ABSTRACTS

BIOLOGICAL SCIENCES – AQUATIC

MONTANA CHAPTER OF THE AMERICAN FISHERIES SOCIETY 41ST ANNUAL MEETING

WARMING TO THE FUTURE: PREPARING FOR THE POTENTIAL EFFECTS OF CLIMATE CHANGE ON MONTANA'S AQUATIC RESOURCES

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2008 INVITED AND CONTRIBUTED PAPER ABSTRACTS

Over 180 members of the Montana Chapter of the American Fisheries Society gathered in Billings, Montana, February 12-14th for the 41st annual meeting of the Chapter. The meeting was organized around the theme of "*Warming to the Future: Preparing for the Potential Effects of Climate Change on Montana's Aquatic Resources*" and the opening plenary session included six very informative papers discussing science and policy related to this topic. **Mike Phillips** and **Dave McGinnis** set the stage by discussing the changing broad scale climate patterns and potential future climate trends and policy needs. The remaining plenary speakers —**Bruce Anderson, Robert Gresswell, Jack Williams, and Bruce Riemen**—brought the issue to ground and focused on the implications of a changing climate on habitat, stream temperatures, and native fishes. A consistent message to a somber audience was that climate change will likely be the biggest issue that aquatic biologists, managers, researchers, and practitioners have ever faced. Consider this: along with 1998, the first five years of the twenty first century were the hottest on record; arctic sea ice has lost nearly half its average thickness since 1950; greenhouse gas concentrations in the atmosphere are approximately 40% higher than pre-industrial levels; growing seasons at higher latitudes are approximately two weeks longer than in the 1950s; and the list goes on. Recognizing much uncertainty, and in some ways incredulity regarding the science of climate change, it is becoming increasingly clearer that change is afoot. What that change means for Montana's aquatic ecosystems remains a difficult question. The plenary session was organized in attempt to catalyze our members to keep this issue in the forefront of their professional activities. How can we as administrators, managers, and researchers better prepare for climate change related issues that seem an inevitable future? Will we be able to respond to a public and constituencies looking to us for guidance and solutions? Is there data that can be collected, research that can be conducted, policies that can be enacted, or activities and traditions that can be changed that will allow us to be better prepared and more proactive to address this issue? Of course there are, but they may not be easy.

The following abstracts presented at the 2008 annual meeting, which cover a range of topics from climate change to big river management, from native fish management and restoration to research on non-game fishes, demonstrates the wide reaching, important and timely work conducted by Montana's fisheries professionals. Based on this and past meetings, there is little doubt that the dedicated individuals, agencies, and organizations represented by the Montana Chapter of the American Fisheries Society will continue to strive to meet the challenges posed by a changing future.

Carter G. Kruse, President. Montana Chapter of the American Fisheries Society.

Climate Change impacts on Montana Waters

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Scientific consensus suggests that climate change is real and that we will soon need to address the ecological changes that will result. While normal weather changes give most of us a sense of uncertainty regarding how climate change might impact on Montana, the long-term picture for Montana can be developed well utilizing climate models and associated analysis of climate change impacts. This talk will describe our current knowledge and predications for Montana's future climate with a focus on fishery concerns. The general science behind climate change simulations will precede a description of how temperature and precipitation are likely to be different in the future. The goal of this talk is to provide a background of potential climate change that may impact on regional fisheries.

Global Warming, Restoration, and the Rocky Mountain Front

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Time will settle any on-going debate about the magnitude or meaning of global warming. In the meantime, restoration specialists are faced with prioritizing actions to maximize potential benefits to fisheries, stream systems, and water quality. The biological consequences of potentially elevated water temperatures, changing water yield, and reduced snowpack have significant implications both for resource management and allocation of limited funding. Data from the Rocky Mountain Front shows trends in reduced water yield and snowpack. In-stream temperature monitoring shows average and maximum temperatures well above thresholds considered sustainable for salmonids. Competition for irrigation water increases pressure on limited supplies and reduces in-stream flow. What happens if the environment becomes yet warmer, or if we respond with assertive restoration? The temperature model SNTEMP provides a means to evaluate an array of potential restoration actions including alteration of stream W/D ratio, baseflow discharge, riparian shading, and groundwater recharge. Application of this model along the Rocky Mountain Front provides a potentially enlightening perspective on our collective restoration focus. Add a couple degrees Fahrenheit to the mean air temperature, or increase riparian coverage 20 percent. Reconsider the in-stream results and your priorities as fisheries manager or stream restoration specialist.

Conserving and Restoring Native Trout in the Face of Climate Change, Invasive Species and Development

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Evidence suggests that factors such as climate change and a century of fire suppression are altering fire regimes in some vegetation types of the western USA, and the probability of large stand-replacing fires has increased in those areas. For example, over 100 million acres have been burned by wildfire in the West during the last 20 years. It appears, however, that even in the case of extensive, high-severity fires, local extirpation of fishes is patchy, and recolonization is often rapid. Lasting detrimental effects on fish populations have been limited to areas where native populations have declined and become increasingly isolated because of anthropogenic activities. Unfortunately, this situation is exacerbated by decreasing water availability at a time when demand is increasing. Furthermore, the potential of invasive species to expand under these altered habitat conditions is poorly understood. Despite incomplete knowledge of the effects of climate change in aquatic systems, it is apparent that managers must begin to develop a broad-based management strategy that focuses on protecting remaining native fish populations and associated habitat from further anthropogenic degradation and restoring degraded habitat and connectivity. Such a strategy will require a watershed-scale approach than integrates conservation and restoration activities throughout the stream network.

