Desert Fishes Council

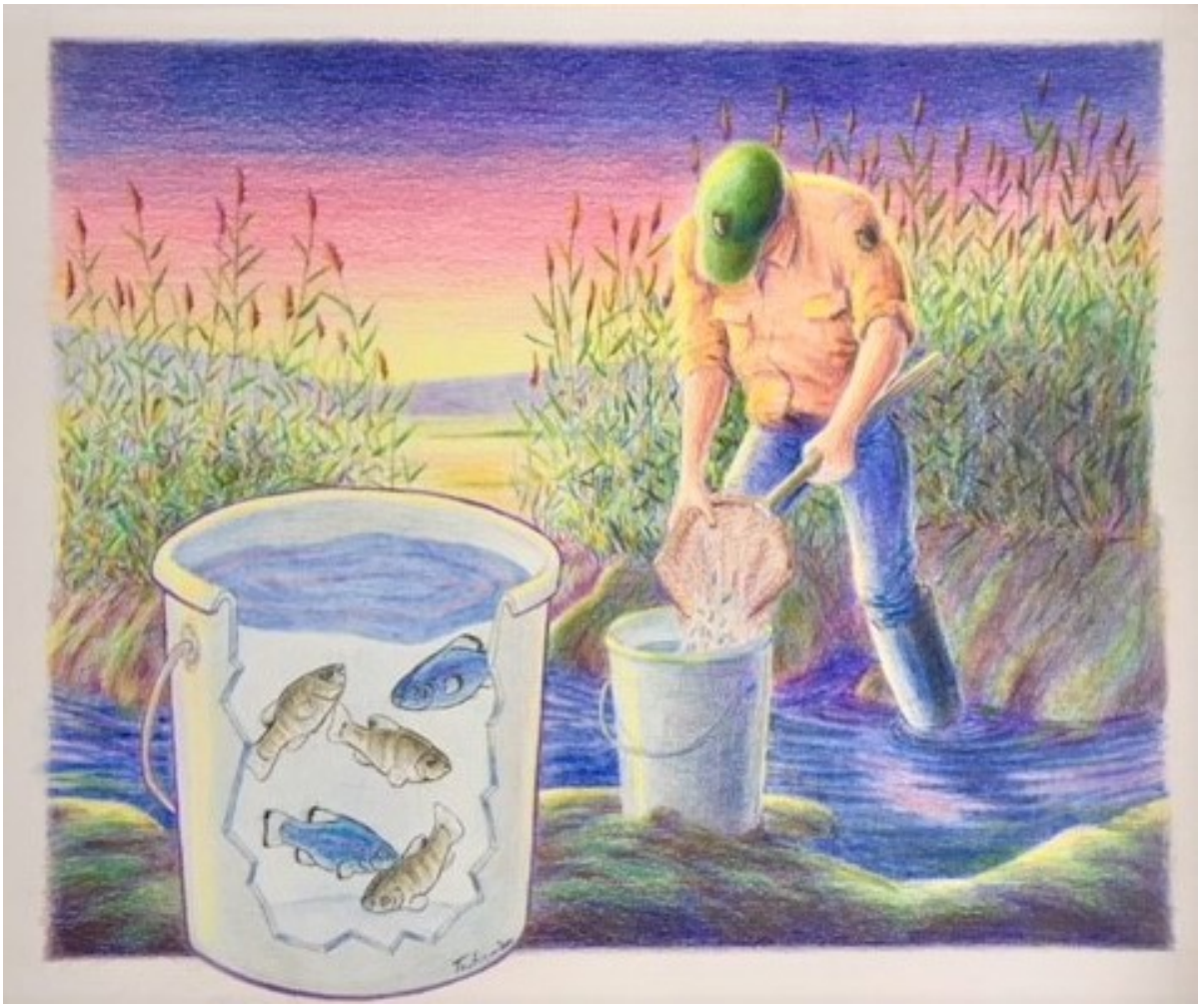
Consejo de los Peces del Desierto

Dedicated to the Conservation of North America's Arid Land Ecosystems

50th Annual Meeting

Long Program

14-18 November 2018
Furnace Creek,
Death Valley National Park, California, USA



Species in a bucket; recovery of Owens Pupfish, Fish Slough, 1969

Overview and Event Locations

Date & Time	Event	Location
Wednesday, 14 November 2018		
16:00-21:00	Registration and Presentation Loading	Furnace Creek Visitor Center
18:00-20:30	Social Mixer	The Oasis Room
Thursday, 15 November 2018		
08:00-18:00	Registration and Presentation Loading	Furnace Creek Visitor Center
08:30-09:00	Welcome	Furnace Creek Visitor Center Auditorium
09:00-11:30	Lee Simons: Advocate for Desert Fishes Symposium	Furnace Creek Visitor Center Auditorium
11:30-13:00	Lunch	
11:30-13:00	Yaqui Catfish Meeting	Furnace Creek Visitor Center Auditorium
13:00-16:00	Standing Between Life and Extinction: Book Preview Symposium	Furnace Creek Visitor Center Auditorium
16:00-17:30	General Session I	Furnace Creek Visitor Center Auditorium
17:45-19:45	Poster Session	Furnace Creek Visitor Center Auditorium
19:45-21:45	Student Networking Session	Furnace Creek Visitor Center Auditorium
Friday, 16 November 2018		
08:30-12:00	General Session II	Furnace Creek Visitor Center Auditorium
12:00-13:30	Lunch	
13:30-17:00	General Session III	Furnace Creek Visitor Center Auditorium
17:15-18:15	Business Meeting	Furnace Creek Visitor Center Auditorium
19:15-21:15	Banquet	The Date Grove
Saturday 17 November 2018		
08:30-12:00	General Session IV	Furnace Creek Visitor Center Auditorium
12:00-13:30	Lunch	
13:30-17:00	General Session V	Furnace Creek Visitor Center Auditorium
Sunday 18 November 2018		
08:00-13:00	Field Trip	Amargosa River

We thank our generous hosts:

Cover artwork by Barbara Terkanian

Events are in Furnace Creek Visitor Center Auditorium unless otherwise specified.

Presenters, please load your presentation by 6:00 pm the day before your presentation.

Student award presentations are highlighted in gray.

Long Program Detail

Wednesday, November 14th

16:00-21:00 Registration and Presentation Loading (Furnace Creek Visitor Center)
18:00-20:30 Social Mixer (The Oasis Room)

Thursday, November 15th

08:00-18:00 Registration and Presentation Loading (Furnace Creek Visitor Center)

08:30-09:00 Welcome (Chairs: Phil Pister and Krissy Wilson)

09:00-11:30 Session 1: Lee Simons: Advocate for Desert Fishes Symposium (Chair: Leslie Fitzpatrick or Brandon Senger)

09:00 Remembrance of Dr. Lee H. Simons

Gary Scoppettone[1], Dean A. Hendrickson[2], Jon Sjoberg[3], David Syzdek[4], Paul Barrett[5] (1-retired; 2-University of Texas at Austin, Biodiversity Collections, United States; 3-Nevada Department of Wildlife, United States; 4-Southern Nevada Water Authority, United States; 5-U.S. Fish and Wildlife Service (retired), United States).

On the occasion of the 50th annual Desert Fishes Council meeting, this session is dedicated to Dr. Lee H. Simons, who devoted much of his adult life to the study and protection of native species and ecosystems. Dr. Simons is honored here today because he exemplified the spirit and soul of the Desert Fishes Council – working together to protect and preserve our native species and natural ecosystems. As a positive force toward these goals, Dr. Simons spent a third of his natural resources career focused on the protection and recovery of federally listed endangered desert fishes in Arizona and Nevada. From

1985 to 1988 Lee worked for Arizona Game and Fish, much of that time focused on recovery activities of Gila topminnow. After earning his PhD at U.C. Davis and working in research, science education and natural resources, Dr. Simons renewed his work with desert fishes from 2008-2016. As Senior Fish Biologist for the Las Vegas Office of the U. S. Fish and Wildlife Service, he concentrated on recovery actions for Devil's Hole Pupfish, Moapa Dace, and Pahranagat Roundtail Chub. Those of us who worked with Lee on endangered desert fish recovery appreciated his intellect, kind manner, leadership, infectious enthusiasm, and all his accomplishments. Remembrance of Dr. Simons's all too short, but stellar desert fish career will be briefly covered by four co-workers representing four different agencies.

09:15 Lee Simons a Carpenter of Convergence: Restoration Project Legacy for Southern Nevada Aquatic Species with Current Status Updates.
Kevin Guadalupe (Nevada Department of Wildlife, United States)

As the Environmental Services lead fish biologist for the United States Fish and Wildlife Service Southern Nevada Field Office, Lee was responsible for recovery of 12 listed fish species. His leadership and kindness at recovery team meetings consolidated agency leads, academics, and local shareholders to cooperate towards ongoing restoration and increasing population numbers. He gave expedient consultation on restoration projects for Pahrump Poolfish *Empetrichthys latos*, Ash Meadows National Wildlife Refuge, Devils Hole, and other listed fish species in the pluvial White River system while also getting in the mud to complete the work. Lee was instrumental in acquiring two national competitive funding opportunities through Cooperative Recovery Initiative (CRI) funding. The Muddy River CRI funding completed two new fish barriers, and hired two new temporary employees entirely devoted to the restoration and monitoring of the Muddy River system. Moapa Dace, *Moapa coriacea* Snorkel counts are currently four times greater than at the time of his arrival with Virgin River Chub, *Gila seminuda* existing in the upper Muddy River for the first time since pre non-native fish invasion. The Pahranagat Cooperative Recovery Initiative funding initiated a Pahranagat Roundtail Chub, *Gila robusta jordani* PIT tag monitoring program, stabilized the refuge population at Key Pittman, and developed a new refuge habitat at Cottonwood Spring. During the 2013 low count of 35 Devils Hole Pupfish, *Cyprinodon diabolis* Lee took charge to bring the multi-agency command team together. He would then praise the recovery response to others in his team. Non-natives removal projects and restoration projects are complete or ongoing in The Virgin River, Muddy River, Pahranagat, Ash Meadows, and at Pahrump Poolfish refuge populations, including a new refuge site initiated in 2018 as a result of his leadership.

09:30 The Direct Impacts of Non-Native Species on Pahrump Poolfish, *Empetrichthys latos latos*
Brandon Paulson[1], Craig Stockwell[1] (1-NDSU, United States)

Desert fishes that evolved in simple communities are hypothesized to be vulnerable to non-native species introductions. Such is the case for the Pahrump Poolfish, *Empetrichthys latos latos*, whose conservation has been frustrated by colonization of invasive species including both Red Swamp Crayfish, *Procambarus clarkii*, and Western

Mosquitofish, *Gambusia affinis*, in refuge habitats. We examined the direct effects of crayfish and mosquitofish on poolfish adult survivorship, and juvenile recruitment under semi-natural conditions in 300-gallon mesocosms. We found that allopatric poolfish populations had significantly higher adult survival (95.6%.03%) than when held in sympatry with crayfish (53.1%.16%; $z = -3.2$; $p < 0.005$) or when sympatric with crayfish and mosquitofish (55.1.21%; $z = -2,98$; $p < 0.010$). Crayfish had no effect on poolfish juvenile recruitment (17.54.12 juveniles per adult) compared to juvenile recruitment for allopatric poolfish populations (13.611.74 juveniles per adult; $z=.6$; $p > 0.05$). However, the combined effects of crayfish and mosquitofish led to significant declines in juvenile recruitment (0.47.13 juveniles per adult; $z = -2.79$; $p = 0.015$). These results mimicked earlier experiments that showed severe impacts of mosquitofish on poolfish juvenile recruitment (Goodchild & Stockwell 2016, Trans. Am. Fish. Soc. 145 (2); 264-268). Thus, our findings combined with earlier work may explain how poolfish have co-persisted with crayfish for numerous years at the Corn Creek refuge, while the dual invasion of crayfish and mosquitofish was associated with a rapid population decline of the largest Pahrump poolfish refuge population at Spring Mountain Ranch.

09:45 Antipredator Club Cell Evaluation in Insular Fishes

Madison Snider[1], Brian Wisenden[2], Craig Stockwell[1] (1-North Dakota State University, United States; 2- Minnesota State University-Moorhead, United States)

Species that evolve in habitats with limited predation are predicted to have reduced investment in antipredator traits, such as the production and detection of chemical alarm cues. Our study focused on epithelial club cells, which are presumed to contain injury-released alarm cues and are present in numerous fish taxa. This evaluation was carried out on four desert fishes in the Cyprinodontiformes; Pahrump Poolfish, *Empetrichthys latos latos*, White River Springfish, *Crenichthys baileyi*, Amargosa Pupfish, *Cyprinodon nevadensis*, and White Sands Pupfish, *Cyprinodon tularosa*. We also sampled three cyprinid species: Hot Creek Valley Tui Chub, *Suphateles bicolor ssp.*, and two non-insular species, Fathead Minnow, *Pimephales promelas*, and Zebrafish, *Danio rerio*. Club cell densities per mm2 of epithelial tissue differed significantly among species ($X2 = 91.81$, $df = 6$, $p < 0.0001$), and pairwise comparisons revealed no differences among Cyprinds or among Cyprinodontiformes. As expected, Fathead Minnows and Zebrafish displayed relatively high densities of club cells (446.5 ± 100.3; 310.4 ± 51.3; mean ± SE, respectively). By contrast, mean club cell densities were low for Pahrump poolfish (17.1 ± 8.5), White Sands pupfish (17.1 ± 9.0), Amargosa Pupfish (1.0 ± 0.6), and White River Springfish (0.0 ± 0.0). In comparison, however, the Hot Creek Valley Tui Chub, a desert cyprinid, displayed club cell densities similar to non-insular cyprinids sampled (137.9 ± 56.3). Thus, phylogeny, and not locality or history of predation, may be the primary driver for expression of club cells and antipredator behaviors present in populations.

