (2) traditional (hereafter OLD), (3) FPC, or (4) RSS--performed best. We also incorporated biomass estimates for fish that were captured, but not weighed, using length-weight regression predictions (FPCRSSreg). Performance of these estimators was evaluated using both simulated and field data. We based performance on reduction in the coefficient of variation (CV) of the biomass estimate and coverage of 95% confidence intervals (proportion of trials for which the 95% estimated biomass confidence intervals included the true biomass). The FPCRSS method had the narrowest CVs and the OLD method had the widest CVs for both the field and simulated data. Because of the high variance for the OLD method, 95% CIs for this method included the true biomass for a higher proportion of trials (nearly 100%) than 95% CIs for the FPCRSS method, but the coverage of the FPCRSS method for two-pass removal estimates was 80% or better for capture probabilities of 0.5 or higher. Using simulated data, we found that removal estimators are biased and that these biases are more pronounced at lower capture probabilities and lower population sizes. This bias in removal population estimators causes a bias in biomass estimates and was partly responsible for poorer coverage of 95% CIs. Our attempts to correct for population estimate bias resulted in much wider confidence intervals for both population and biomass estimates. For 607 field biomass estimates where all captured fish were weighed, the median CV for the FPCRSS method (0.05) was significantly lower (Wilcoxon sign-ranked test: $P < 0.001$) than the OLD method (0.76). When a portion of captured fish was not weighed, but estimated using length-weight regression relationships, the FPCRSSreg method had significantly lower CVs (median = 0.06; Wilcoxon sign-ranked test: $P < 0.001$, $n = 130$) than the old method (median = 0.86).

Using fixed and portable half-duplex PIT tag antennas to evaluate fish movement in a stream network: a case study in the upper Big Hole River basin

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Passive integrated transponder (PIT) technology is commonly used to evaluate the movement, habitat use, and dynamics of stream fish populations and assemblages. One distinct advantage of this technology is the ability to collect information over the life span of individually identifiable fish using passive monitoring sensors. In the upper Big Hole River basin, we used a combination of fixed and portable half-duplex PIT tag antennas to evaluate salmonid movement and habitat use at multiple spatial and temporal scales. In the summer and autumn of 2009, we used a network of 15 fixed stations and a series of portable antenna surveys to relocate PIT-tagged fish in the mainstem Big Hole River and tributaries within the valley-bottom. We used multiple antenna designs to account for the considerable range in stream size (approximately 2 to 60 meters wetted width). We directly evaluated the detection efficiency of our portable antennas in five tributaries and one reach of the mainstem. Overall, we conservatively estimated a 54% ($n = 6$, $SD = 0.13$) detection efficiency for one-pass surveys, with detection efficiencies varying among fish species and, to a lesser extent, among sites. Detection efficiency estimates for shed tags were consistent among sites and averaged 93 % ($n = 4$, $SD = 0.10$). Challenges, successes, and failures in implementing these antennas will be discussed. Overall, using a combination of fixed and portable antennas proved a useful and efficient approach to evaluating fish movement in this stream network.

Poster Presentations

Effects of Carbon Dioxide on Rainbow Trout Larvae: Application for Invasive Fish Eradication

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Currently, efforts are underway to eradicate invasive fish species that threaten the ecological integrity of aquatic ecosystems. Several studies have examined the effects of anesthetizing fish for easier handling, surgical procedures, tagging and management. Carbon Dioxide (CO2) is an approved and efficient anesthetic for adult fish in medicine and aquaculture and is favorable due to lack of residues, zero withdrawal period and does not need to be registered as its classification is generally regarded as safe (GRAS). Carbon dioxide has also shown to have lethal effects on other life history stages of fish. In this study, various early life stages of Rainbow trout (Oncorhynchus mykiss) larvae were exposed to CO2 in the form of dry ice pellets to determine the critical period of sensitivity for mortality in a model salmonid species. Studies were conducted in aluminum tanks ($n = 3$ tanks per treatment, with three chambers in each tank with 40 larvae per chamber) with 68 liters of filtered creek water (dissolved CO2 = 4 mg/l, dissolved O2 = 8.125 mg/l, pH = 7.78, temperature = 12.9 C°, conductivity = -55 mV, Total alkalinity as CaCO3 = 160 mg/l). Larvae exposed at post hatch day 10 had increased susceptibility to CO2, when compared with earlier embryonic stages. The results of the experiment indicate that early rainbow trout life history stages are susceptible to CO2 but only at late embryonic stages and may have implications for systematically eradicating invasive salmonids.