Potential Consequences of Climate Change to Persistence of Cutthroat Trout Populations

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Warmer water, changes in stream flows, and increasing frequency and intensity of disturbances are among the factors associated with climate change that are likely to impact native trout populations in the western U.S. We analyzed three of these factors—increased summer temperatures, uncharacteristic winter flooding, and increased wildfires—that are likely to affect broad-scale population persistence among subspecies of cutthroat trout, (*Oncorhynchus clarkii)*. Our models suggest that risk will vary substantially among and within subspecies. Up to 78 percent of currently occupied habitat of Bonneville cutthroat trout (*O. c. utah)*, 65 percent of westslope cutthroat trout (*O. c. lewisi)*, and 29 percent of Colorado River cutthroat trout (*O. c. pleuriticus)* will be at high risk from one or more of the three factors examined. Each subspecies contains two or more river sub-basins (Geographic Management Units) where all remaining populations either fail to meet basic persistence criteria and/or are at high risk from climate-associated impacts, indicating a high likelihood of genetic and life history losses within those areas. Stress from climate change is likely to compound existing problems associated with habitat degradation and introgression from introduced salmonids. Recognition of the increased risk from climate change may alter the management paradigm of isolation and require increased control efforts for invasive non-native species. Regardless of the management avenue chosen, more populations are likely to become isolated and vulnerable in the near future. We argue for early intervention within certain sub-basins to increase resistance and resiliency to at-risk populations and habitats prior to further disturbances associated with a rapidly changing climate.

Implications of Climate Change for Fishes in Headwater Streams: What's Changing and What Can We Do About It?

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Bruce Rieman has recently retired as a research scientist and program manager for the USDA Forest Service, Rocky Mountain Research Station in Boise, Idaho. He has 34 years experience in research, management and research program administration dealing with fishes, fisheries, and conservation biology. His work has extended throughout the Interior Columbia River Basin, but also has influenced aquatic natural resource management in much of the interior west. His most recent focus has been in collaboration with a team of physical and biological scientists investigating fish population dynamics, habitat relationships, and factors influencing persistence of local and regional populations. The implications of wildfire and climate change have been important elements of this work.

Is There Anybody Out There? Survival Estimation of Hatchery-Reared Pallid Sturgeon

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No recruitment of endangered pallid sturgeon (*Scaphirynchus albus*) has occurred in the upper Missouri River basin in at least 30 years and this species will likely be extirpated by 2024. Accordingly, the extant pallid sturgeon genetic pool is being preserved through captive propagation and stocking until habitat restoration permits re-establishment of self-sustaining populations. However, few recaptures of stocked fish and violation of model assumptions precluded evaluation of stocking programs over the past 10 years; no empirically derived survival estimates existed for hatchery-reared pallid sturgeon. We used a telemetry approach to develop a habitat-based sampling design that met model assumptions and yielded adequate recaptures to estimate survival of hatchery-reared pallid sturgeon stocked in the Yellowstone River. Telemetered fish appeared to preferentially select bluff pools and selectively sampling this habitat type resulted in catch rates (8.7 fish/hr or 1.6 fish/trammel net drift) 20 to 90 times greater than those of previous sampling designs. Apparent annual survival of three common stocking ages was estimated using Cormack-Jolly-Seber models. Probability of survival to age 2 of 13 month-old fish released in summer (0.19) was higher than that of 10 month-old fish released in spring (0.08) and 3 month-old fish released in autumn (0.01). Annual probability of survival for 13 month-old fish stocked in summer increased and stabilized (0.70) by age 4. Survival estimates for all stocking ages were lower than anticipated and suggest that stocking rates should be increased by an order of magnitude to meet current population targets and avoid local extinctions.

Effects of Varying Discharge on the Ichthyoplankton Assemblage in the Marias River, Montana

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Many lotic fish species use fluctuations in discharge as a cue for spawning. The effects of spring discharge variation on the spawning behavior of fish populations in the upper Missouri River have not been documented. Contrasting discharge events in the Marias River during the spring of 2006 and 2007 gave us the unique opportunity to study the response of ichthyoplankton density and richness to discharge variation. The objectives of this study were to examine spatial and temporal variation in the density of ichthyoplankton in the lower Marias River and to investigate the effects of varying discharge on the timing and location of spawning for resident fish species, especially sturgeon (*Scaphirhynchus* spp.). We sampled ichthyoplankton every four days in June and July of 2006 and 2007 at five sites in the Marias River, one site in the Teton River, and two sites in the Missouri River. Estimates of larval fish density varied temporally in the Marias River. Overall density of larval fish in the Marias River was greater in 2006 (0.206 fish/m^3) than in 2007 (0.089 fish/m^3). In 2006, sturgeon spawning occurred in the Marias River in conjunction with the spring hydrograph peak (134 m^3/s) when temperatures were between 15 °C and 20 °C, while no evidence of sturgeon spawning was documented in the Marias River in 2007 in absence of a spring hydrograph peak (15 m^3/s). These data suggest that increased discharge in the Marias River provides a spawning cue to sturgeon, while increasing overall ichthyoplankton density.

Mercury Dynamics in South Dakota Walleye: Water Level Fluctuations, Seasonal Variation and Reproductive Condition

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Consecutive years of high precipitation during the mid-1990s caused dramatic surface area expansions in many glacial lakes and wetlands of eastern South Dakota. In several of these lakes, walleyes (*Sander vitreus*)and other game fishes were found to contain elevated mercury (Hg) concentrations (>1 µg/g). Using data from recent habitat surveys and state-wide Hg sampling, we explored relationships between physicochemical attributes of lakes and Hg concentrations in walleye. Lakes that experienced the greatest change in surface area (Δ ha) between wet (1999-2001) and dry (1975-1979) years contained walleye with the highest Hg concentrations. We collected walleye from two high Hg lakes to determine if Hg concentrations fluctuate seasonally. Tissue Hg concentrations of walleye adjusted for length were significantly higher in the spring in both Bitter (42.9 %; $P < 0.008$) and Twin Lakes