10:00 Recovery on Private Land – Pahranagat Roundtail Chub Progress

Christiana Manville[1], James Harter[1], Cody Anderson[2] (1- U.S. Fish and Wildlife Service, United States; 2-Great Basin Institute, United States)

The Pahranagat Roundtail Chub, *Gila robusta jordani*, is a federally endangered species whose native habitat resides entirely within an active cattle ranch of the Pahranagat

Valley, Lincoln County, Nevada. The current distribution consists of 2.2 miles of stream channel and 1.5 miles of a cement-lined irrigation ditch. Working through the USFWS's Partners for Fish and Wildlife Program, we have developed a working relationship with the landowner, allowing us to implement five restoration projects over the last nine years. Some projects directly benefit chub, while others help the landowner manage resource concerns that otherwise hinder the cattle operation. Since 2014, we have intensified research in the field, including implementing seasonal snorkeling surveys, mark-recapture studies of adults, larval fish monitoring, and evaluating fish habitat. Important results of these studies lead to the discovery that juvenile fish are lost to the system during the irrigation season, which has led to yearly salvaging of juveniles. Through these studies we significantly improved our understanding of this species and needs for future recovery efforts. This conservation program was made possible by funds from the USFWS's Cooperative Recovery Initiative (CRI) program. Finally, we acknowledge Lee Simons for his leadership in writing the CRI Proposal in 2013, developing the monitoring program, and for his strong support of conservation on private lands.

10:15 History and Status of Fish Conservation on the Upper Muddy River, Nevada

Michael R. Schwemm[1], Brandon L. Senger[2], David J. Syzdek[3] (1- United States Fish and Wildlife Service, United States; 2- Nevada Department of Wildlife, United States; 3- Southern Nevada Water Authority, United States)

The headwaters of the Muddy River, Clark Co., Nevada, is formed by discharge of numerous thermal springs and seeps, and the sole habitat of the endangered cyprinid, *Moapa coriacea*. The species was common when described, but early reports indicate its decline in the middle 1960s, a result of the combined threats of habitat modification and exotic invasive species. When the USFWS acquired several springs in 1979 to establish the Moapa Valley National Wildlife Refuge, much the habitat had been converted to modified channels and swimming pools used for aquatic recreation. The process to return the habitat to natural flowing channels and reduce non-native fishes is ongoing, and a story of gradual success. Here, we review the history of research, major management actions, and the recovery program that established partnerships central for the recovery of habitat and species. Particularly noteworthy for the recent accomplishments in the upper Muddy River is the role of biologist Lee Simons (USFWS, Las Vegas). His leadership provided the coordination responsible to direct and fund an extensive series of fish barrier construction projects, monitoring, salvage operations and stream renovation efforts. Today, the working group and partnerships enhanced by Lee's work continue to benefit the resource.

10:30 Ten Years of Restoration Projects for the Endangered Moapa Dace, *Moapa coriacea* at the Warm Springs Natural Area, Clark County, Nevada

David Syzdek (Southern Nevada Water Authority, United States)

The Moapa Warm Springs in Southern Nevada is a regional spring complex that form the headwaters of the Muddy River. These thermal springs, and associated streams, are habitat for an endemic suite of thermophilic aquatic species that includes the federally-endangered Moapa Dace (*Moapa coriacea*). Currently, the Southern Nevada Water Authority (SNWA) and stakeholders are undertaking recovery actions for the Moapa dace

and its habitat. These include construction of fish barriers, reduction in or removal of non-native and invasive species, riparian and aquatic habitat restoration, and development of an ecological model for the Moapa Dace. To facilitate recovery of the dace and other native species, SNWA purchased the 1,218-acre Warm Springs Ranch in September 2007 and designated it the Warm Springs Natural Area for conservation and environmental stewardship purposes.

In 2008, Moapa Dace numbers suddenly declined to a record low of 459 individuals. Working with the US Fish and Wildlife Service (USFWS), Nevada Department of Wildlife (NDOW), and other stakeholders and researchers, SNWA is conducting stream restoration work and intensive habitat improvements to reverse the population's decline. Following the February 2008 nadir, dace numbers recovered somewhat but have yet to reach recovery levels. NDOW and SNWA has successfully treated the Upper Muddy River with rotenone to control the invasive and predatory Blue Tilapia (*Oreochromis aureus*). Furthermore, stream restoration and clearing of dense stands of invasive tamarisk (*Tamarix* spp.) and Fan Palm (*Washingtonia filifera*), is facilitating the re-establishment of native riparian vegetation, providing prevention of future wildfires, and continued improvement in Moapa dace numbers.

In 2015, a removable fish barrier was opened which allows this fish access to its entire historical range. Moapa Dace numbers are currently stable and work continues to improve dace habitat, improve stream connectivity, and to monitor for invasive species.

10:45 Virgin River Long-Term Fish Community Monitoring

Ron Kegerries[1], Brandon Albrecht[1], Harrison Mohn[1], Ron Rogers[1] Aaron Ambos[2] (1-BIO-WEST, Inc., United States; 2-Southern Nevada Water Authority, United States)

From 1993 through 2017, BIO-WEST, Inc., with funding and support from various agencies, has monitored the lower Virgin River to assess the long-term fish community dynamics and the success of stocking efforts to establish and enhance Woundfin, *Plagopterus argentissimus* populations. Native fish relative abundance increased in the upper study reaches following flood events, while nonnative fish abundance declined during these post-flood periods. Reaches above the Bunkerville Diversion are still considered the source of all native fishes within the lower Virgin River. A historical comparison of both native and nonnative fish species captured in the lower Virgin River since 1998 shows species composition to be similar across years indicating that positive trends associated with flooding are short-lived. Long-term catch rate analysis for the lower Virgin River show that native fish abundance has not significantly changed, but nonnative fish abundance has declined significantly in the last two decades. A similar analysis of habitat shows little variation in habitat types, substrate, or cover present at sampling locations within the study area. This monitoring yields a long-term perspective to assess fish populations within the lower Virgin River by providing Virgin River Chub, *Gila seminuda* population estimates, and provide a holistic understanding of the fish community in anticipation of future nonnative fish species removal. Consistent data collection will continue to be important in monitoring the rare fishes of the lower Virgin

River and update recovery goals, particularly given the growing water demand in the region.

11:00 Devils Hole and the Legacy of Lee Simons: 2011-2016

Kevin P. Wilson[1], Jeffry A. Goldstein[1], Ambre L. Chaudoin[1], John G. Wullschleger[2], Brandon L. Senger[3], Michael R. Schwemm[4], Olin G. Feuerbacher[4], Corey W. Lee[4], Javier Linares-Casenave[4], Jon C. Sjoberg[3] (1- Death Valley National Park, United States; 2-Water Resources Division, National Park Service, United States; 3-Nevada Department of Wildlife, United States; 4- US Fish and Wildlife Service, United States)

Devils Hole has a history of conservation and recovery efforts dating back to the late 1940s. Since this time several individuals have played leading roles in keeping the iconic Devils Hole Pupfish *Cyprinodon diabolis* from becoming extinct. One such person was Dr. Lee Simons, a naturalist and desert fishes specialist, who during his tenure at the US Fish and Wildlife Service's Las Vegas office significantly influenced management decisions. Lee was an integral part of the Devils Hole pupfish team for five years. During this time, Lee witnessed the species decline to the lowest count on record of 35 observable pupfish in the spring of 2013 and increase to one of the highest counts in the last 10 years: 131 fish in fall 2015. Lee was instrumental in developing a captive propagation effort entitled "Recovery and Husbandry of Devils Hole Pupfish Eggs from Devils Hole" that is still in use today, and the guiding document to establish the refuge population at Ash Meadows. Lee will always be remembered for his critical thinking, camaraderie, and contributions of experimental design to the recovery teams on which he served. Even though Lee's time involved with Devils Hole was too brief, his efforts afforded lasting impacts on how managing agencies address recovery efforts in the future. P.S. Don't forget your knee pads!

11:15 Comparative Study of Microbial Biogeochemistry of Devils Hole and Ash Meadows Fish Conservation Facility

Duane Moser[1], Joshua Sackett[1], Brittany Kruger[1], Scott Hamilton-Brehm[2] (1-Desert Research Institute, United States; 2-Southern Illinois University Carbondale, United States)

Devils Hole is a tectonic cavern partially filled with deeply sourced groundwater from the Death Valley Regional Flow System (DVRFS). A single skylight in this vast underground system is the sole natural habitat for the critically endangered Devils Hole Pupfish, *Cyprinodon diabolis*. In Devils Hole, this fish survives under conditions (e.g. high temperatures and low dissolved oxygen concentrations) that would be lethal to most fish. The water of Devils Hole is highly oligotrophic, with extremely low productivity and organic carbon and nutrient concentrations. Like most cave-dominated systems, with the possible exception of the summer when direct sunlight reaches the water surface, the foundations of the food web in Devils Hole are primarily microbial. In the mid-2010s, the Ash Meadows Fish Conservation Facility (AMFCF), a full-scale replica of the uppermost 6.7 m of Devils Hole, was constructed by management agencies to establish a backup population of *C. diabolis*. To gain a more predictive understanding of the capacity of these unique paired natural and manmade environments to support fish, we evaluated their physical parameters and chemistry in combination with next-generation DNA

sequencing of planktonic and benthic bacterial and archaeal communities (16S rRNA gene libraries). Major ion concentrations were consistent between the two systems, but water temperature and dissolved oxygen dynamics differed. Bioavailable nitrogen (primarily nitrate) was 5x lower in AMFCF. Devils Hole and AMFCF nitrogen:phosphorus molar ratios were 107:1 and 22:1, indicative of different nutrient control mechanisms. Both sites possess extraordinarily high microbial diversity, with over 40 prokaryotic phyla represented at each; with 37 shared between them and nearly half deriving from candidate phyla – so-called microbial dark matter lineages. The abundance and composition of predicted photosynthetic primary producers (Cyanobacteria) was markedly different between sites: Devils Hole planktonic and sediment communities were dominated by large and visually conspicuous *Oscillatoria* spp. (13.2% mean relative abundance), which proved virtually undetectable in AMFCF. Conversely, AMFCF was dominated by a predicted heterotroph from the Verrucomicrobiaceae family (31.7%); which was comparatively rare (<2.4%) in Devils Hole. We propose that the paucity of bioavailable nitrogen in AMFCF, perhaps resulting from physical isolation from allochthonous environmental inputs, is reflected in the microbial assemblage disparity, influences biogeochemical cycling of other dissolved constituents, and may ultimately impact survivorship and recruitment of refuge populations of the Devils Hole pupfish. This work was dedicated to Lee Simons in a recent publication in PLOS One (Sackett, et al. 2018 13(3):e0194404). Our project was in large measure inspired by conversations with Dr. Simons, who contributed to both its conceptual design and provided insightful comments during preparation of the manuscript. His advocacy and friendship will be missed.

11:30-13:00 Lunch (on your own)

11:30-13:00 Yaqui Catfish Meeting (auditorium or adjacent patio)

13:00-16:15 Session 2: Standing Between Life and Extinction: Book Preview Symposium (Chair: David Propst)

13:00 The Next Chapter in the Battle Against Extinction

Jack Williams[1], David Propst[2] (1-Trout Unlimited, United States; 2-University of New Mexico, United States)

Water was a critical fuel for economic and population growth in the post-World War II North American West and its appropriation for human use brought new challenges to aquatic organisms that had evolved in harsh environments but were little prepared for extensive alteration of fragile aquatic habitats. At that time, neither the general public nor natural resource agencies had much regard for native fish species if they had no immediate and tangible worth to humans. But an increasing awareness by resource managers and academics of the plight of this vanishing fauna spawned the Desert Fishes Council in 1969. With passage of the Endangered Species Act in 1973, additional impetus for conservation of native aquatic organisms was provided. So began The Battle Against Extinction, a seminal book published in 1991 that chronicled progress and issues in arid-land native fish conservation. Since then, new technologies and evolving strategies

provide new opportunities, but climate change exacerbates lingering threats. Now we launch a new effort to examine the ecology, policies and politics of desert fish conservation. As W.L. Minckley and Jim Deacon noted, it is not a lack of scientific expertise that prevents progress in conservation, rather, it is the lack of will by society to implement needed actions. The fate of many arid-land aquatic species and ecosystems now hangs in the balance.

13:15 Reflections on Some Good Friends: the Pioneers of the Desert Fishes Council
Phil Pister (Desert Fishes Council, United States)

The battle to save desert fishes has been fortunate to have some of the most dedicated and thoughtful advocates for conservation. Today, I will reflect on the pioneers of the Desert Fishes Council: Carl Hubbs, Bob Miller, Salvador Contreras-Balderas, W.L. Minckley, Jim Deacon, Clark Hubbs, and Bob Behnke. Biographies of these seven, as well as one for myself, are included in the upcoming book Standing Between Life and Extinction. Join me for some great times with these giants of desert fish conservation.

13:30 Mining Hidden Waters: Groundwater Depletion, Aquatic Habitat Degradation and Loss of Fish Diversity in the Chihuahuan Desert Ecoregion of Texas
Gary Garrett[1], Megan Bean[2], Robert Edwards[1], Dean Hendrickson[1] (1-The University of Texas at Austin, United States; 2- Texas Parks and Wildlife Department, United States)

Desert ecosystems are particularly susceptible to anthropogenic influences. This is especially true where limited water resources can be impaired by excessive water mining and concomitant depletion of aquifers. Herein, the decline of aquatic habitats throughout the Chihuahuan Desert of Texas is discussed and observations on relationships among declining aquifer levels, aquatic habitat degradation, and status of native fishes are presented. Examples from the Big Bend reach of the Rio Grande, Balmorhea Springs Complex, Pecos River, and Devils River reveal a decline in distribution and abundance of native fishes. Ongoing and impending land-use practices and increased demands on groundwater and surface water resources point to future reductions. However, activities are underway that represent a source of optimism for conservation of aquatic habitats and native fishes in the region. Native Fish Conservation Areas are being established to enhance management of desert ecosystems to restore and maintain functional watersheds, conserve aquatic habitats, and support populations of native fishes. Increased landowner awareness of the value of cooperative conservation of aquatic resources and their inclusion in management decisions are critically important, particularly in Texas where the majority of land is privately owned. Ultimately, archaic Texas water laws need revision and reformulation if desert aquatic systems are to be restored and preserved.