Long-term trends in the relative abundance and size structure of sport fishes in the Flathead River, Montana, following changes in Kerr Dam operations

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We studied long-term trends in the relative abundance and size structure of four sport fish taxa in the Flathead River, Montana, following changes in operations at Kerr Dam. In 1997 Kerr Dam was changed from a power-peaking and load-following facility to a base-load facility. The new base-load operations were designed to reduce fluctuations by establishing within- and between-day ramping-rate restrictions (i.e., maximum hourly and daily rates of change). We monitored spring and autumn trends in the relative abundance of two size classes (substock and stock) of northern pike (Esox lucius), Oncorhynchus spp., brown trout (Salmo trutta), and smallmouth bass (Micropterus dolomieu) from 1998-2008 using nighttime electrofishing. We documented significant ($P < 0.05$) increasing trends in the autumn catches per unit effort (fish/h) of both substock and stock sizes of all taxa, except stock northern pike. Trends in spring relative abundances were similar to those in autumn, except that increases in smallmouth bass catch rates were not significant ($P > 0.05$). We also examined long-term patterns in the size composition of fishes following changes in dam operations. All four taxa had either an initial strong downward shift in annual median total length or a decrease in the minimum sizes of fish captured, or both, a pattern consistent with enhanced survival of smaller fishes and highly suggestive of benefits from changes in dam operations. Our results imply that modifications in the operation of Kerr Dam led to significant increases in the relative abundance of four sport fish taxa in the Flathead River.

The effect of human activity on the movement of Dicamptodon aterrimus, the Idaho Giant Salamander, in the Lochsa drainage of central Idaho

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Movement influences fundamental ecological and evolutionary processes including population persistence and gene flow. It is, however, relatively unknown how fragmentation of habitats by anthropogenic disturbances influences the movement of stream organisms. We examined the relationship between the presence of road culverts and the movement patterns of Dicamptogon aterrimus, a large stream salamander, along two streams in the Lochsa River watershed of central Idaho. With this research, we tested whether road culverts affect the frequency of movement. To determine movement patterns, we conducted a mark-recapture survey of 30-meter reaches above and below road culverts and in reaches away from culverts during the summers of 2008 and 2009. Using a multi-strata model and Akaike's information criterion for model selection, we estimated survival and transition probabilities within and among stream reaches. We found that the presence of road culverts does not effectively halt movement along the stream channel and, therefore, should not stop gene flow among local populations. It may, however, hinder important demographic contributions, but this is in need of further study. Additionally, the frequency of movement between reaches separated by culverts was varied significantly between the two streams indicating that D. aterrimus populations may each react differently to the presence of road culverts. This research shows the need to understand variations in the response of distinct populations of stream organisms to human disturbance for effective amphibian conservation practices to be implemented.

Effects of electricity and altered conductivity on rainbow trout (Oncorhynchus mykiss) embryos: A study to determine the efficacy of electricity for the eradication of invasive salmonids.

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Electricity has been an applied means of facilitating capture and removal of invasive fishes for many years. Current methods involve the use of electrodes to establish a current through which passing fish will be susceptible to a brief shock to stun. This method, however, only affects free swimming individuals and is not inclusive of early life history stages such as embryos within spawning substrate. This study evaluates the susceptibility of embryonic and larval stage rainbow trout to direct DC current between 2-20v/cm in varying conductive waters to determine lethality for invasive salmonid eradication efforts. Rainbow trout embryos (n = 10 embryos per exposure) were initially exposed to homogeneous electric fields for 5s with a water conductivity of 220uS/cm from 1 day post fertilization (DPF)/ 27 temperature units (TU) to 15DPF/405TU. Mortality was assessed 24h post exposure and the LV50 (lethal voltage) at 220uS/cm was determined for each TU. Embryos from six periods of development were then exposed to their respective LV50 voltages in varying conductive waters (20-600uS/cm). Susceptibility to direct DC voltages increased with voltage but overall susceptibility decreased with development. Susceptibility to a constant voltage increased with increasing conductivity and was consistent throughout early development (81TU – 292TU), but the effects of increased conductivity were not enhanced in eyed embryos after 364TU. Results indicate that direct DC current applied prior to eyed embryonic stages, the period of greatest trout embryo susceptibility, is an effective means of eradicating invasive and nuisance salmonids.