(67.6 %; $P < 0.017$) compared to summer and fall samples. To evaluate factors affecting walleye reproduction, we compared reproductive characteristics between a low (Pelican Lake, mean Hg = 0.05 µg/g) and high Hg (Bitter Lake, mean Hg = 0.99 µg/g) lake. Mean monthly blood plasma concentrations of estradiol-17β and testosterone for both male and female walleyes were suppressed in fish from Bitter lake (high Hg) compared to Pelican lake (low Hg). To evaluate the influence of Hg on fertilization success, we conducted laboratory experiments to quantify effects of extrinsic (i.e., waterborne MeHg concentration) and intrinsic (i.e., Hg concentration of parental males) factors associated with Hg contamination. Fertilization success decreased significantly with increased waterborne MeHg concentration ($F_{[4,90]} = 70.5$, $P < 0.001$) and ranged from 28 percent at 1 mg/L to 65 percent at 0 mg/L. This study suggests that top-level predators in naturally contaminated lakes may be at risk for impaired reproductive success. Closely monitoring the relationship between walleye Hg concentration and recruitment dynamics would provide further insight into the toxicological effects of Hg on the reproductive success of walleyes.

What I Learned about Pallid Sturgeon on My Summer Vacation...A Summary of Findings From Reclamation-Sponsored Research In the Missouri and Yellowstone Rivers in Montana

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In support of Endangered Species Act consultation, Reclamation's Montana Area Office has been involved in several activities furthering the knowledge of pallid sturgeon (*Scaphirynchus albus*) in relation to Reclamation projects in the Missouri and Yellowstone Rivers. In the Upper Missouri River basin, responses by fish to a high spring flow in the Marias River in 2006 were measured and compared to a flat base flow in 2007. Responses included fish movements into the Marias River, movements in the Missouri River and increased production of larval fish and eggs in the Marias. Physical habitat monitoring showed a response in habitat formation via natural ecological processes such as sediment transport and woody debris movement in 2006. Radio telemetry data is indicating an area of the Missouri river that appears to be important to shovelnose and pallid sturgeon, possibly for staging or spawning that will be studied further. Sturgeon were captured on video in the Marias River using DIDSON technology, and information on spiny softshell turtles is also being collected. Other research efforts have been focused on developing fish passage on the Lower Yellowstone River near Glendive, Montana, and protecting fish from entrainment into the irrigation canal. Some of this work includes engineering design and sturgeon swimming studies. Larval pallid sturgeon were studied to investigate swimming endurance, impingement survival, screening effectiveness, and recovery of impinged fish from traveling fish screens.

Western Native Fishes Database; Species Status, Distribution, and Information Needs

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The Western Native Fishes Database is a project developed by the Native Species Committee of the Western Division of the American Fisheries Society (WDAFS). The goal of the project is to compile the most recent information on approximately 300 fish species native to western North America including the Canadian Provinces of British Columbia and Yukon; the Sonoran, Chihuahuan, and Baja California Norte States of Mexico; and the United States that include, or are west of, the continental divide; and Hawaii. Garcia and Associates (GANDA) completed the database design in the summer of 2004, data compilation in 2006, and an extensive peer review in 2007. The database can be queried by species, region, or HUC. The WDAFS envisions the database being used to track regional status of native fishes and to assist agencies and biologists in developing management plans that extend beyond political boundaries. This presentation provides an update on the project to its potential audience, describe the peer review process, and solicit input on our next phase which will allow mapping in real time.

Milltown Reservoir Dam Removal and Sediment Excavation

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The Milltown Dam is located approximately seven miles east of Missoula, Montana, at the confluence of the Blackfoot and Clark Fork rivers and was originally constructed to provide hydropower-generated electricity for a major sawmill in 1907. In 1908, a major flood resulted in a widely-spread overbank condition that washed tailings from major copper mining operations in the Butte and Anaconda area, approximately 100 mi upstream of Milltown. The backwater condition created by the dam resulted in the deposition of an estimated 7 million cubic yards of sediment behind the reservoir. A portion of these sediments contained elevated concentrations of metals, particularly copper and arsenic. EPA listed the Milltown Reservoir Sediment Operable Unit (MRSOU) on the National Priorities List in 1982 based on arsenic detected in Milltown groundwater wells located adjacent to the reservoir sediments. In late 2004 EPA selected a remedial action for the MRSOU, which included removal of the dam and excavation of 2.2 million yards of contaminated sediments. Initial drawdown and construction for the first phase of the project began in June 2006. This presentation summarized design and construction strategy for removal of the dam, the work conducted to date and measures implemented to minimize impacts to the Clark Fork River fisheries.

Distribution, Life History, and Movements of Yellowstone Cutthroat Trout in the Upper Yellowstone River Drainage

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The Yellowstone Lake ecosystem has long been a stronghold for native Yellowstone cutthroat trout (*Oncorhynchus clarkii bouvieri)*. However, recent declines in this assemblage, due to non-native lake trout (*Salvelinus namaycush)* and whirling disease, prompted fisheries investigations into the 1244-km^2 upper Yellowstone River watershed. The Yellowstone River is the largest tributary to Yellowstone Lake; however, because of its remoteness, little is known about the life-history of fishes using this watershed. During 2003- 2007 radio telemetry, electrofishing, and snorkeling were used to determine cutthroat trout distribution, life-history, and habitat use. Movements of 151 adults were tracked by aircraft and ground surveys. Cutthroat entered the river in April and migrated as far as 67 km to spawn. Spawning aggregations within the park were rare, found in only five locations. These sections were predominately runs with gravel substrate. Tagged fish typically spent < 3 mos in the river, the majority (72%) returned to the lake, 26 percent migrated downstream until signal loss, and 2 percent stayed in the river. Raft-mounted electrofishing and snorkeling of the main-stem Yellowstone River found 1.1 and 3.4 fish/km >200 mm respectively. The majority were found in 8 of the 39 sections surveyed. These sections contained pool habitats or runs/glides > 1.5m in depth, all contained woody debris. Densities of fish < 200 mm were 3.95 and 2.7 fish/km, respectively. Smaller fish were found in all habitats with the exception of pools. These data suggested that the majority of cutthroat trout in the Yellowstone River above Yellowstone Lake express a lacustrine-adfluvial life-history.