13:45 The Exotic Dilemma: Lessons Learned from Efforts to Recover Native Colorado River Basin Fishes
Brandon Albrecht[1], Ron Kegerries[1], Ron Rogers[1], Paul Holden[1] (1-BIO-WEST, Inc., United States)

Native fishes of desert aquatic ecosystems have been dramatically impacted by nonnative species. Over time, habitat modification and degradation have set the stage for the influx

of many nonnative taxa. Traditionally, nonnative fish control has meant attempting to eliminate every individual nonnative from the habitat of interest. In larger systems, complete elimination has proven impossible, and managers have sought ways for nonnative and native species to coexist or to reduce the stress of nonnative taxa on native species. This paper is the result of a chapter contribution to the new book, Standing Between Life and Extinction, and describes the nonnative fish dilemma, lessons learned, and possible pathways for remediation while providing several examples from the Colorado River basin. We suggest that habitat complexity and more natural flow regimes can help enable native fishes to persist in the face of nonnative fishes. We conclude that a multiplicity of tools, techniques, and education remain important if we are to benefit and maintain our native fish fauna.

14:00 Ghosts of Our Making: Extinct Aquatic Species of the North American Desert Region

Jack Williams[1], Don Sada[2] (1-Trout Unlimited, United States; 2-Desert Research Institute, United States)

One of the primary priorities of conservation is to prevent extinctions. Thirty-three fishes and 23 aquatic invertebrates are recorded as recently extinct within the desert and adjacent regions of the United States and Mexico. Additionally, five fishes are listed as extinct in the wild. The process of extinction often begins with habitat degradation or other disturbance that diminishes local populations or causes local extirpations that lead to the entire species or subspecies being more susceptible to loss. Extinction itself is often linked to some catastrophic change in water supply, such as water diversion or spring failure due to over withdrawal of groundwater. Introductions of nonnative species that may prey on, compete with, or hybridize with native species, are more common in extinction of desert fishes than for aquatic invertebrates. Increasing numbers of endangered and extinct species are a cautionary account about our own future. The question for humans is whether the warning signs will be obeyed or whether society proceeds headlong into a future where our own species may be at risk.

14:15 The Value of Specimen Collections for Conserving Biodiversity

Adam E. Cohen[1], Dean A. Hendrickson[1], Gary Garrett[1] (1-Biodiversity Center, Dept. Integrative Biology, University of Texas at Austin, United States)

Specimen collections are critically important for modern ecological, evolutionary, and biogeographical studies and are increasingly aiding in conservation decision-making. The information collections contain in the form of specimen-backed occurrences, field notes and images can provide insights and guidance for researchers and resource managers, and serve as a verifiable base-line representing historical conditions. The Fishes of Texas Project is a regional, quality-controlled, database of museum specimens compiled from many collections and an online user interface allowing users to view, map and download data. It has enhanced conservation decision-making for aquatic species in Texas and might serve as a template for similar regional projects.

14:30 The Devils Hole Pupfish: Science in a Time of Crisis

Mark Hausner[1], Kevin Wilson[2], Kevin Brown[3] (1-Desert Research Institute, United States;

2-National Park Service, United States; 3-University of California Santa Barbara, United States)

The preservation of the Devils Hole ecosystem and the recovery of the Devils Hole Pupfish (*Cyprinodon diabolis*) was a great success story for the Desert Fishes Council and for the scientists and resource managers involved in the conservation efforts. “Battle Against Extinction” described the collaborative ecosystem-level research that led to the Supreme Court decision setting a minimum water level in Devils Hole. This minimum water level reflected the best available scientific information at the time, and as the water level in Devils Hole recovered the *C. diabolis* population tracked that recovery closely. As the *C. diabolis* population appeared to stabilize through the 1980s and early 1990s, ecosystem-level monitoring in Devils Hole was phased out in favor of other priorities. The lack of contemporary data, however, left resource managers unprepared to proactively address the unexpected and unexplained decline in the *C. diabolis* population that began in the mid-1990s. This decline became an existential crisis in 2006, when a spring survey counted just 38 individuals, and again in spring 2013 with a survey of just 35 fish. In this talk, we review the responses of both scientists and resource managers to these crises, as well as the role played by scientific research in formulating management responses. In 2006, most of the research on the Devils Hole ecosystem was 20-30 years old, and the lack of current knowledge hampered the management response to the critically low population survey. The 2006 survey, though, spurred further research in the ecosystem, and the management response to the 2013 survey was both better informed and more effective than the 2006 response. Using Devils Hole as a case study, we argue that research into threatened and endangered ecosystems – even when they appear to be stable – is critical to the management and conservation of these resources.

14:45 Long-Term Monitoring of a Desert Fish Population Aravaipa Creek, Arizona
Peter Reinthal[1], Heidi Blasius[2], Mark Haberstich[3] (1-University of Arizona, United States; 2-Bureau of Land Management, United States; 3-The Nature Conservancy, United States)

Since the publication of Battle Against Extinction in 1991 there have been substantial changes to the natural and anthropogenic landscapes of the desert southwest. Environmental impacts have accelerated with increasing human populations but, unfortunately, scant attention is given to long-term changes in natural aquatic biotas. Beginning in 1963, W.L. Minckley, colleagues, and students monitored and studied fish assemblages of Aravaipa Creek, Arizona. Minckley’s monitoring efforts continued until his death in 2001 and since then by the authors of this chapter. This represents the longest continuous record of abundance and distribution of any fish assemblage in the region. Considerable scientific information has been gained from these efforts and forms the basis for much that is known about several iconic native desert fishes. These data provide a comparative baseline to characterize responses to biotic and abiotic events and modifications of Aravaipa Creek. Data obtained provide critical information on fish assemblage dynamics, species ecology, impacts of human-induced alterations and management, and insights on potential consequences of global warming. Herein we present results from 54 years of Aravaipa Creek fish monitoring and illustrate how fish populations respond to changes in the Aravaipa catchment.

15:00 Conservation and the Historical Distribution of Gila Trout

David Propst[1], Thomas Turner[1], Jerry Monzingo[2], James Brooks[3], Dustin Myers[2] (1-University of New Mexico; 2-Gila National Forest, USDA Forest Service; 3-JEB Outfitters)

Restoration of a species to historically occupied habitats is a common conservation strategy, especially for interior North American salmonids. An essential early, if not first, step is to determine the historical range of target organism. For many southwestern fishes this has proven difficult as historical habitats were compromised or destroyed by European settlers before scientific investigations catalogued the native fauna of the region. Further complicating accurate delineation of native ranges were paucity of historical collections, introduction of nonnative species, and the shifting taxonomic designations of remnant populations. Following its description in 1950, Gila Trout *Oncorhynchus gilae* was the presumptive native trout of the entire Gila River drainage in New Mexico and Arizona. But the description of Apache Trout *O. apache* from a Gila River tributary in 1972 interjected uncertainty to the historical range of Gila Trout. Was Gila Trout limited to the upper Gila River in New Mexico and were the native trout of the Agua Fria and Verde drainages taxonomically distinct from Gila Trout? Absence of uncompromised specimens from Arizona streams precludes definitive resolution of this question, but historical accounts and several museum specimens support a close affinity of these populations with Gila Trout. Consequently, Gila Trout conservation efforts should continue to include its restoration to suitable habitats throughout the Gila River drainage, exclusive of Apache Trout streams.

15:15 Large-River Fish Conservation in the Colorado River Basin: Progress and Challenges with Endangered Razorback Sucker

Kevin Bestgen[1], Thomas Dowling[2], Brandon Albrecht[3], Koreen Zelasko[1] (1-Larval Fish Laboratory, Colorado State University, United States; 2-Wayne State University, United States; 3- BIO-WEST, Inc., United States)

Razorback Sucker *Xyrauchen texanus*, a historically widespread and abundant warmwater fish endemic to the Colorado River basin, has declined dramatically. Habitat alteration, dams that block migration routes and alter natural sediment, stream flow, and thermal regimes, channel change, and nonnative fish predation are reasons for decline of razorback sucker. Lack of recruitment was evident more than 50 years ago and all wild fish were eventually extirpated, with the possible exception of the small Lake Mead population. Extensive restoration efforts have had mixed outcomes. Various propagation programs have restored reproducing adults in lakes Mohave, Havasu, and Powell in downstream basin reaches, and the San Juan, Colorado, and Green rivers in the upper Colorado River basin. However, nonnative predators reduce survival of stocked fish and recruitment is non-existent except in Lake Mead. Localized recruitment in Lake Mead, and new strategies to enhance juvenile production in isolated lower Colorado River backwaters and connected Green River floodplain wetlands offer examples of recent successes. Further progress toward restoration of large-river fishes including Razorback Sucker requires additional flow, habitat, and nonnative fish management, and continued long-term support for conservation programs.

15:30 Politics, Imagination, Ideology, and the Realms of Our Possible Futures
Christopher Norment (Department of Environmental Science and Ecology, College at Brockport, United States)

The future of southwestern aquatic habitats and their native species is uncertain, due to possible impacts of climate-induced drought, population growth, and overutilization of scarce water resources, but also to politically and ideologically motivated attacks on the U. S. Endangered Species Act, and federal land management and regulatory authority. However, a potentially more profound danger is the development of a "post-truth" culture that accepts the notion of "alternative facts" and distrusts science. Such attitudes mean that the practice of science, as well as its findings, have political implications, a development that will make it difficult to develop effective approaches to counter likely, future droughts in the American Southwest, and consequent threats to regional aquatic biodiversity. Crafting a sustainable future for the Southwest and its native species and ecosystems will require a robust scientific understanding of the region's natural variability and system complexity, and advances in public policy and management. However, it also will require effective political action, and that a critical mass of people transcend blinding ideology, convention, and human short-sightedness. Finally, we must imagine the realms of our possible futures, and consider the historical context of past, present, and future efforts to protect regional aquatic biodiversity in the American Southwest.

15:45 Searching for Common Ground Between Life and Extinction
Christopher Hoagstrom[1], Kevin Bestgen[2], David Propst[3], Jack Williams[4] (1-Weber State University, United States; 2-Colorado State University, United States; 3-University of New Mexico, United States; 4-Trout Unlimited, United States)

Lineages of desert fishes that have persevered millions of years, through droughts exceeding any in the historical record, now collectively spiral toward extinction in the industrialized desert signaling the loss of functioning aquatic ecosystems. A century of large-scale water-resource development for agricultural and urban expansion has diminished these ecosystems to a point that exceeds prehistoric mega-droughts, although the accompanying climate is relatively wet. Anthropogenic habitat degradation and introductions of nonnative species exacerbate ecological depreciation. Persistent impacts create an ecological ratchet that now elevates extinction risks for remnant populations. Full restoration of natural habitats may be impossible today, but preservation and rehabilitation of remnant ecosystems and functions are critical. Collaborative approaches to reverse ratchet-like impacts could reduce extinction risks but need more public support and wider application. This is a wicked problem because resource managers face many limitations and require cooperation among numerous private and governmental organizations representing diverse values and priorities. Greater fusion of science, environmental ethics, and ecological economics could unveil common ground among stakeholders, which will be critical to forestall looming threats.

16:00-17:30 Session 3: General Session I (Chair: Kaleb Smith)

16:00 Feeding Ecology of Co-Occurring Early Life Stage Suckers in a Regulated River
Casey Pennock[1], Michael Farrington[2], Keith Gido[1] (1-Kansas State University, United

States; 2-American Southwest Ichthyological Researchers L.L.C., United States)

Survival of early life stage fish is affected by multiple factors including environmental conditions, biotic interactions, and starvation. Low survival of early life stage Razorback Sucker, *Xyrauchen texanus*, in the San Juan River, NM & UT is thought to cause a recruitment bottleneck. Conversely, two other native sucker species, Flannelmouth Sucker, *Catostomus latipinnis*, and Bluehead Sucker, *C. discolobus*, recruit to adulthood successfully. To explore a potential factor leading to this discrepancy among species survival, we used museum specimens collected from the San Juan River in 2007 to investigate diets of co-occurring early life-stage (< 30 mm SL) Bluehead, Flannelmouth, and Razorback Sucker. We evaluated both the diversity of diet (number of diet categories) and frequency of occurrence of different diet items. Bluehead and Flannelmouth Sucker did not differ in diet diversity, but on average had 40% and 42%, respectively, more diverse diet compared to Razorback Sucker. Discriminant function analysis (DFA) correctly classified species by frequency of occurrence of diet items 65% of the time, and accuracy varied among species. A low frequency of occurrence of most diet items in Razorback Sucker drove most of the variation (76%) explained by DFA. Razorback Sucker might be less efficient foragers compared to Bluehead and Flannelmouth Sucker. The lack of some diet items (i.e., sand, adult diptera) from Razorback Sucker diets suggests more constrained diet and potential habitat differences compared to other sucker species. Findings from this study shed light on differences in feeding ecology among species that have potential to influence success of early life stages through resource use or predation mechanisms.

16:15 Laboratory Experiments to Determine Effectiveness of Light Traps to Detect Razorback Sucker Larvae

Catherine Devlaming[1], Kevin Bestgen[2] (1-Colorado State University, United States; 2-Larval Fish Laboratory, Dept. of Fish, Wildlife, and Conservation Biology, United States)

Detection of endangered Razorback Sucker *Xyrauchen texanus* larvae by light traps is used to prompt flow releases to inundate Green River floodplain wetlands, habitat which may increase survival of those early life stages. However, little is known about the efficacy of light traps to capture or retain larvae. In the laboratory, we investigated effects of light trap set time, release distance from trap, light presence, and turbidity on capture and retention rates of four early life stages of Razorback Sucker. Mean capture rates of protolarvae prior to the development of a swim bladder (7-9 mm total length [TL]) was 40% (28-55%) over the various treatment effects, but rose to 76% (73-80%) after protolarvae formed a swim bladder (9-10 mm TL). Mesolarvae (11-17 mm TL), the most commonly captured life stage in field sampling, had similar mean capture rates as later protolarvae at 86% (82-90%). Capture rates of metalarval (mean = 42%, range 21-63%; 15-24 mm TL) and juvenile (mean = 24%, range 20-28%; 22-37 mm TL) life stages were lower. Retention rates were generally > 75% and increased to 97% for juveniles. The relationship between set time and distances of 1-5 m on capture indicated longer set times positively influenced capture rates while distance had little effect. Light traps may be a useful gear to detect first presence of Razorback Sucker larvae in riverine backwaters each spring, timing of which is used to begin high flow releases from Flaming Gorge Dam to

inundate Green River, Utah, floodplain wetlands.