The Effects of Ultraviolet Light on Rainbow Trout (Oncorhynchus mykiss) Embryos

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There currently exists a need to develop new approaches to control aquatic invasive and nuisance species. The effects of light radiation such as ultra-violet wavelengths of light have shown negative effects, such as increased embryo mortality in early embryonic salmonid larvae. This study explores the use of light radiation for eradication of invasive fish. Experiments were conducted to evaluate dose and critical period of sensitivity for mortality of rainbow trout (*Oncorhynchus mykiss*) embryos after exposure to visual and ultra-violet light radiation. Endpoints recorded include exposure intensity, effective distance from source, duration of exposure, malformations and mortality. Introduced light may be an effective and feasible eradication technique of early life history stages of fish and invertebrate invasive species in situ, as light can be implemented and removed with minimal environmental impact.

Effect of Hatchery Rearing Environment on Survival and Performance of Outplanted Westslope Cutthroat Trout Used for Population Recovery

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Reintroduction of native fish stocks is an important management tool used to mitigate the effects of invasive species and loss of habitat. One means of reintroduction is the use of hatchery fish to create or supplement native populations in areas of their historic range. The use of hatchery fish for reintroduction can be inefficient as low survival and competition with wild fish has been noted. This study has attempted to develop and evaluate the effectiveness of enriched hatchery rearing strategies on increasing the efficiency and effectiveness of hatchery reintroductions by examining behavioral, morphological, and physiological differences among westslope cutthroat trout *Oncorhynchus clarki lewisi* reared in varying levels of enriched environments. Social behavior, predator avoidance, cover seeking behavior, fin condition, growth, stress response, immune function, and muscle content have been evaluated during the first phase. Preliminary results show divergence in growth, fin condition, and social and cover seeking behaviors among the different rearing environments. Findings have suggested that manipulating hatchery rearing environments can alter behavior and morphology but determining if these alterations improve survival once outplanted is currently unknown.

Seasonal fish losses through Hauser Dam, Montana, 2007 to 2008

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Management of fish populations in Hauser Reservoir, Montana, is hindered by undesirable and unpredictable downstream fish entrainment through Hauser Dam. We quantified fish entrainment through the dam using hydroacoustics at turbine intakes from July 2007 to November 2008 and over the spillway from May 21 to July 18, 2008. Species composition was characterized using multiple netting gears. Total estimated entrainment was 145,470 ± 6,204. Annual entrainment from summer to autumn was higher in 2007 (N = 79,031 ± 4,378) than in 2008 (N = 52,513 ± 3,966). Spillway entrainment was 19% of annual entrainment in 2008 and was correlated with spillway discharge; turbine entrainment was not. Turbine entrainment increased from summer to autumn in both years, probably in response to autumn turnover and releases of hatchery rainbow trout. Spill entrainment in 2008 resulted in similar entrainment between summer and autumn, but autumn turbine entrainment increased in 2008. About 60% of entrained fish were smaller than 220 millimeters. We applied species composition by size to the hydroacoustic data to identify fish species entrained, but many fish (N = 55,529 ± 4,397) could not be reliably assigned to species because concurrent net catches did not include individuals of similar size. Total entrainment of identified fish was made up of mostly rainbow trout (33.3%) and walleye (30.2%). Identification of patterns in spatial and temporal fish losses affords fishery managers the ability to make more informed decisions about operation of this dam.

A multimedia information and education tool on the importance of bull trout and the relationship between bull trout and the Salish and Pend d'Oreille people

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The Confederated Salish and Kootenai Tribes have undertaken a large-scale watershed restoration project in an effort to benefit bull trout in the Jocko River drainage. An important component of this comprehensive project is education and outreach. In this poster and an accompanying digital presentation we will give an overview of a multimedia information and education project that describes the ecology and importance of bull trout, the relationship between bull trout and the Salish and Pend d'Oreille people, and the Tribes' current efforts to restore habitats. The project is composed of an integrated set of educational materials that will include an interactive DVD entitled "Explore the River: Bull Trout, Tribal People and the Jocko River", a curriculum, a website, a storybook "Bull Trout's Gift", and an accompanying field journal to be published by the University of Nebraska Press.

Cache Lake, located at the headwaters of Reese Creek, Yellowstone River Drainage, Yellowstone National Park, has retained its historically fishless condition. (Yellowstone National Park photo)