Landscape distribution and biological diversity of cutthroat trout in the Snake River headwaters, Wyoming

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We used a landscape scale approach to facilitate the synthesis of ecological, morphological, genetic, and life history information regarding the distribution and organization of Yellowstone cutthroat trout, (*Oncorhynchus clarkii bouvieri*) and fine spotted Snake River cutthroat trout, (*Oncorhynchus clarkia)* subspecies, in the Snake River headwaters of northwest Wyoming. Our work focused on the largely connected stream networks up and down stream of Jackson Lake dam. Systematic sampling allowed us to hierarchically analyze for morphological or geographic structuring from the stream reach

to basin scale. Differences in landscape distribution were observed, with the large-spotted morphotype decreasing in occurrence along a north-south gradient. Multivariate analyses of spotting patterns can discriminate between the large-spotted and fine-spotted morphotypes, with < 10 percent misclassification rates. We were unable to genetically differentiate between the morphotypes using an 1150 bp region of the ND1-ND2 mitochondrial genome, however, two genetic clades and differences among drainages were apparent. We observed a range of mobility by cutthroat trout that exhibited resident and fluvial life histories. Ranging behavior of fluvial migrants varied from < 5.0 km in headwater streams, to > 40.0 km in larger rivers with complex seasonal movements among several streams. As climate changes, future conservation of cutthroat trout in the Snake River headwaters should continue to emphasize maintenance of phenotypic variability, protection of existing genetic structure, as well as restored habitat connectivity to sustain life history variability. Conserving the biological diversity exhibited by these native cutthroat trout need not be encumbered by taxonomic distinction, especially given that a changing climate may favor one or neither of the morphotypes.

Evaluating Effects of Small Dams on Migratory Bull Trout in the Clearwater River Drainage, Montana

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Dams are well known for their negative impacts on fish populations. As a result, dam removal decisions are becoming increasingly common. In collaboration with Montana Fish, Wildlife and Parks and the USDA Forest Service, we are using the Clearwater River Drainage in West-Central Montana to explore effects of small dams on migratory bull trout (*Salvelinus confluentus*). We captured 41 adfluvial bull trout below two small dams, implanted radio tags ($n = 17$) or pit tags ($n = 24$), and released them above the dams. We are monitoring movements of these radio-tagged fish and other bull trout tagged in the surrounding lakes. These dams are upstream migration barriers. Fifteen of 17 radio-tagged fish we moved over the dams, as well as several fish tagged in the lakes swam into a spawning tributary and presumably spawned. We confirmed two additional spawning tributaries where bull trout recruitment is likely due to migratory fish. The relatively large number of bull trout captured below the dams compared with redd counts in the spawning tributaries provides evidence that these barriers may have large impacts on population sustainability. Post-spawning mortality rates were high and attributed to low water conditions, high cost of spawning, and predators. Our ongoing research will further monitor mortality rates and work to quantify the impact of these barriers on bull trout in the drainage. This information will contribute to the decision-making process involving dam modifications or removal to balance the benefits of upstream passage for native fish with the risk of expansion by undesirable non-native fish.

The Influence of Beaver on Brook Trout Invasion and Native Westslope Cutthroat Trout Displacement in Rocky Mountain Streams of Southwestern Montana

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Invasion of ecosystems by nonnative species is often responsible for reshaping natural biological communities. In the Rocky Mountains, brook trout (*Salvelinus fontinalis*) invasion has been implicated in the decline of westslope cutthroat trout (*Oncorhynchus clarkii lewisi*), a native species of special concern in Montana. Although research has established that negative interactions between these species likely occur at the juvenile stage, there remain gaps in our understanding of the landscape factors that influence the extent of invasion, and resulting cutthroat declines. For example, beaver (*Castor canadensis*) are capable of altering stream habitat characteristics considerably, but we do not know how beaver disturbance influences brook trout invasion success, and the consequences for native cutthroat trout. To address this, I used temperature loggers, mark-recapture, and habitat surveys to establish how beaver affect (i) brook and cutthroat trout distributions within watersheds, and (ii) species interactions between cutthroat and brook trout. Distribution and temperature data show that beaver-induced stream warming sustains brook trout invasion at higher elevations, while brook trout presence acts to reduce cutthroat trout growth rates. Ongoing analyses of growth rates from scales, and examination of demographic rates of both species will lend greater insight into how beaver impact this system.

Assessing Distribution and Abundance Patterns of Cutthroat and Brook Trout Using Thermal Data Coupled with Physiological Models of Fish Growth

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Distributions and abundances of native westslope (*Oncorhyncus clarkii lewisi*) and Yellowstone cutthroat trout (*O.c.bouvieri*) have declined in Montana during the last century. Nonnative salmonids and habitat and climate change have been implicated in this decline. Cutthroat trout in Montana are currently restricted primarily to higher elevation stream habitats, where mountain ranges appear to function as island refuges, especially within the upper Missouri basin. Preliminary analyses indicate restriction of cutthroat trout to upper elevation refuges might be partially explained by thermal gradients. Competitive interactions between cutthroat and nonnative salmonids may be partially regulated by temperature. We explored methods for evaluating whether temperature might help explain distribution and abundance patterns of cutthroat and brook trout at over 1000 sites we sampled throughout the Northern Rocky Mountains. Patterns of cutthroat trout occupancy appeared associated with elevation and air temperature predictions at various scales, from state-wide to the stream

scale. We used an existing thermal model to predict daily water temperatures. We linked this model with relationships between fish growth and water temperature developed in laboratory studies to integrate the potential influence of the thermal regime on fish at each sample site. We collected water temperature data at over 100 sites through several years to develop, validate, and calibrate this thermal model. If thermal information significantly contributes to our understanding of the current distributional patterns of these species, managers can use these relationships to target areas for cutthroat trout conservation that have the best likelihood for success. Managers could also use these models to locate and conserve streams for future cutthroat trout conservation under the assumption of continued global warming.