16:30 The Influence of Groundwater Fluctuations on the Distribution and Habitat Associations of Two Cyprinid Fishes in a Desert Spring Complex

Mark Grover[1], Chris Crockett[2] (1-Arizona Game & Fish Department, United States; 2-Utah Division of Wildlife Resources, United States)

Relationships between temporal variation in groundwater levels and the distribution and habitat use of two cyprinid fishes, Least Chub (*Iotichthys phlegethontis*) and Utah Chub (*Gila atraria*), were examined at a spring complex (Leland Harris Spring Complex) in the Snake Valley of the Great Basin, Utah, USA in which groundwater has been monitored since 2009. Seasonal declines in shallow groundwater were associated with protracted periods of high evapotranspiration during 2009-2017. Temporal changes in groundwater levels explained 97% of the variation in the mean values of surface water levels obtained from measurements taken over a three-year period at 47 monitoring points. Bathymetric data, combined with data from surface water monitoring, indicated that the volume of surface water present in springs and spring-fed ponds when groundwater levels were at their lowest was only 19% of the volume of water present during peak groundwater levels. Visual and minnow trap surveys indicated that Least Chub and Utah Chub were usually associated with relatively deep water, but migrated annually from deep springs to ponds, which were used as spawning and juvenile habitat, when groundwater and surface water levels were high, returning to core spring habitats as ponds receded during the late summer and early fall. Populations of both species became increasingly fragmented as groundwater and surface water levels declined. Least Chub and Utah Chub tended to use the same core habitats from one year to the next during the late summer and fall, and were positively associated at both the habitat and microhabitat level. The strong relationship between surface water and groundwater levels, and the dependence of Least Chub and Utah Chub on seasonal expansion of lentic habitats for reproduction, indicate that predicted reductions in groundwater levels resulting from proposed groundwater withdrawal projects would eliminate most of the spawning and juvenile habitat in the spring complex.

16:45 Fine-Scale Analysis of Population Structure in the Relict Dace Using RAD Sequencing

Mandi Finger[1], Alyssa Benjamin[1] (1-University of California, Davis, United States)

We have examined the population structure and diversity of relict dace within Goshute, Butte, Steptoe, Spring, and Ruby valleys in eastern Nevada. We used RAD sequencing on our samples, a method of interrogating the entire genome of each individual. Our results concur with the recent Housten et al. (2015) paper, in that there is a major split within the relict dace range: Ruby and Butte valleys are similar, and Goshute, Steptoe, and Spring valleys are similar. However this is relative, because nearly all populations are highly distinct within the valleys. We will discuss our results and provide recommendations for management.

17:00 Hope in a Highly Regulated River: Native Fish Recovery in the Colorado River

David L. Rogowski[1], Jan K. Boyer[1] (1-Arizona Game and Fish Department, United States)

In many rivers altered by dams, native fishes have been extirpated or persist at small fractions of their original abundance and distribution, despite extensive recovery programs. The Colorado River is one of the most regulated rivers in the world, and native fish populations in the Colorado River basin have declined due to threats from invasive species and habitat change (e. g., dams, water diversions). However, over the past 19 years within the Grand Canyon, native fishes have increased in abundance and expanded their ranges in the highly regulated Colorado River. We used data from a long term monitoring program (2000-2018) to describe changes in native and nonnative fish abundance and spatial distribution. Fish were sampled using boat electrofishing and baited hoop nets at randomly selected sites (stratified by ~ 8km reaches) between Glen Canyon Dam and Lake Mead (406-503 river kilometers). Catch per unit effort was calculated as an index of relative abundance. Native fishes increased in abundance during the study period; conversely most non-native species decreased in abundance. Non-native species comprise most of the species assemblage in cold tailwater habitat between Glen Canyon Dam and the Little Colorado River Confluence, but downstream of the Little Colorado River, native fish outnumber non-native fish. Western (downstream) reaches of the Grand Canyon appear to provide particularly important habitat for native fish. Native fishes increased in abundance with increasing river mile, and most age-1 and younger fish were captured in western Grand Canyon. We hypothesize that a combination of an increasing amount of riverine habitat as Lake Mead recedes, tributary refugia, impediments to establishment of warmwater predators, and modifications to Glen Canyon Dam operations, has contributed to the native fish recovery observed in the Colorado River in Grand Canyon.

17:15 Efficacy of Mechanical Removal of Nonnative Fish from Closed Systems. an Update on Bonita and Aravaipa Creeks

Heidi Blasius[1], Jeff Conn[2] (1-Bureau of Land Management, Safford Field Office, United States; 2-Desert Fish Advocate, United States)

Bonita and Aravaipa Creeks are located within southeastern Arizona and are unique in that they still support intact native fish assemblages and exceptional riparian and aquatic values. Past native fish recovery actions, including construction of fish barriers that prevent or hinder future upstream incursions of nonnative fishes from downstream sources, have benefitted both creeks. However, both native fisheries are still threatened by the presence of nonnative predatory and competitive fish species. To reduce the threat of nonnative fishes in both systems, the BLM, Safford Field Office, collaborated with federal, state, private, and non-governmental partners to begin mechanical removal of Green Sunfish in 2009 at Bonita Creek and 2010 at Horse Camp Canyon, Aravaipa Creek. Green Sunfish were targeted due to their highly piscivorous nature and their ability to thrive in these two systems. In Bonita Creek, nonnative fishes were removed from a 1.9 mile reach dominated by beaver dam pools and glides. Beaver dams effectively reduce the movement of green sunfish within the removal area. In Horse Camp Canyon, nonnative fishes were removed from a 0.5 mile reach that is characterized by boulder-strewn bedrock pools and slots. Boulders and other natural features restrict movement of fish into the removal reach of Horse Camp Canyon except during seasonal flood events when a surface connection exists to Aravaipa Creek. Baited Gee metal minnow traps, collapsible Promar traps, and hoop nets were the primary removal methods used at both creeks. Occasionally seines, dip nets, and backpack electrofishers were used to augment and assess efforts.

Total effort using Gee metal minnow traps, collapsible Promar traps, hoop nets, and custom and crab traps was 46,677 overnight net sets from 2009-2017, which resulted in the removal of 22,709 Green Sunfish from Bonita Creek. In 2018, 1,146 overnight net sets at Bonita Creek resulted in zero Green Sunfish captured. No Green Sunfish have been seen or captured from Bonita Creek since October 2017. A total of 3,910 Green Sunfish were removed from Horse Camp Canyon from 2010-2015, and 2018. The majority (n=2,675) were captured with Gee metal minnow traps and Promar collapsible nets. Seining, dip netting, and backpack electrofishing captured 1,235 Green Sunfish. No Green Sunfish have been seen or captured since October 2015. Results to date, suggest Green Sunfish have been eliminated from both systems above their barriers.

17:45-19:45 Session 4: Poster Session

17:45 Biodiversity, Biogeography, & Conservation of North American Desert Fishes I: Areas of Endemism

Christopher Hoagstrom[1], Derek Houston[2], Norman Mercado-Silva[3] (1-Weber State University, United States; 2-Western State Colorado University, United States; 3-Universidad Autonoma del Estado de Morelos, Mexico)

A literature review of phylogenetic diversity indicates that North America hosts 333 lineages of fishes restricted to the desert region (i.e., the region with <0.65 aridity index). These 'desert endemics' have diverse distributions from large river basins to small springs. A comparison of endemic-lineage distributions with modern and prehistoric drainage boundaries reveals 30 distinct areas of endemism, with endemic lineages per area ranging from 1 to 43 (mean = 15 ± 11 SD). Faunal composition in each area is unique. Although some 'widespread' endemics occupy multiple areas of endemism that have a history of interconnection, 82% of endemics are restricted to single areas, and no endemics occupy more than five areas. A major biogeographic boundary subdivides the region into Northern Great Basin-Colorado Plateau (13 areas) and Southern Desert-Eastern Steppes (17 areas). Only 3% of desert-endemics span this boundary. These either dispersed between the upper & lower Colorado River basin following the formation of the Grand Canyon or crossed between the Lahontan and Mojave areas of endemism via Mono Lake. Thus, desert-fish conservation should target all areas of endemism individually and collectively to ensure preservation of native biodiversity.

17:45 Biodiversity, Biogeography, & Conservation of North American Desert Fishes II: Faunal Assembly

Christopher Hoagstrom[1], Derek Houston[2], Norman Mercado-Silva[3] (1-Weber State University, United States; 2-Western State Colorado University, United States; 3-Universidad Autonoma del Estado de Morelos, Mexico)

Desert-endemic fishes represent 53 clades from 14 families (based on a literature review). Many clades produced multiple endemic lineages (mean = 6 ± 8.2 SD). Estimates for timing of lineage origins are asynchronous (with some exceptions). Initiation of desert-endemism spanned a period of 23 million years, depending on lineage. Some clades diversified sequentially (e.g., *Exoglossum*; *Moxostoma*; *Cyprinodon*). Faunal dissimilarity among areas of endemism indicates that most lineage diversity arose independently, by area. Our conceptual model of faunal assembly illustrates a 2- or 3-step process in which

an incipient-endemic lineage can diverge at any time, independent from other lineages, and an area of endemism may provide habitats in headwaters, alluvial streams & rivers, or springs. Step one: Founders colonize areas of endemism via passive (barrier formation) or active (dispersal) mechanisms. Step two: Persistence, possibly with adaptation, establishes residency. Areas with endemics become centers of survival. Step 3 (optional): Over time, areas accumulate diverse faunas through periodic colonization and/or in situ diversification. Areas accruing faunas become centers of accumulation. Areas with in situ diversification become centers of origin. Because of this process, each area of endemism has a unique assemblage with its own history. Hence, each area is a self-contained target for desert-fish conservation.

17:45 Restoration of Aquatic Habitats and Native Fishes in the Desert: Some Successes in Western North America

Anthony Echelle[1], Alice Echelle[1] (1-Oklahoma State University, United States)

Aquatic conservation issues in deserts of the American West center on nonnative species, altered surface-flow dynamics, and overexploitation of inherently scarce water. Resulting levels of degradation are effectively irreversible except locally. Consequently, restoration success is relative to might have been, or would be, without the effort. Presented here are case studies of such successes. One non-desert project is included because it involves the first federally delisted, non-extinct fish (Oregon Chub) and exemplifies restoration of a western, floodplain species in its natural habitat. Other studies include two primarily floodplain species (Gila Topminnow and Desert Pupfish) transplanted into semi-wild refuges (e.g., stock tanks, ponds, and protected springs); stream-dwelling species (Modoc Sucker and Fossil Creek, Arizona, assemblage) positively affected by habitat restoration or restored stream-flow; and assemblages of species endemic or native to springs. The latter include one instance of rescue and transplantation of endemics from a now-dry spring system (Rancho Nuevo springs, Chihuahua) and examples of expanded habitat via marsh (ciénega) restoration (El Pandeño, Chihuahua) or creation of artificial ciénegas (Balmorhea area, Texas). Keys to these successes are governmental inter-agency cooperation, conservation oriented NGOs, and engagement of private landowners and other stakeholders. Most successes are short-term without the political and societal will to protect and restore natural systems.

17:45 Fifty Years of Desert Fishes Council Proceedings as a Resource for Retrieving Otherwise Lost Knowledge and Control of Shifting Baselines

Dean Hendrickson[1], Gary Garrett[1], Lloyd T. Findley[2], Edwin P. Pister[3] (1-University of Texas at Austin, Biodiversity Collections, United States; 2-CIAD - Unidad Guaymas, Mexico; 3-Desert Fishes Council, United States)

All volumes of the Desert Fishes Council Proceedings have been available online for many years, but as a large collection of single-year separate files in diverse formats, making exploration of the total content inefficient. Recognizing the considerable potential value of the now 50 years of knowledge relevant to the DFC mission, we have made at least some progress toward making all of the Proceedings content more readily accessible and useful and report on that here.

Prior to 1992, the content of all volumes is in graphic-based PDF files (usually one file for each year), so their text is not searchable by computers. All abstracts from 2008 - 2017 have been searchable in a partially normalized database made available online as a Google Fusion Table so relatively rigorous online searching and summarization of that content is facilitated. The 1992-2007 content originated in digital format starting with abstract submission by authors on 5 1/2 inch floppy disks sent via Post (and later via email) to the editor. However, formatting of the published content varied over those years, and it was edited in text processors, not in the database, so final content is now available only in the format of the PDFs used for printing each volume.

Significant manual work by humans would still be required to extract all content into a single, fully normalized database, but on the occasion of the 50th anniversary of the Council, the first author applied automated Optical Character Recognition to all pre-1992 graphics-based content, and then concatenated all Proceedings volumes and all abstracts from 1969-2017 into a single, massive (152 mb) text-based, downloadable and searchable PDF file now permanently archived on the web:

Hendrickson, Dean A., Edwin P. Pister, Lloyd T. Findley, and Gary P. Garrett. 2018. "Compiled Proceedings of the Desert Fishes Council" Volume 1 (1969–2017): 4057 pages. https://doi.org/10.15781/T2QB9VR0N.

Though work should continue toward getting all DFC Proceedings content extracted, fully normalized into a single, easily analyzed database accessible to both computers and humans, we here report on our own applications of this now somewhat more accessible knowledgebase. This new fully text-based format clearly has the potential to help counter shifting conservation baselines by easily exposing often forgotten or simply overlooked, previously "gray" or "dark" biodiversity data. We welcome input from users of this resource before we add all content from the 2018 meeting to produce and publish version 2 of this file.

17:45 Lower Colorado River Area Report

Lesley Fitzpatrick (Retired, United States)

The Lower Colorado River Area encompasses five states in the United States and two in Mexico. The drainages comprising this Area arise in both countries and are unique yet connected to each other. In the waters of the Area, many native invertebrates, fish, amphibians, and reptile species live here, competing with human land and water use as well as the introduction of nonnative plants and animals.

The science we do is complex, and its release is largely contained within the group of agencies and involved parties. But we do not spend a lot of time and effort to reach out to the public about what we do. So, this poster looks at some of those efforts that are attempting to educate the can to some extent, their interest in the conservation of native aquatic species is a factor. At Desert Fishes Council and other professional meetings, we present the science to each other; we do not often consider the outreach and education efforts that reach the public and can have tremendous impact on how our efforts are supported.

Three efforts are shown; two are ongoing and one is the result of the interest of news media to educate the public. These are:

Marsh Education's Sharing Tails

The Lower Colorado River Multi Species Conservation Program Outreach Program

The Arizona Republic 3-day series on the Grand Canyon

If we want to be relevant to the larger world, we need to focus our efforts at educating the public about native aquatic species.

17:45 See the Light: Construction of a Collapsible Larval Fish Light Trap Using a Low-Power LED Light Source

Alton Livingstone (Oregon State University, United States)

Light traps have been shown to be valuable in the conservation and monitoring of endemic desert fishes. To use this method sampling in Rio San Bernardino, Sonora, Mexico, a trap was developed that is of a robust, power-efficient design. This trap disassembles and nests into itself for safe storage and transport and can be easily assembled in the field without tools. Using two lithium coin cells as a power source, light from a light emitting diode is diffused by the translucent high-density polyethylene quatrefoil trap body. Initial field tests indicate this to be an effective design and a possible alternative to more typical quatrefoil light traps of acrylic or polycarbonate construction.

17:45 Current Conservation Status of Some Freshwater Fishes and Their Habitats in Mexico

Maria De Lourdes Lozano Vilano[1], Armando J. Contreras-Balderas[1], Gorgonio Ruiz-Campos[2], María E. Garcia-Ramirez[1] (1-Retired, México; 2-Universidad Autónoma de Baja California, México)

We present new information regarding the status of some endemic freshwater fishes of México from eight states and 24 localities. From earlier descriptions summarized in 1991, two fishes were known extinct, but by 2017, the total increased to 15 taxa either extinct or gone from the wild and present only in captive populations. Species in the genus *Cyprinodon* are the most threatened taxa at the sites we visited. Main reasons for rapid declines or extinctions are spring drying due to increased water consumption by domestic, industrial, and agricultural practices, and negative effects of nonnative species. The destruction of aquatic habitats occurs everywhere in Mexico and requires more protected areas for fishes. The future of this group of vertebrates, especially in arid zones, is in jeopardy of disappearing forever. The number of species declining or extinct continues to rise, increasing the importance of protection by Mexican laws.

17:45 Native Fish Dominance in the Grand Canyon, Arizona

Ronald Rogers[1], Brandon Albrecht[1], Ronald Kegerries[1], Harrison Mohn[1], Mark McKinstry[2], Brian Healy[3], Robert Schelly[3] (1-BIO-WEST, Inc., United States; 2-Bureau of Reclamation, United States; 3-National Park Service, United States)

In 2012, BIO-WEST, Inc. (BIO-WEST) researchers observed sonic-tagged Razorback Suckers moving from the Colorado River inflow area of Lake Mead upstream into the lower Grand Canyon. As tracking efforts attempted to define movement patterns and habitat use, it became apparent that these fish were using the Colorado River in the lower Grand Canyon. Small-bodied sampling began in the Grand Canyon in 2014 from river mile (RM) 179.1 (Lava Falls Rapid) to RM 280.0 (Pearce Ferry) and continued through 2015 until researchers learned that Razorback Sucker spawning was occurring upstream of this area. Since 2016, small-bodied fish community sampling in the Grand Canyon has been conducted from RM 88.5 (Phantom Ranch) to RM 280.0. These efforts have resulted in the capture of four native (Bluehead Sucker *Catostomus discobolus*, Flannelmouth Sucker *Catostomus latipinnis*, Humpback Chub *Gila cypha*, and Speckled Dace *Rhinichthys osculus*) and eight nonnative fish species, as well as documentation of young-of-the-year (age-0) catostomids and cyprinids. These results show that approximately 90% of the Grand Canyon fish community is comprised of native species and demonstrates the need for continued research throughout the Grand Canyon to determine mechanisms allowing for native fish domination.

17:45 Report on the Development of a Refuge Pond for the Sonoyta River Form of the Longfin Dace at the CEDO Research Station, Rocky Point, Sonora, Mexico

Chuck Minckley[1], Alan Berman[2] (1-retired, United States; 2-CEDO, Tucson Office, United States)

The Longfin Dace (*Agosia chrysogaster*) is a small fish (<10 cm) native to the southwestern United States and northern Mexico. Populations are widespread, and many are reduced, existing in uncertain conditions, impacted by introduced fishes, the over-use of ground water, and climate change which continues to impact freshwater ecosystems. As a result, the population in the Rio Sonoyta, a tributary of the Colorado River, present along the US-MX border, is faced with extinction. This prompted concerned scientists at CEDO, the Intercultural Center for the Study of Deserts and Oceans, in Puerto Penasco, the U.S. Fish & Wildlife, Arizona Game and Fish Department, and non-governmental environmental groups to establish several new populations in man-made refuge ponds in and around Puerto Penasco, Sonora, Mexico.

Today, the species is extirpated from the Sonoyta River and one population remains, at CEDO, where, for 11 years, a population of Longfin Dace has thrived in a small pond with the native, endangered Sonoyta River Pupfish, *Cyprinodon eremus*. In the fall of 2018, because of concern with interspecies competition and predation, in the small habitat, CEDO built a new pond for longfin dace using funds provided by Ms. Terri Hamstra and a Conservation Grant from the Desert Fishes Council. The pond was constructed with volunteer labor provided by Dennis Caldwell, a pond designer, and the CEDO staff. Longfin Dace were introduced into the pond in late August, and by 22 October 2018, several fry were observed in the pond. Based on this success, CEDO is moving forward with ongoing conservation efforts for these native fish. Phase II of this recovery program involves creating an interpretive display about the importance of freshwater habitats in the Sonoran Desert and showcasing the endangered and physiologically unique fishes occurring in this unique ecosystem.

17:45 Summary of Pond Construction of a Holding Pond for the Endangered Yaqui Catfish

Chuck Minckley[1], Alton Livingstone[2] (1-retired, United States; 2-Cuenca Los Ojos, United States)

The Desert Fishes Council and North American Native Fish Association provided funding for the development of a holding pond for the Yaqui catfish, *Ictalurus pricei*, as part of an ongoing effort to recover this species in Mexico by UNISON and interested persons. The pond was constructed in July 2018 is 50 X 30 meters. The eastern third is shallow (.05 – 1 m); the western side is 2-m deep. Water is supplied by a continuously flowing artesian well located to the north. The pond is on San Bernardino Ranch, Sonora, Mexico, about 25 km east of Douglas, Arizona – Agua Prieta, Sonora. It is immediately across the International Border from San Bernardino-Leslie Canyon National Wildlife Refuge. Its purpose is to hold this species temporarily until they can be moved to a hatchery.

The Yaqui catfish is the only described species of catfish native to the United States, west of the continental divide. Yaqui catfish is functionally extinct in the United States, and experiencing widespread population declines in Mexico. It is listed as threatened under the Endangered Species Act in the United States and is subject to special protection by SEMRNAT in Mexico.

The pond also contains a population of Yaqui Topminnow, *Poeciliopsis sonoriensis*, and Yaqui Chub, *Gila purpurea*. Aquatic vegetation consists of *Potomogeton* sp., *Typha* sp., *Schoenoplectus* sp., and *Najas* sp.

17:45 Long-Term Perspective of Native Fishes Within the Muddy River, Nevada

Harrison Mohn[1], Brandon Albrecht[1], Ronald Rogers[1], Ron Kegerries[1], David Syzdek[1] (1-BIO-WEST, Inc., United States; 2-Southern Nevada Water Authority, United States)

The Moapa (Muddy) River of southern Nevada once held a healthy assemblage of native species that included the Virgin River Chub *Gila seminuda*, Moapa Dace *Moapa coriacea*, Woundfin *Plagopterus argentissimus*, Moapa Speckled Dace *Rhinichthys osculus moapae*, Desert Sucker *Catostomus clarki*, Flannelmouth Sucker *Catostomus latipinnis*, and Moapa White River Springfish *Crenichthys baileyi moapae*. By the 1960s only one native fish species, the Virgin River Chub, was captured below the Wells Siding Diversion, and sampling through the 1970s indicated that the fish assemblage in this section of river consisted predominantly of nonnative species. Above the Wells Siding Diversion, only the Virgin River Chub remains as a sustainable population, stocking of Moapa Speckled Dace is required to maintain the species, and the Moapa White River Springfish and the Moapa Dace are found only in the uppermost reaches of the river. We make comparisons of the present day fish community composition, relative abundance, and distribution to historical collections stemming from the 1960s and 1970s, which indicate an overall decline in the abundance and distribution of native fishes. Floods in the past 12 years have shown benefits for the chub population in years following flood events, while populations decrease again after a couple years post-flood. To date, PIT tagging data shows Virgin River Chub exhibit life spans of at least 6 years in the Muddy River, which perhaps allows the population as a whole to outlast difficult conditions between flood events. Further

difficulties for native fish include connectivity issues due to diversion dams as well as summer temperatures that often remain above 30.0°C, which is above the optimal temperature for Virgin River Chub of 24°C (critical maximum temperatures between 28°C and 36°C). Nonnative species are a principle concern within the Muddy River at this time, but are being mitigated through the use of rotenone by the Nevada Department of Wildlife upstream of the Wells Siding Diversion. The Virgin River Chub holds no special protection within the Muddy River at this time, despite being the same endangered species that occurs in the Virgin River.

17:45 Conservation Agreement and Strategy for Springsnails in Nevada and Utah

Chris Crookshanks[1], Jon Sjoberg[1], Jeri Sjoberg[2], Kevin Wheeler[3], John Wullschleger[4], Deb Koziol[5], Laurel Saito[6], Cynthis Tait[7], Eric Miskow[8], Sandra Brewer[9] (1-Nevada Department of Wildlife, United States; 2-U.S. Fish and Wildlife Service, United States; 3-Utah Division of Wildlife Resources, United States; 4-National Park Service, United States; 5-Natural Resource Conservation Service, United States; 6-The Nature Conservancy, United States; 7-U.S. Forest Service, United States; 8-Nevada Natural Heritage Program, United States; 9-Bureau of Land Management, United States)

There is an increasing concern and need for the conservation of springsnails and other endemic mollusks and for the unique spring and springbrook habitats on which they depend (Hershler et al 2014; Abele 2011). Nationwide, several of these species have been listed as endangered or threatened under provisions of the ESA; others are undergoing review by the U.S. Fish and Wildlife Service (USFWS) for possible future listing actions. These species can be particularly susceptible to localized threats such as water diversion, capping, groundwater pumping, invasive or exotic species, development, or trampling by ungulates. These threats can be addressed but development and implementation of consistent and appropriate strategies and actions are needed. Firm commitments from agencies and entities responsible for management of occupied sites, including private landowners, are also needed so management actions can be applied effectively.

This poster describes the development of a comprehensive Conservation Agreement and Strategy (CAS) for springsnails and their associated habitats in Nevada and Utah. A Conservation Agreement (Agreement) between multiple agencies, stakeholders, and other interested parties was completed in 2017. The corresponding Strategy is currently being drafted and is expected to be completed in October, 2019. The conservation actions described in the Strategy are expected to lead to the protection and enhancement of these unique species and their associated habitats. In Utah and Nevada, Conservation Agreements and Strategies (CAS) have been an important conservation tool for more than 20 years and, in many cases, have resulted in precluding the need to list at-risk species.

17:45 Black Canyon City Heritage Park Native Fish Refuge Population Update

Lacey Schmitt[1], Tony Robinson[1] (1-Arizona Game and Fish Department, United States)

Refuge populations play a critical role in the conservation of threatened and endangered species in the southwest. Through a successful partnership between Arizona Game and Fish Department and Black Canyon City, the pond at Black Canyon City Heritage Park holds refuge populations of Gila Topminnow (*Poeciliopsis o. occidentalis*) and Desert

Pupfish (*Cyprinodon macularius*). These captive populations provide an important dual purpose; a source population for translocations by the Arizona Game and Fish Department, and a conservation, restoration, and public education opportunity for Black Canyon City. The pond was initially stocked with Gila Topminnow and Desert Pupfish in 2011 and 2012. Unfortunately, nonnative Mosquitofish (*Gambusia affinis*) and Tilapia (Tilapia spp.) were discovered in 2015. The pond was drained to remove the nonnative fish, which are known to prey upon and compete with topminnow and pupfish. After drying for about a month, the pond was refilled and left fallow for a few months to allow for natural recolonization by insects, algae, and aquatic vegetation (food resources for fish). In March 2017, 122 salvaged Desert Pupfish were returned to the pond and in June 2018 we stocked 734 Gila Topminnow. We monitored the pond in August 2018 and found the Gila Topminnow population greatly increased, with 1,429 individuals captured. Desert Pupfish are also doing well and appear to be re-established as we captured 504 individuals. In this poster, we provide an overview of this cooperative project, as well as future plans for the pond.

17:45 Broodstock Density Mediates Larval Production of Captive-Spawned Loach Minnow and Spikedace

Kristopher Stahr[1], Joshua Walters[1], Hannah Smith[1] (1-Arizona Game and Fish Department, United States)

Loach Minnow, *Tiaroga cobitis*, and Spikedace, *Meda fulgida*, are two endangered fishes endemic to the Gila River Basin of Arizona and New Mexico. Habitat degradation and the introduction of non-native fishes have resulted in population declines, and as such captive propagation is an important facet for continued recovery. However little information exists on the spawning of these fishes, both in the wild and in captivity. Therefore the goal of this study was to determine whether a relationship existed between broodstock density and larval production to guide future propagation efforts. Three different broodstock densities (low, medium, and high) were used for both Loach Minnow and Spikedace. Both species were spawned in linear raceways (1m × 1m × 4.5m) with each tank receiving separate artesian water flow and programmable recirculation pump to mimic natural conditions. Each spawning tank was prepared identically, respective for each species. We found that lower broodstock densities resulted in the highest larval fish production per raceway for both species. However, future replicates are needed to confirm these results, and thus experiments will continue for at least one additional year.