Interactions Between Bull Trout and Lake Trout for Simulated Cover Habitat

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Population-level declines of bull trout (*Salvelinus confluentus*) have been observed following establishment of lake trout in lake ecosystems. The mechanism responsible for these declines is unknown; however, competitive interactions between these two species of char may occur at one or more ontogenetic stages. Cover habitat in lakes (e.g., interstices of rocky substrate) may allow detection of food resources while providing protection from predators for juvenile bull and lake trout. We examined use of simulated cover habitat in the laboratory to determine if bull trout and lake trout behavior reflects cover use in the presence of conspecifics, and if bull trout and lake trout alter behavior in the presence of heterospecifics. Behavioral observations were made to determine if fish were 1) using cover, 2) stationary on the bottom of the tank, 3) stationary in the water column, or 4) swimming. In the presence of conspecifics, on average bull trout used cover habitat 38 percent of the time, were stationary on the bottom 33 percent, swam 15 percent, and were stationary in the water column 9 percent. In the presence of conspecifics, on average lake trout used cover habitat 2 percent of the time, were stationary on the bottom < 1 percent, swam 38 percent, and were stationary in the water column 58 percent. Neither bull trout nor lake trout responded differently in the presence of heterospecifics. Bull trout and lake trout had essentially opposite behavioral responses in the presence of simulated cover habitat. Therefore, these data provide no support for the hypothesis that these species compete for cover habitat.

Effects of Fire on Stream Temperatures in the Bitterroot River Basin, Montana

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Stream temperature is an important abiotic factor affecting the distribution of native trout. Much of our understanding of the effects of wildfires on stream temperatures is derived from individual case studies. In 2000, major wildfires burned in the Bitterroot River Basin, Montana. We used a Control-Impact design to examine immediate effects of wildfire on maximum stream temperature and a Before-After-Control-Impact design to evaluate recovery of maximum summertime stream temperatures after wildfires. We examined temperature data from 33 streams at three kinds of sites: those in largely unburned watersheds, those downstream of burns, and those within burns. To account for potential seasonal differences in recovery, we analyzed August and September separately. During the fire, there were no significant increases in maximum water temperature in sites located within or downstream of burns. One year after the fire, there was a significant fire effect in August (1.7°C ±0.33) and September (2.3°C ±0.16) at sites located within the burned area compared with reference sites. But, there was no significant increase in temperature in sites downstream of burns compared to reference sites. We saw a significant increase in temperature for all treatment groups over the last 12 years indicating regional warming. Maximum summertime temperature increased 0.4°C (95% CI±0.33), 1.1 °C (95% CI ±0.63), and 2.8 °C (95% CI ±0.87) in reference, below-burn, and within-burn areas, respectively. There was no recovery of stream temperatures in burned areas five years after wildfires. These results are similar to other studies where wildfires have localized, long-term impacts on stream temperatures.

Evaluating Surgical Implantation of 23-Mm Passive Integrated Transponder (PIT) Tags in Arctic Grayling

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Passive integrated transponder (PIT) technology is useful for evaluating movement, habitat use, and the dynamics of fish populations and communities. One distinct advantage of this approach is the ability to collect information throughout the life of individually identifiable fish using passive (remote) monitoring sensors (fixed and portable antennas). Despite widespread use of PIT tags in a variety of salmonids, some questions remain concerning post-implantation survival in some species. To determine potential negative effects of using PIT tags in Arctic grayling (*Thymallus arcticus*), we (1) implanted 23-mm

half-duplex tags in Arctic grayling and measured subsequent short-term mortality, and (2) reviewed literature concerning the effects of using PIT tags in fish. We PIT-tagged grayling from 158 to 340 mm in total length, and after four days, we observed 100-percent survival and 100-percent retention of PIT tags. Furthermore, published reports suggested that survival and growth of PIT-tagged salmonids ≥ 100 mm does not differ significantly from controls. These results support the assertion that PIT-tagging Arctic grayling >150 mm will not negatively affect grayling populations or research results. Subsequent research to determine the minimum size of Arctic grayling that can be implanted with 23-mm PIT tags without negative effects is warranted.

Spatial and Temporal Dynamics of Spawning Between Native Westslope Cutthroat Trout, Introduced Rainbow Trout, and Their Hybrids, With Implications for Hybridization and Loss of Adaptation

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Populations of many native salmonids in western North America are threatened by introgression with introduced rainbow trout (*Oncorhynchus mykiss*; RBT), yet little is known about the reproductive factors influencing the spread of hybridization in the natural environment. We used radio telemetry to assess spatial and temporal spawning distributions of native westslope cutthroat trout (*O. clarkii lewisi*; WCT; $N = 27$), introduced RBT ($n = 51$) and their hybrids ($n = 47$) in the upper Flathead River system, Montana and British Columbia, from 2000 to 2007. Radio-tagged trout moved upriver towards spawning sites as flows increased during spring runoff and spawned in 29 tributaries. WCT migrated greater distances and spawned as flows declined in headwater streams dominated by snowmelt runoff, whereas RBT and RBT-hybrids (backcrosses to RBT) generally spawned earlier in low elevation streams fed by springs or headwater lakes; WCT-hybrids (backcrosses to WCT) spawned intermediately in time and space. Both hybrid groups spawned over relatively long time periods that produced temporal overlap with spawning WCT in most years. Spatial overlap between parental species occurred in four streams (two streams where F_1 hybrids and two streams where RBT spawned in the same areas used by WCT) and spawning sites used by both hybrid groups overlapped in 17 streams. One stream, Abbot Creek, supported a relatively high proportion of spawning by RBT and RBT-hybrids (47%), and a genotypic gradient was found extending upstream from the site, indicating that this location is likely the ultimate source of introgression in the study area. The spatial distribution of RBT, RBT-hybrids, and F_1 hybrids indicates hybridization is being promulgated upstream by long distance movements of individuals with high amounts of RBT admixture, but the spatial distribution of later-generation backcrosses suggests stepping-stone invasion may also be an important mechanism for spreading nonnative genes, corroborating conclusions from previous genetic studies. Our data suggest that (1) spatial and temporal overlap was occurring in the lower drainage, but streams in the middle and upper drainage still provided reproductive segregation; (2) introgression erodes discrete spawning behavior of migratory WCT, which will likely lead to lead to loss of local adaptation; and (3) the spread of hybridization is likely to continue and