17:45 Comparing and Contrasting Pupfish, Headwater Catfish, and Northern Largemouth Bass

Harlan Bean (Starkey Elementary, United States)

I would like to compare and contrast pupfish, bass, and catfish. I will teach you about fish. I am going to compare and contrast the habitats, food webs, and how they live.

17:45 Lee Simons: a Legacy in Southern Nevada

James Harter[1], Christiana Manville[1] (1-U.S. Fish and Wildlife Service, United States)

Lee Simons, Ph.D., served as the Senior Fish Biologist at the Southern Nevada Fish and

Wildlife Office from 2008 to 2016. During his tenure, he was invaluable to recovery efforts for the Devils Hole Pupfish, *Cyprinodon diabolis*, Moapa Dace, *Moapa coriacea*, and Pahranagat Roundtail Chub, *Gila robusta jordani*, in addition to several other desert fishes. Lee was exceptional at building collaborative partnerships, as partners on the Devils Hole Incident Command Team and Muddy River Biological Advisory Committee strongly attest. He excelled at bringing funding and other resources to southern Nevada that resulted in recovery actions for many of the listed fish species. Lee was successful at writing grants for species conservation and obtained several Cooperative Recovery Initiative Grants, funding from the National Fish Passage Program, and several Southern Nevada Public Lands Management Act grants. Lee was active within the research community and facilitated research on desert fishes with the U.S. Geological Survey, University of Nevada Reno, UC Berkley, University of Arizona, and other institutions. Lee not only held a passion for natural resources, but for life in general. Lee was a friend and mentor for those both inside and outside the USFWS, and always took the time to lend an ear or provide help to others. Many of the projects Lee started continue today and illustrate a legacy in southern Nevada.

17:45 Water Quality and Sediment Chemistry of Selected Habitats of the Mohave Tui Chub, Mojave National Preserve, California, 2018
Katherine Earp (US Geological Survey, United States)

The Mohave Tui Chub, *Siphateles bicolor mohavensis*, was extirpated from the Mojave River drainage in California and listed as endangered in 1970. A source population of Mohave Tui Chub exists at MC Spring in Zzyzx and has been used for several reestablishment efforts in subsequent decades. Two potential habitats within the Mojave National Preserve with perennial sources of water have been identified by the National Park Service as candidates for Mohave Tui Chub reestablishment: West Pond and Rainbow Wells Pond. West Pond, an artificial pond at Zzyzx near MC Spring, contained a population of Mohave Tui Chub which died off in 1985 due to changes in water quality. The pond was rehabilitated in the past several years through re-excavation and by pumping fresh groundwater into the pond. Rainbow Wells Pond is an abandoned excavated mine site located on Cima Dome. The bottom of the excavation intersects the water table, forming a pond. In cooperation with the National Park Service, the U.S. Geological Survey conducted a study to monitor water-quality conditions at West Pond and Rainbow Wells for one year and characterize their suitability for reestablishment of Mohave Tui Chub populations. Water quality and sediment chemistry were determined through discrete quarterly sampling. Temperature was monitored continuously with deployed loggers. Data were also collected at three existing Mohave Tui Chub habitats in Mojave National Preserve to provide further information on the range of acceptable physical and chemical conditions. Initial water quality results at West Pond indicate that the pond is favorable habitat for the Mohave Tui Chub. Initial water quality results at Rainbow Wells Pond suggest that the dissolved oxygen concentrations are lower than the long-term tolerable ranges for Mohave Tui Chub.

17:45 The Effects of Red Swamp Crayfish, *Procambarus clarkii*, on Experimental Populations of the Amargosa Pupfish, *Cyprinodon nevadensis amargosae*
Bailey Gillis[1], Brandon Paulson[1], Craig Stockwell[1] (1-North Dakota State University,

United States)

Invasive crayfish species threaten the persistence of numerous desert fishes, but how crayfish density influences native fish persistence is not well understood. One hypothesis predicts that negative impacts increase with higher crayfish densities (Rogowski & Stockwell 2006; Biol. Invasions 8:79-87), while an alternative hypothesis predicts that impacts decrease with higher crayfish densities, presumably due to interference competition (Taylor & Thomas 2013; Freshwater Sci.32:1309-1317). To test these hypotheses we established experimental populations of Amargosa Pupfish, *Cyprinodon nevadensis amargosae,* and Red Swamp Crayfish, *Procambarus clarkii*, that included allopatric pupfish (control); pupfish + low-density crayfish; pupfish + high-density crayfish and pupfish + high-density tethered crayfish. The latter two treatments were compared to evaluate if conspecific interactions among crayfish affected impacts on pupfish. We found significant effects of crayfish on pupfish adult survival ($X2 = 11.8$; $P < 0.01$). Adult survival did not differ between the control (97 ± 8.0%) and low-crayfish treatments (84 + 13%; $P > 0.05$). Adult survival was significantly lower for the high-density crayfish treatment (69 ± 14%; $P < 0.02$) compared to the control. However, adult survival did not differ between the low-crayfish and high-crayfish treatments ($P > 0.05$), nor between the high-crayfish and high-density tethered treatments ($P > 0.05$). Crayfish had significant effects on juvenile productivity ($X2 = 15.8$; $P < 0.002$). Juvenile productivity did not differ between the control (705 ± 92 juveniles / tank) and low-crayfish treatment (704 ± 167; $P > 0.05$), while both of these treatments had higher juvenile productivity than the high-crayfish treatment (271 ± 107%; $P < 0.006$ and $P < 0.006$, respectively). When comparing the two high-density crayfish treatments, tethering resulted in significantly higher juvenile productivity (494 + 156; $P < 0.03$). Our results show density-dependent effects of crayfish on experimental pupfish populations. Limiting conspecific interactions among crayfish did not affect adult survival, but increased juvenile production. Our results suggest that short-term solutions to crayfish invasion may be simply to reduce crayfish densities.

17:45 Laughlin Lagoon Avian Predation Monitoring

Layne Huber (National Park Service, United States)

Reclamation and other stakeholders perform a variety of conservation related activities in the region. The conservation of Bonytail Chub (*Gila elegans*) and other native fish species is currently managed under the Multi-Species Conservation Program (MSCP) Fisheries Program. There are three components to the Fisheries Program; continued monitoring of existing Bonytail populations, population augmentation through repatriation, and hatchery research and efficiency. Existing population monitoring indicates that fish are not self-replacing in the wild (Minckley et al. 2003). This lack of success on the part of native fish has largely been attributed to predation of larvae and juveniles by non-native fish (Minckley 1983, Minckley 1991). The augmentation effort has attempted to circumvent this predation risk by releasing hatchery stock at the sub-adult stage (>300mm) which should be large enough to avoid predation by non-native fish (Mueller 1995). However, MSCP staff are now concerned with avian predation of repatriated sub-adult fish. The Lower Colorado River is used by several resident and migratory piscivorous (fish-eating) bird species including cormorants, *Phalacrocorax* spp., Great Blue Herons, *Ardea*

herodias, and Osprey, *Pandion haliaetus*. Other species of interest include American White Pelican, *Pelecanus erythrorhynchos*, Great Egrets, *Ardea alba*, Common Mergansers, *Mergus merganser*, and grebes, *Aechmophorus* spp. Currently, the effects of avian predation are unknown. However, if the threat level could be determined, MSCP could attempt to mitigate for it by altering release strategies or altering stocking numbers. This report details on-the-ground and remotely sensed avian predation monitoring conducted in 2015, 2016, and 2017 as part of the MSCP at Laughlin Lagoon, NV. The goals of this study are to 1) determine the minimum number of fish from each Bonytail Chub stocking effort that are eaten by birds, and 2) determine the relative abundance of piscivorous bird species at the Laughlin Lagoon release site.

17:45 The Renovation and Modernization of the Aquatic Research and Conservation Center

Ryan Mann[1], Kristohper Stahr[1], Joshua Walters[1] (1-Arizona Game and Fish Department, United States)

The Arizona Game and Fish Department's Aquatic Research and Conservation Center in Cornville, Arizona serves the primary function of housing and propagating rare lineages of small-bodied desert fishes, such as the endangered Loach Minnow and Spikedace, supporting conservation efforts in Arizona and New Mexico. The facility also conducts research and provides resources and space for emergency salvage operations. The facility was built incrementally with limited grant funding and has been largely built using military surplus shipping containers as tanks. While adequate for meeting current conservation needs, the existing systems' limited production levels and research capabilities and were insufficient for future conservation goals. Thus, a renovation was initiated in 2014, with the objectives of expanding and improving holding and spawning capacity for fish, modernizing fish culture and hatchery infrastructure, and increasing biosecurity. To date, $1.2 million has been contributed to the project and two of three planned phases have been completed, improving overall functionality and performance of the facility.

17:45 Genetic Variability and Inbreeding of the Sonoyta Pupfish *Cyprinodon eremus* Miller and Fuiman, 1987, in Artificial Refuge and Wild Populations of Sonora, Mexico

Variabilidad Genética y Endogamia del Pez Cachorrito del Sonoyta *Cyprinodon eremus* Miller y Fuiman, 1987, en Refugios Artificiales y Poblaciones Silvestres del Estado de Sonora, México

Roman Rodriguez-Ramirez[1], Alejandro Varela-Romero[2], Nohelia Guadalupe Pacheco Hoyos[2], José Manuel Grijalva Chon[2], Marco Antonio López Torres[2], Anthony A. Echelle[3] (1-Universidad de Sonora, Posgrado en Biociencias, Mexico; 2-Universidad de Sonora, DICTUS, Mexico; 3-Departament of Integrative Biology, Oklahoma State University, United States)

The Sonoyta Pupfish is an endemic species from the Sonoyta River basin (Sonora) and the Quitobaquito Spring (Organ Pipe National Monument) along the international border. Anthropogenic impact has been the main cause of the reduction of Sonoyta Pupfish populations. As a conservation strategy, refuge populations were established in Sonora and

Arizona. However, there is a lack of studies of the refuge populations of Mexico and the United States, and they were established without considering the genetic variation and the structure of the populations of origin. The isolation of each refuge population can cause its reduction in genetic variability, making it impossible to use it in future reintroductions in natural habitats. The goal of this work is to evaluate the genetic variability and the population structure of the refuge and wild populations of the Sonoyta Pupfish. For the genetic evaluation, wild specimens' populations and existing artificial refuges have been collected (Centro Ecológico de Sonora y Centro Intercultural de Estudios de Desiertos y Océanos) and DNA extractions were performed. The PCR protocol for 10 microsatellites was standardized to evaluate the number of alleles (A), the heterozygosity observed (Ho), the genetic differentiation estimates of the microsatellite data (Rst). As advances, 565 PCR products from 10 microsatellite loci have been obtained, where polymorphism has been found.

El cachorrito del Sonoyta es una especie endémica de la cuenca del río Sonoyta (Sonora) y el manantial de Quitobaquito (Monumento Nacional Organ Pipe) a lo largo de la frontera internacional. El impacto antropogénico ha sido la principal causa de la reducción de las poblaciones del cachorrito del Sonoyta. Como estrategia de conservación, se establecieron poblaciones de refugio en Sonora y Arizona. Sin embargo, se carece de estudios exhaustivos de las poblaciones de refugio de México y Estados Unidos, ya que se establecieron sin considerar la variación genética y la estructura de las poblaciones de origen. El aislamiento de cada población de refugio puede causar su reducción en la variabilidad genética imposibilitando su uso en futuras reintroducciones en hábitats naturales. El objetivo de este trabajo es evaluar la variabilidad genética y la estructura poblacional de las poblaciones de refugio y silvestres del cachorrito del Sonoyta. Para la evaluación genética, se han colectado ejemplares de poblaciones silvestres y de los refugios artificiales existentes (Centro Ecológico de Sonora y Centro Intercultural de Estudios de Desiertos y Océanos) y se realizaron las extracciones de ADN. Se estandarizó el protocolo de PCR para 10 microsatélites para evaluar el número de alelos (A), la heterocigosidad observada (Ho), las estimaciones de diferenciación genética de los datos de microsatélites (Rst). Como avances se han obtenido 565 productos de PCR de 10 loci microsatélites, donde se ha encontrado polimorfismo.

17:45 Does Sympatry Influence Dietary Niche Overlap? an Analysis of Gut Content in *Poeciliopsis prolifica* and *Poeciliopsis latidens* (Cyprinodontiformes: Poeciliidae)

Alexandra Duffy[1], Andrea Roth-Mozón[1], Jerald B. Johnson[1] (1-Brigham Young University, United States)

Interspecific competition for resources can promote adaptive radiations through the processes of competitive exclusion and character displacement. The expectation is that if similar species co-occur (sympatry), they will evolve distinct dietary niches to avoid negative effects due to competition. In this study, we investigated trophic resource use in two congeneric livebearers fishes, *Poeciliopsis prolifica* and *P. latidens* that co- occur in western Mexico. We compared the digestive tract weight, length, and gut content between sympatric and allopatric populations of both species. We expected to find less dietary overlap in both species when they were found in sympatry than when found alone in allopatry. We will discuss the most prominent food items in each species and potential

contribution of dietary niche differentiation to the stable coexistence of these two closely-related species. This work will aid our understanding of how species can coexist and what promotes species divergence in resource use when species occur in sympatry. Additionally, this study will provide important ecological information of these species, as it is the first dietary description for both species.

17:45 Study and Conservation Strategies of Yaqui Catfish, *Ictalurus pricei*, in Northwest Mexico: Recovery and Management Plan

Estrategias de Estudio y Conservación del Bagre Yaqui, *Ictalurus pricei*, en el Noroeste de México: Programa de Recuperación y Manejo

Alejandro Varela-Romero[1], Chuck Minckley[2] (1-Universidad de Sonora, Mexico; 2-Cuenca Los Ojos A.C., United States)

The Yaqui Catfish, a species threatened species in Mexico and with different status in the United States of America (USA), has been of interest to different agencies in recent years. For conservation purposes, members of the Desert Fishes Council (DFC) have initiated activities for the systematic evaluation of their populations in Northwest Mexico, including several academic institutions and NGO´s in Mexico and the USA. Additionally, there is a sacred and commercial interest in using the Yaqui Catfish as a marketing strategy by the Pascua Yaqui tribe. Collections in the Bavispe River subbasin, found Yaqui Catfish only in Arroyo Cajón Bonito. We reported those collections in report for the scientific collection permit to SEMARNAT, and applied for renewal the permit with the following objectives for the Yaqui Catfish recovery and management plan in Northwest Mexico. The initial objectives of the plan are evaluation of the population status of the Yaqui Catfish in its current distribution; evaluation of the genetic integrity of wild populations using nuclear and mitochondrial markers; detection of Yaqui Catfish populations throughout their historical distribution by means of eDNA; capture of live Yaqui Catfish and their transport to a pond within the Yaqui River basin in Mexico to create a captive breeding stock; evaluation of the genetic integrity of individuals of the Yaqui Catfish reproductive stock for future use as a breeding population; development of a joint binational strategy between USFWS and Institute of Aquaculture of the State of Sonora (IAES) to promote the reproduction of the stock in captivity in facilities of the IAES in the lower basin of the Yaqui River; detection and selection of historical extirpation localities for the Yaqui Catfish within its historical range for future repopulation. The Yaqui Catfish recovery and management plan aims to achieve establishment of a captive reproductive population of Yaqui catfish within its natural range for use in conservation of the species. So far the institutions involved are DICTUS University of Sonora, Cuenca Los Ojos A.C., Institute of Aquaculture of the State of Sonora, Faculty of Sciences of the Autonomous University of Baja California, CIBNOR La Paz, and Oklahoma State University.

El bagre Yaqui, una especie amenazada de extinción en México y considerada con diferentes estatus en Estados Unidos de Norteamérica (USA), ha sido interés de diferentes agencias en los últimos años. Para fines de conservación, integrantes del Desert Fishes Council (DFC) han iniciado actividades de evaluación sistemática de sus poblaciones en el Noroeste de México, incluyendo varias instituciones académicas y ONG´s en México y

USA. Adicionalmente, existe un interés sagrado y comercial de utilizar el bagre Yaqui como estrategia de mercadeo por la tribu Pascua Yaqui. Como resultado de recolectas en la Subcuenca del Río Bavispe, se reporta la existencia de bagre Yaqui sólo en el arroyo Cajón Bonito. Se cumplió con la entrega del informe de la licencia de recolecta científica ante la SEMARNAT y se sometió la solicitud de licencia de recolecta científica para los objetivos que se enlistan para el programa de recuperación y manejo del bagre Yaqui en el Noroeste de México. Los objetivos iniciales del programa son la evaluación del estatus poblacional del bagre Yaqui en toda su distribución actual, la evaluación de la integridad genética de las poblaciones silvestres utilizando marcadores nucleares y mitocondriales, la detección de poblaciones de bagre Yaqui a lo largo de toda su distribución histórica por medio de eDNA, la captura de ejemplares vivos de bagre yaqui y su transporte a un estanque dentro de la cuenca del Río Yaqui en México para crear un stock reproductivo en cautiverio, la evaluación de la integridad genética de los individuos del stock reproductivo de bagre Yaqui para su uso futuro como población reproductora, el desarrollo de una estrategia binacional conjunta entre el USFWS y el Instituto de Acuacultura del Estado de Sonora (IAES) para promover la reproducción del stock en cautiverio en instalaciones del IAES en la cuenca baja del Río Yaqui y la detección y selección de localidades de extirpación histórica registradas para el bagre Yaqui en cuencas de su distribución histórica con fines de repoblamiento futuro. El programa de recuperación y manejo del bagre Yaqui pretende lograr el establecimiento de una población reproductiva en cautiverio del bagre Yaqui al interior de su distribución natural para utilizarla con fines reproductivos para su conservación. Hasta el momento las instituciones involucrados son el DICTUS Universidad de Sonora, Cuenca los Ojos A.C., Instituto de Acuacultura del Estado de Sonora, Facultad de Ciencias Universidad Autónoma de Baja California, CIBNOR La Paz, Oklahoma State University.

17:45 A Holocene Snail Fauna in the Middle Snake River Sub-Basin, Southern Idaho, U.S.A.

Bowler Peter[1], Terrence Frest[2] (1-University of California, Irvine, United States; 2-Formerly with Deixis Consultants, United States)

Comprehensive lists of the modern native and non-native mollusk fauna in the Middle Snake River Sub-Basin were compiled over two decades ago (Bowler and Frest, 1991; Bowler, 1992; Frest and Bowler, 1993; Frest and Johannes, 1993). Subfossils recovered from sand, basalt cobble, and Melon Gravel substrates at the confluence of the Malad and the Snake Rivers reveal a diversity of species present as a holocene fauna. The collection site is above the present elevations of both rivers and its sediments were deposited after the Bonneville Flood approximately 14,500 years ago. Fourteen native taxa were identified and two of these species are currently Federally listed as Threatened (*Taylorconcha serpenticola*, Hannan, 2016; Bogan, 2000) or Endangered Species (*Physa natricina* Taylor, endangered throughout its distribution; Rabot/U.S. Fish and Wildlife Service, January 22, 2018). Several species no longer occur in either river at the confluence. Subsequently introduced non-native mollusks present near the site include the New Zealand Mudsnail (*Potamopyrgus antipodarum*, which appeared in the Middle Snake River in ca. 1986 (Bowler, 1991) and is abundant in the Snake and Malad Rivers), *Ferrisia rivularis* (Malad River), and *Corbicula fluminea* (Snake River at the mouth of the Malad River).

17:45 Spatial and Temporal Variation in Benthic Macroinvertebrate Assemblages Structure in Salinized Reaches of the Pecos River

Connor L. Brown[1], Kelbi D. Delaune[1], Allison A. Pease[1] (1-Texas Tech University, United States)

In the Permian Basin region of Texas, salinization has occurred in the Pecos River as natural saline inputs have been exacerbated by flow-regime change and other anthropogenic impacts. Recent studies have shown that fish diversity has declined with salinization in the Pecos River, but impacts on benthic macroinvertebrate assemblages have not been examined in recent decades as salinization has intensified. In this study, we deployed Hester-Dendy multi-plate samplers for 6-8 weeks in summer and fall 2017 to assess the structure of colonizing benthic macroinvertebrate assemblages at three sites in the lower Pecos River (two in the salinized Permian Basin region, one in the Edwards Plateau region). Invertebrate biomass and taxonomic richness was lowest in the salinized Permian Basin sites, with assemblages dominated by dipteran taxa. As specific conductance decreased and habitat heterogeneity increased in the Edwards Plateau reach, more diverse benthic macroinvertebrate assemblages colonized the samplers. Additionally, diversity of benthic macroinvertebrates and biomass increased from summer to fall. Results of this work add to our understanding of how river salinization affects ecological communities. Because river salinization is a common issue in dryland regions, and it is expected to increase with climate change, such information is important for conservation and management.

17:45 Freshwater Mollusk Water Quality Tolerances and Observations About the Effects of Dams in the Middle Snake River Sub-Basin, Southern Idaho

Peter Bowler[1], Terrence Frest[2] (1-University of California, Irvine, United States; 2-formerly with Deixis Consultants, United States)

Relative water quality sensitivities of 59 native and introduced freshwater mollusk species from thirteen families within the Middle Snake River sub-basin, southern Idaho, are presented. When ranked on a scale of ascending tolerance from 0 - 10, within the native fauna 11 taxa are very sensitive to water quality and fall within the 0 - 2 range, 13 species lie within the 2 - 5 range, and a group of 16 species can tolerate water quality within the 6 - 10 range. Three exotic species are very pollution tolerant, as is another group of six non-native taxa occurring primarily in thermal plumes from warmwater hatcheries. The most sensitive species have declined significantly within the mainstem river and many now are abundant only in tributary springs. Several are locally extirpated and are known only from shells, and several are federally listed as Threatened or Endangered taxa. Other rare endemics such as *Stagnicola hinkleyi* (F.C. Baker, 1906) are near extinction. Even within the second tier of species, there has been continuing decline. The Idaho Department of Fish and Game studies in the late 1940s and early 1950s suggest an historic fauna dominated by *Fluminicola spp*. and other sensitive taxa, which was dramatically reduced by severe diurnal instream flow fluctuations from the operation of hydroelectric dams. Continued, though less severe, “load-following” dam operations and chronic subsequent poor water quality shifted the fauna to more pollution tolerant, ubiquitous taxa. The New Zealand Mudsnail, *Potamopyrgus antipodarum* (Gray, 1843), is currently the dominant macroinvertebrate at most sites. Water quality tolerances are reported for 10 other native

taxa in tributaries or elsewhere in the Snake River system.

17:45 Evolution of Gonopodial Asymmetry and Behavioral Laterality in the Livebearing Fish *Xenophallus umbratilis*

Mary-Elise Johnson[1], Erik S. Johnson[1], Jerald B. Johnson[1] (1-Brigham Young University, United States)

The livebearing fish *Xenophallus umbratilis* shows an unusual form of handedness, where the male intromittent organ (gonopodium) terminates with either a dextral or sinistral twist. We tested the hypothesis that these two morphs are maintained in the wild by negative frequency-dependent selection, wherein males with the rare morph are favored in a mating context when they are uncommon. We sampled males from multiple populations and found that some populations show a clear dextral bias in the gonopodium, where others show a sinistral bias. However, the ratio of left- to right-handed males appears to be dynamic as evidenced by our sampling of a single population over time wherein we found an extreme shift in the ratio of left- to right-handed males over a relative short period of time, from March to June. In addition to presenting these field results, we will also present our findings from two laboratory experiments exploring the mechanism by which rare males morphs have a mating advantage when they are rare. First, we show that mature females actively avoid male mating attempts by positioning their bodies to the side of males in such a way that the most common male morph is not able to successfully mate with females, but the rare morph is. Second, to determine if different male morphs vary in how they approach potential mates, we used a detour test where males are forced to approach from either the left or right side. This is a key first step in determining if this species exhibits behavioral laterality that is linked to gonopodial morphology. We present our results to date on these questions, and outline several additional experiments that are in progress that we anticipate will throw light on the evolution of brain lateralization in fishes, and potentially help explain why handedness has evolved in bilaterally symmetrical organisms.

17:45 Beaver-Mediated Ponds Provide Cold Water Refugia in a Degraded Desert Stream

Melody Feden[1], Howard Whiteman[2] (1-Murray State University, United States; 2-Murray State University, Watershed Studies Institute, High Lonesome Ranch Institute, United States)

Temperature is one of the most important habitat parameters for freshwater organisms. Water temperature can limit growth, reproduction, and the distribution of aquatic species. In some areas, climate change is increasing air temperature and reducing snowpack, resulting in an increased need for cold water refugia in stream ecosystems. In the last few decades the North American Beaver (*Castor canadensis*), once almost completely extirpated from the United States, has seen population increases due to decreased trapping and a changing narrative about their importance to stream ecosystems. Yet, there is still a lack of understanding of how beaver dam building activities affect stream temperature dynamics. In this study, I tested the hypothesis that beaver ponds decrease stream temperatures more than riffle habitat. In addition, I investigated whether beaver ponds stratify and create cold water refugia. Research was conducted in Kimball Creek, a third order stream in the Colorado River basin. At 1800m in elevation, it is considered a high

desert ecosystem that gets approximately 10 inches of precipitation per year and is degraded because of current and historic cattle grazing and agricultural activities. Kimball Creek has a dense beaver population with approximately 20 dams per stream kilometer. To investigate the effects of beaver pond habitats on stream temperature, I choose 10 beaver ponds with 10 corresponding riffle habitats of similar length, and installed temperature loggers at the inflow and the outflow of each habitat. In seven of the beaver ponds, I installed temperature loggers at the deepest point of the pond, with 2-3 loggers spaced equally from the bottom to the top of the water column. Preliminary results indicate that beaver ponds do not increase stream temperature more than riffle habitats and that they do create cold water refugia that differs from the surface temperature by up to 5°C. These beaver-mediated cold water refugia could allow for greater survivability and species distribution for cold water species in desert aquatic ecosystems.

17:45 Nevada Area Report

Eric Miskow (Nevada Natural Heritage Program, United States)

With many thanks to a number of co-authors (not all were available at time of abstract submission, but to be acknowledged during the presentation); Nevada waters contain 16, endangered and 6 threatened species of fishes as well as numerous undescribed At-risk fish taxa. A summary, overview and status of Nevada's desert fishes, current research and management projects in the state will be addressed.

17:45 Homogenizing Effects of Historic Lake Bonneville: Can Phylogeography Inform Community Assembly?

Trevor Williams[1], Jerald B. Johnson[1] (1-Brigham Young University, United States)

What structures ecological communities? This is one of the predominant questions asked in community ecology. Traditionally, ecologists have tackled this question by investigating the contemporary biotic and abiotic factors that govern community assembly, such as predation, competition, and environmental filtering. Though informative, this approach neglects historical factors and may be overlooking important assembly drivers such as shared dispersal histories or climatic alterations that can have lasting effects on community pattern. However, modern phylogeographic techniques are now able to estimate and model species responses to historical phenomena and therefore can be used to examine historical community assembly.

We investigated the contemporary and historical factors governing community assembly of freshwater fishes in the Bonneville Basin in Utah. The Bonneville Basin is composed of several isolated, closed drainage basins that over the past 30,000 years have been temporarily connected by large lakes due to climatic change during the last glacial maximum. Approximately 14,500 to 16,000 years ago, the entire Bonneville Basin was covered by Lake Bonneville, thereby connecting all of the separate basins and presumably allowing aquatic species to migrate throughout the Bonneville Basin. Because its geologic history, as well as its fish taxa, are well studied, Lake Bonneville is an ideal system for studying both the historic and contemporary factors that govern community assembly.