genomic extinction is imminent if hybrid populations with high amounts of RBT admixture are not reduced or eliminated.

Local-Habitat, Landscape, and Biotic Factors Associated with the Distribution of Hybridization Between Native Westslope Cutthroat Trout and Introduced Rainbow Trout in the Upper Flathead River System

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Invasion of nonnative fishes in freshwater systems is often facilitated through the interaction of environmental and biotic factors operating at multiple spatial and temporal scales. We evaluated the association of local-habitat features, large-scale landscape characteristics, and biotic factors with patterns of occurrence and degree of hybridization between native westslope cutthroat trout (*Oncorhynchus clarkii lewisi*; WCT) and nonnative rainbow trout (*O. mykiss*; RBT) in 35 streams of the upper Flathead River system in Montana., and British Columbia, Canada. The presence or absence of hybridization and the proportion RBT admixture for each sampled population was estimated using seven diagnostic microsatellite loci. Local-habitat features included measures of stream size, gradient, and elevation. Landscape variables included measures of mean and maximum summer water temperature and of land disturbance (upstream road density and the number of upstream road crossings). The abundance of trout within sampled sites and distance to the source of hybridization, e.g., Abbot Creek, were used as measures of the biotic potential for invasion to occur. We defined nine candidate logistic regression models that represented various combinations of these three factors and used an information-theoretic approach to evaluate the relative plausibility of competing models. Models combining local habitat (width) with landscape characteristics of mean summer temperature and number of road crossings in combination with the biotic variable distance to the source of hybridization were the most plausible models, yielding overall classification accuracies of about 88 percent. However, individual effects within these models could not be discerned because of collinearity. The presence of hybridization was positively associated with mean summer water temperature and number of upstream road crossings and negatively correlated with distance to the source of hybridization and stream width. Linear regression analyses showed that the distance to the source of hybridization was the only factor related to the proportion RBT admixture among hybridized sites. Finally, trout (> 75 mm) density was negatively related to stream width and elevation among the study streams. Our results suggest that hybridization increases in streams with warm water temperatures, high land use disturbance and close to the primary source of hybridization. Management strategies for preserving nonhybridized WCT populations should attempt to eradicate populations with high levels of RBT admixture in warmer streams with high densities of hybrid fish.

Yellowstone Cutthroat Restoration In Goose Creek

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Goose Creek is a tributary to the Stillwater River in Park County north of Cooke City, Montana. Goose Lake, located at the head of the creek, has recently become the wild brood source of Yellowstone cutthroat trout (*Oncorhynchus clarkii bouvieri;* YCT) for the Montana hatchery system. A small cascade that is not a complete barrier to fish passage has to date precluded brook trout (*Salvelinus fontinalis*) from colonizing Goose Lake. Brook trout dominate the creek downstream from this cascade. Three lakes are present on a tributary stream to Goose Creek and these lakes also harbor brook trout populations. There is approximately 6 mi of stream between the cascade barrier and the confluence with the Stillwater River. Near the confluence there is a series of three natural waterfalls that isolate Goose Creek from the rest of the drainage. In August of 2007, Goose Creek and the three lakes were treated with rotenone in the formulation CFT Legumine to remove brook trout. The goal of the treatment was to prevent brook trout from colonizing Goose Lake and to expand the range of YCT in the drainage. Rotenone was applied at a rate between 1.5 and 3 parts/million (ppm) to the lakes and 1 ppm in the stream. Rotenone was applied to the lakes using an outboard powered boat and a trash pump system. Drip station and backpack sprayers were used to treat the stream and associated backwaters. A helicopter was use to transport equipment and personnel into and out of the site. The success of the project has yet to be determined. The area will be treated a second time in 2008 to insure a 100 percent kill of brook trout was accomplished.

Effects of Fish Size and Stream Characteristics on Piscicide Effectiveness

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The piscicides rotenone and antimycin are important tools in fisheries conservation but their application can be both inefficient and ineffective. Current information on the toxicity of these piscicides is based on a narrow size class of fish and persistence of toxicity is not known for a wide range of environmental conditions. For example, the toxicity of piscicides has been assessed in separate studies using juvenile and adult rainbow trout but has not been compared across a wide range of fish sizes. We determined the toxicity of rotenone and antimycin to a wide range of sizes rainbow trout (*Oncorhynchus mykiss*) and determined the applicability of piscicide persistence models over a wide range of environmental conditions. We tested the toxicity of rotenone (12.5 ug/L) and antimycin (7.5 ug/L) to rainbow trout from 31-345 mm total length. Rotenone killed fish faster than antimycin but no significant relationship existed between size of fish and time to death. We also developed models that measured the detoxification of piscicides caused by the interactive effects of combined stream characteristics. These models were tested against measurements of piscicide persistence in stream applications. The predictive ability of the models was good using reclassification procedures but varied when models were applied to data from stream applications. Models to predict the persistence of piscicides in streams will enhance the efficiency and effectiveness of piscicide applications.

TOXICITY OF FINTROL® (ANTIMYCIN) AND PRENFISH® (ROTENONE) TO THREE AMPHIBIAN SPECIES

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The toxicity of two piscicides, Fintrol® and Prenfish®, to Columbia spotted frogs (*Rana luteiventris*), long-toed salamanders (*Ambystoma macrodactylum*), and Rocky Mountain tailed frogs (*Ascaphus truei*) of varying life stages was determined from 96-h tests. The 96-h LC50 values for Fintrol ranged from 13.7 to 192 µg/L and for Prenfish the range was 0.009 to 9.65 mg/L. Tailed frog larvae were the most sensitive to both piscicides, surviving exposure to Fintrol as low as 3.7 µg/L, and having 10-percent mortality to the lowest test concentration of Prenfish tested (0.005 mg/L). Spotted frog adults survived exposure to Fintrol at concentrations six times the label prescription, and survived exposure to Prenfish up to 4.5 times the label prescription. Long toed salamander larvae survived exposure to Fintrol at levels ~ 30 percent higher than the label prescription, but had a similar sensitivity to Prenfish as some species of fish. Comparing the results of these tests with tests on fish and other amphibians showed that when used in the field, Fintrol would likely not have an impact on any of the species or life stages tested, and Prenfish would not likely impact adult amphibians but could have an impact on larvae.

AGE MODERATED EFFECTS OF FINTROL® (ANTIMYCIN) ON LARVAL AMPHIBIANS

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The use of piscicides to remove competing and hybridizing non-native fish has become a commonly considered option in conservation programs focused on preserving and restoring native salmonid fishes in the intermountain west. However, piscicide projects have been criticized, especially by opposed publics, as heavy handed, with unintended and harmful effects on non-target organisms – primarily aquatic macroinvertebrates and amphibians. Past experiments and field observation have generally shown field level dosages of Fintrol®, an antimycin based piscicide, to have relatively little effect on larval (tadpoles) and adult amphibians. In 2003, while conducting a piscicide treatment, we observed mortality of western toad (*Bufo borealis*) larvae in side-channel water that had been sprayed with Fintrol®. In 2004 *in situ* bioassays were conducted during a stream application of Fintrol® (10µg/L for 7-8 hrs) to determine the effect of treatment on amphibians. Adult, sub-adult, and larval Columbia spotted frogs (*Rana luteiventris*), as well as larval western toads, were placed in live cars in the treatment section. All spotted frog age-classes survived until release 48 hrs post-treatment; however, western toad larvae experienced 100-percent mortality. From 2005

to 2007 we conducted a series of laboratory experiments (water pH of 7.5-8.0 and 21 °C) with these two species to better determine if the mortality we observed in the field was species, age, or dosage related. Amphibian larvae were exposed to a series of Fintrol® dosages (0 – 120 µg/L) at different stages of maturity in a total of 141 aquaria exposure trials. Mortality was high for both species at field level dosages (5-20 µg/L) at early post-egg larval stages (Gosner stage 22-24). Mortality decreased as larvae aged and by Gosner stages 29-30 both species seemed relatively resistant, at least as measured in terms of direct mortality, to moderate dosages of Fintrol®. After Gosner stage 30 very high dosages of Fintrol® (60-80 µg/L) were required to cause mortalities > 50 percent. These results suggest that carefully timed Fintrol® treatments might have minimal effects on at least these two species of amphibians. However, treatments conducted under different water quality conditions may lead to different results.

Pearl Dace in the Big Muddy Creek Watershed: Extirpation Saved by the Barrier

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During 2007, we reviewed Pearl Dace (*Margariscus margarita*) occurrence records and systematically resurveyed sites of current and previous occupation in the Big Muddy Creek watershed in NE Montana. Thirteen sites (4 main-stem Big Muddy and 9 tributary sites) were surveyed in June, and then re-sampled in September following Bramblett's prairie fish sampling protocols. Four of these locations had old museum pearl dace voucher records that had been resampled by MSU from 2000-2003, and are now confirmed absent. Northern pike captured in June surveys were vouchered; therefore the September survey could potentially document stream reach recolonization. Introductions of northern pike have been implicated in the decline of numerous local populations of native minnow species including the pearl dace. Our surveys collected 14 (9 native) prairie stream species. Pearl dace were only collected at one tributary stream site in the Big Muddy. Species that were closely associated with the pearl dace were fathead minnows, brook sticklebacks, northern redbelly dace and white suckers. Sites with northern pike present ($n = 4$) had significantly fewer fish species ($P = 0.0304$) than non-pike stream reaches ($n = 22$). Furthermore, samples from stream reaches with barriers from the mainstem Big Muddy ($n = 11$) had significantly more fish species ($P = 0.011$) and numbers of individuals ($P < 0.0001$) than sites without barriers ($n = 15$). Intact native prairie fish communities are becoming rarer to find. By documenting "non-pike" refuge areas or initiating pike removal projects, reintroductions of pearl dace may be considered as a management tool for the persistence of this species in the glaciated prairie streams of Montana.

Mate Choice and Reproductive Ecology in The Phoxinus Eos/Phoxinus Eos-Neogaeus Complex

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The Northern Redbelly Dace (*Phoxinus eos*) and the Finescale Dace (*Phoxinus neogaeus*) can hybridize to form an all-female, gynogenetic (asexual) "species", *Phoxinus eos-neogaeus,* which requires sperm from one of the parental species to stimulate development of diploid, clonal ova. This hybrid occurs in Montana along with one of the parental species, *P. eos*. We investigated the reproductive ecology of this complex including mate choice in *P. eos* males and in the hybrid, and various clutch characteristics in both species. Mate choice experiments used a choice-tank with the "choosing" fish in a central section and one "choice" fish at either end behind clear, perforated dividers. Each trial was recorded from above for approximately 8 min, after which the fish at the ends were swapped, and the trial repeated. Results for each "chooser" fish thus consisted of the proportion of time spent in each third of the central section, for two combined trials. Clutch characteristics were determined by dissecting preserved females and counting, weighing and measuring appropriate enlarged oocytes or ova. Results indicated that male *P. eos* showed no preference for either the sexual *P. eos* females or the asexual *P. eos-neogaeus* hybrids. Further, though females of both types preferred larger males to smaller males, the strength of this preference did not differ between the two types of females. Finally, reproductive traits did not differ between the two types of females. We suggest that these results may be due to the incorporation of some sperm into the offspring of the hybrid females.

Yellowstone Lake Cutthroat Trout—Last Gasps of Life or Beginnings of Renewal: Will Non-Native Species Removal Efforts Aid Yellowstone Cutthroat Trout?

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Yellowstone Lake cutthroat trout (*Oncorhynchus clarkii*), an icon of western trout fishing and once the bright spot in a dim outlook for native cutthroat trout populations throughout the west, are seriously threatened by a nonnative lake trout population. Soon after discovery, Yellowstone National Park initiated an intensive gillnetting program aimed at suppressing lake trout numbers to levels that would allow cutthroat trout to sustain a healthy population. From 2001 to date we have removed almost 270,000 lake trout (*Salvelinus namaycush)* from the system. Despite this effort, lake trout in Yellowstone Lake are still present in high numbers and evidence suggests that the population is continuing to expand. A new spawning site was discovered in 2006; 2004 saw the highest number of mature lake trout removed from the lake to date; and increasing numbers of smaller, immature lake trout have been removed for the last six years. Suppression efforts are surely slowing the rate of expansion of lake trout in Yellowstone Lake, but will the program be able to decrease lake trout enough to provide adequate protection for native cutthroat trout? Recent increases in catch of cutthroat trout

juveniles throughout the lake are very encouraging. However, an upward trend in catch-per-unit-effort of lake trout by gillnets is cause for concern. In addition, and perhaps even more serious is the three-fold increase in lake trout catch by anglers in 2007. In past years this statistic has been a good indicator of catch rates on the spawning grounds during the following year.

Spawning Demographics and Early Life History of Lacustrine-Adfluvial Bull Trout in Quartz Lake, Glacier National Park, Montana

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Habitat fragmentation and introduction of nonnative fishes, e.g., brook trout (*Salvelinus fontinalis*) and lake trout (*Salvelinus namaycush*), have resulted in substantial reductions in the native range of bull trout (*Salvelinus confluentus)*, contributing to the listing of Columbia River basin bull trout as threatened under the U.S. Endangered Species Act in 1998. Therefore, recent invasion of lakes in Glacier National Park by nonnative lake trout is a major concern. Because lake trout were first captured in Quartz Lake in July 2005, we sought to document unique characteristics of the lacustrine-adfluvial bull trout population prior to changes associated with the lake trout invasion. Specifically, we are investigating spawning demographics and early life history of bull trout in Quartz Lake. Starting in August 2007, a 'picket fence' weir with trap boxes was positioned in Quartz Creek at the inlet of Quartz Lake to capture adult bull trout spawners ascending and descending Quartz Creek. Electrofishing was used to sample juvenile bull trout rearing in Quartz and Rainbow creeks. Redd counts were conducted in Quartz and Rainbow creeks during mid October. Physical habitat was assessed in both streams, and temperature loggers were placed throughout the stream network. A gauge was installed near the mouth of Quartz Creek to monitor flow. Analyses will focus on effects of physical habitat characteristics on the distribution and abundance of bull trout in tributaries to the lake. The resulting information will provide a reference for future remediation in Quartz Lake and other bull trout refugia in Glacier National Park.

Piscicide Drip Station Placement Efficiency

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Eradication of nonnative fish using piscicides is a common restoration and conservation tool for native salmonids in the state of Montana. Piscicide drip stations are commonly placed at locations that are most convenient for access by the piscicide applicator. Little guidance exists on the most effective drip station placement in different channel types, e.g., straight, meander, and riffle, and within a stream cross-section, i.e., edge and center. Placement may affect mixing distance and therefore application efficiency. We compared mixing distances between locations in a channel cross-section and among different channel types. Because direct measurement of piscicide concentration in the field is impossible, sodium chloride (salt, NaCl) was used as a tracer. NaCl solution was applied at the center or the edge of three channel types. Conductivity was measured at stream cross sections downstream from the application site at 10 regularly spaced intervals. Measurements formed a grid that identified the plume of the simulated piscicide and its mixing rate. The simulated piscicide was considered evenly mixed through the stream when the variation among measurements within a cross-section was < 1 percent. ANOVA was used to compare mixing distances between application location and among channel types. Significant differences existed in mixing distances between edge and center applications when variation in discharge volume was accounted for. Piscicides should be applied to the center of a stream channel to minimize mixing distance.

The Effect of Flow Regulation on Snake River Cutthroat Trout: Potential Consequences of Alternate Flow Regimes on the Behavior and Survival of Three Life-Stages

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An undisturbed river network is characterized by numerous channel processes and structures that act as behavioral cues or habitat for organisms. In response to this environmental variability, organisms evolve adaptations which allow them to persist. When river systems are altered, e.g., dammed, organisms (or life-stages of organisms) may not be adapted or able to respond to the novel environmental conditions, and the range of adaptations, e.g., life-history types, expressed by organisms may be constrained. Snake River cutthroat trout (*Oncorhynchus clarkii bouvieri*) have persisted in the Snake River through a century of flow regulation. However, it is unknown to what degree flow regulation has reduced the variability of cutthroat trout adaptations or influenced survival. As a first step in exploring how a disturbed environment affects the expression of Snake River cutthroat trout adaptations, we developed a conceptual framework of how life-stage specific survival might relate to flow regulation at Jackson Lake Dam on the Snake River. This conceptual framework will structure future research on the range of adaptations currently expressed by Snake River cutthroat trout and the implication of adaptation loss on the potential for Snake River cutthroat trout to respond to future disturbances.