To investigate the historic factors governing community assembly, we gathered sequence

and allozyme data from Genbank and the literature and used them in coalescent simulations to test whether fish species were able to migrate through Lake Bonneville. To determine the contemporary factors working on community assembly, we used co-occurrence null models to analyze whether species are randomly or non-randomly structured in respect to each other. Co-occurrence null models were run on historic occurrence data collected before 1940 in order to minimize the effects of non-native introductions on communities. These methods allowed us to analyze two sets of hypotheses. If Lake Bonneville allowed migration to occur, we hypothesized that communities would be structured randomly due to ecological drift. If Lake Bonneville did not allow migration, we hypothesized that communities would be structured non-randomly, likely due to biotic and abiotic habitat requirements.

We found that fish species had independent responses to the rise of Lake Bonneville. Some species were able to migrate while others did not. Likewise, the co-occurrence null models indicated that fish communities are structured randomly. These results support our hypothesis that Lake Bonneville allowed homogenization of communities across the Bonneville Basin. Current membership in communities seems to be structured due to ecological drift as lake levels dropped and communities became isolated. Our results further show how phylogeographic methods can be implemented to investigate the historical aspects of community assembly.

17:45 Predacious Diving Beetle (Dytiscidae) Dynamics Within a Refuge Tank Ecosystem for the Endangered Devils Hole Pupfish (*Cyprinodon diabolis*)

Mitchell Stanton[1], Olin Feuerbacher[2], Jennifer Gumm[2], Corey Lee[2], Javier Linares-Casenave[2] (1-Great Basin Institute, United States; 2-United States Fish and Wildlife Service, United States)

The Ash Meadows Fish Conservation Facility (AMFCF) was established, in part, to maintain a captive population of Devils Hole Pupfish. Part of this effort included creation of a 100,000 gallon ecosystem simulation which was stocked with algae and invertebrates from Devils Hole, in addition to fish raised from eggs collected from Devils Hole. While the refuge tank has successfully maintained the fish population through multiple generations, efforts to recover eggs from the refuge tank have been largely unsuccessful. Predacious diving beetles (Dytiscidae) have been observed in the laboratory and in the refuge tank consuming both eggs and larvae. Beetle traps were designed and deployed in an attempt to reduce the numbers of beetles. Several treatments with varying substrate and baits were tested for effects on capture efficiency and retention. No treatments differed from controls, however, the traps proved effective in capturing substantial numbers of beetles. Two species of beetles were routinely captured in the traps, and these populations seemed to roughly segregate spatially within the tank. The apparent effects of beetle trapping on egg recovery success were immediate and dramatic. This work has allowed AMFCF to begin propagating additional fish derived from refuge tank eggs without being wholly reliant on wild-collected eggs.

17:45 Multispecies Character Displacement in Mexican Freshwater Fish Communities

Andrea Roth-Monzón[1], Jerald B. Johnson[1] (1-BrighamYoung University, United States)

Competition has long been recognized as a central force in shaping evolution, particularly through the mechanism of character displacement. However, research on character displacement is biased as it has focused almost exclusively on pairs of interacting species while ignoring multispecies interactions. Yet communities are seldom so simple that only pairs of species interact, and it is not clear if inferences from pairwise interactions are sufficient to explain patterns in nature. A more realistic approach is to ask how traits evolve when multiple species interact. Here we test for character displacement in a natural system of freshwater fishes in western Mexico that contains different combinations of up to four closely related species of the genus *Poeciliopsis*. We focus on three fundamental questions in this system: (1) is there character displacement in the different species of *Poeciliopsis*, (2) how does number of co-occurring species affect character displacement in each species, and finally, (3) does number of co-occurring species affect trait displacement equally for all species. This work is important because it recognizes that trait evolution can differ as a function of number of species interacting, but could also be different for each of the interacting species. Our work suggests that future studies of character displacement should move beyond pairwise competitive interactions to provide a more realistic understanding of how species evolve in natural fish communities in the wild.

17:45 Upper Colorado Basin Area Report

Paul Badame (Utah Division of Wildlife, United States)

Activities continue in an effort to improve the status of many native fishes of the Upper Colorado River Basin. These activities are guided principally by four programs: the Upper Colorado River Endangered Fish Recovery Program, the San Juan River Basin Recovery Implementation Program, the Range-wide Conservation Agreement for the Colorado River Cutthroat Trout, *Oncorhynchus clarkii pleuriticus*, and the Range-wide Conservation Agreement and Strategy for the "Three Species" (Roundtail Chub, *Gila robusta*, Bluehead Sucker, *Catostomus discobolus*, and Flannelmouth Sucker, *C. latipinnis*). The two recovery programs, which collectively work towards the recovery of Colorado Pikeminnow, *Ptychocheilus lucius*, Razorback Sucker, *Xyrauchen texanus,* Bonytail, *Gila elegans*, and Humpback Chub, *Gila cypha*, use the protection of in-stream flow, habitat restoration, nonnative fish control, propagation, life history monitoring, and information and education to bring benefits to the four "big river fishes." Both Humpback Chub and Razorback Sucker have been recommended for downlisting in the last year. Tasks to assist the species under Conservation Agreements included multiple remote sensing projects in tributaries throughout the basin; tamarisk control and watershed habitat restoration efforts are occurring; distribution and density monitoring throughout their ranges; and renovation of trout streams and reintroduction of the Colorado River cutthroat trout continue in Colorado, Utah, and Wyoming.

17:45 Desert Fishes Research and Management in Texas: Rio Grande, Pecos, and Devils Rivers

Megan Bean[1], Gary Garrett[2], Russell Martin[1] (1-Texas Parks and Wildlife Department, United States; 2-The University of Texas at Austin, United States)

Texas Parks and Wildlife has been working on education and outreach opportunities to

engage elementary age children, the general public, and a trial educational program in a state prison unit. Pecos Pupfish (*Cyprinodon pecosensis*) continues to be at risk of extirpation from Texas. Partners continue to work with the Fort Worth Zoo to maintain a refuge population and to work with landowners to set up new populations in isolated locations. Texas Parks and Wildlife and the University of Texas continue to lead collaborative planning and conservation efforts through the Native Fish Conservation Area workshops and planning meetings. This area report will also provide updates for research on Rio Grande Blue Sucker (*Cycleptus elongatus*), Rio Grande Shiner (*Notropis jemezanus*), Rio Grande watershed mussels, Balmorhea Springs complex fish, and habitat restoration projects.

17:45 The Aquatic eDNA Atlas and Applications for Desert Fish

Yvette Paroz (U.S. Forest Service Southwestern Region, United States)

The eDNA Atlas is an open-access database developed through crowd-sourced field surveys that provides precise spatial information on the occurrence locations of aquatic species in the U.S. The eDNA samples constituting the database are collected using a standardized field sampling protocol by numerous natural resource agencies and non-governmental organizations partnered with the National Genomics Center for Wildlife and Fish Conservation (NGC), which is a science collaborative within the Rocky Mountain Research Station of the U.S. Forest Service. The eDNA Atlas database contains results from thousands of sites and dozens of species and is annually updated with additional results for a growing list of species. Many markers are being developed for desert fish and other aquatic species. Initial results indicate that eDNA is a powerful tool for detection of cryptic species especially in lotic environments.

19:45-21:45 Student Networking Session (Chair: Heidi Blasius)

Friday, November 16th

08:30-12:00 Session 5: General Session II (Chair: Anthony Robinson)

08:30 Demographics of Riparian Lizards in the Chiricahua Mountains in Relation to Water Availability and Emerging Aquatic Insects as a Potential Food Source

Earyn McGee[1], Rezwana Islam[1], Noel Hamideh[1], Michael Bogan[2] (1-University of Arizona, United States; 2- University of Arizona, School of Natural Resources and the Environment, United States)

Severe drought is causing perennial streams to flow intermittently, presenting an unprecedented level of ecological disturbance. The loss of aquatic prey could negatively impact riparian and terrestrial species, including lizards. Because lizards play important roles in riparian food webs it is crucial to understand the cascading effects of stream drying on lizard communities. We hypothesized that perennial streams provide aquatic subsidies to lizards living in riparian areas. We predicted that lizard abundances would be greater, and that individuals within a species would grow larger and faster, along perennial streams. We quantified the abundance of lizards along three paired 100-meter perennial (wet) and ephemeral (dry) stream reaches with similar microhabitat but differing water

availability in the Chiricahua Mountains of southeastern Arizona. We also measured individual growth rate during a 4-week mark-recapture study of Yarrow's Spiny Lizard (*Sceloporus jarrovii*) and the Striped Plateau Lizard (*Sceloporus virgatus*). Aquatic insects were collected in high abundances, suggesting a potential food source for lizards along perennial streams. When considering mass at first capture, we found that *S. jarrovii* were larger at perennial versus ephemeral reaches (P = 0.0025) but the mass of *S. virgatus* did not differ among reaches (P = 0.53). Additionally, we failed to detect differences in lizard abundances between paired perennial and ephemeral reaches (P = 0.37 for *S. jarrovii*; P = 0.5 for *S. virgatus*). Low sample sizes prevented us from performing statistical analysis on the mark-recapture data. Future research should quantify trophic links between lizards and potential aquatic subsidies.

08:45 Should One Age a Warmwater Fish in a Coldwater System?

Pilar Wolters[1], Dave Rogowski[1] (1-Arizona Game and Fish Department, United States)

Accurate estimation of age and growth rates of fish provide vital information for fishery management. The construction of Glen Canyon Dam and subsequent release of cold hypolimnetic water from Lake Powell drastically lowered the water temperature of the Colorado River, negatively affecting the growth of warmwater native and nonnative fishes. In 2013, we began collecting Common Carp dorsal spines for aging and determining growth rates in fish captured from two locations 1) a seasonally warmed backwater upstream of Lees Ferry and 2) the mainstem Colorado River. Two biologists aged digital images of 212 Common Carp spine sections. No identifying information was included in the images. Exact agreement between the readers was poor, with only 8.1% and 27.3% agreement for Common Carp from the Lees Ferry backwater and mainstem Colorado River, respectively. Reader inconsistencies as well as recapture data from tagged fish suggests that aging warmwater fish species in a cold, relatively stable temperature regime is neither precise nor accurate. The results of our study could provide insight on the accuracy and practicality of aging warmwater native fishes of the Colorado River such as Flannelmouth Sucker, Bluehead Sucker and the endangered Razorback Sucker and Humpback Chub.

09:00 Severely Understudied Impacts of Fishes in North America's Arid Land Aquatic Ecosystems

Eric Moody[1], Ellen Albright[1], Katie Cope[1], Rachel Fleck[1], Haley Grigel[1], David Ortiz[1], Grace Wilkinson[1] (1-Iowa State University, United States)

Fishes serve as keystone species in many freshwater ecosystems by modifying habitat, altering nutrient cycling, and imposing top-down effects on food webs. As a result, the important role of threatened fishes in ecosystems is often cited as a reason why they should be protected. However, it is unclear to what extent the role of many threatened fishes in ecosystem dynamics is understood. We conducted a literature review of studies of the ecosystem impacts of fishes in North America to examine whether certain species and/or regions are understudied. We found that threatened species were frequently studied at higher latitudes, but that the ecosystem role of fishes was poorly studied regardless of imperilment at lower latitudes. Taxonomically, salmonids were exceptionally over-studied relative to the number of species in North America, while many families that predominate

in arid and semiarid regions were understudied (e.g., Cyprinidae, Poeciliidae, and Cichlidae) or completely unstudied (e.g., Cyprinodontidae, Goodeidae, and Atherinopsidae). We then developed an index describing the relative degree of imperilment and our understanding of the ecosystem role of the fish fauna for the freshwater ecoregions of North America. According to this index, most desert ecoregions and those of the central Mexican plateau are severely understudied despite their highly imperiled fish fauna. Future work on the ecosystem-scale importance of these threatened species will provide more concrete support for campaigns to protect them from extinction and improve management of these waterbodies.

09:15 A Comparison of Riffle and Beaver Pond-Dwelling Trout in Northeastern Utah

Susan Washko[1], Phaedra Budy[2], Brett Roper[3], Trisha Atwood[4] (1-School of Natural Resources and the Environment, University of Arizona, United States; 2-Department of Watershed Sciences, Utah State University, United States; 3-USDA Forest Service, National Stream and Aquatic Ecology Center, Logan, UT, United States; 4-Department of Watershed Sciences, Utah State University, United States)

Beavers are increasingly implemented as agents in stream restoration, though little work has shown how fish utilize beaver habitats. While beaver ponds provide many types of refugia to fish, foraging habits, habitat preference, and growth within beaver ponds remains unclear. Trout were expected to forage more within beaver ponds relative to riffles due to hypothesized greater availability of aquatic macroinvertebrates. We also hypothesized that an ample feeding source combined with a lower velocity habitat would result in higher growth for trout that use beaver ponds, and due to this we suspected trout would demonstrate a preference for beaver ponds over riffles. Through a variety of stream surveys and experiments in the Logan River watershed, we determined that there were no differences in growth, body condition, or diet between trout caught in beaver ponds and trout caught in riffles. Brown Trout were larger in beaver ponds, while Bonneville Cutthroat Trout were larger in riffles. Some trout did exhibit fidelity to beaver ponds, though riffles housed more trout per volume of stream. In this system, trout may be highly adapted to beaver-created habitats such that they can utilize both beaver ponds and riffles.

09:30 Implications of Using Treated Wastewater as Habitat for Desert Fishes

Drew Eppehimer[1], Kelsey Hollien[1], Zach Nemec[1], Hamdhani[1], Larissa Lee[1], David Quanrud[1], Michael Bogan[1] (1-University of Arizona, United States)

Discharge of treated wastewater and upgrades to water reclamation facilities have been instrumental in returning aquatic biodiversity and riparian habitat to the Santa Cruz River in southern Arizona. The endangered Gila Topminnow has recently recolonized effluent-dependent reaches of the river, but the long-term health effects of living in effluent and the potential for these fish to persist in effluent reaches are unknown. Using non-native Western Mosquitofish (*Gambusia affinis*) in the lower Santa Cruz River (Tucson, AZ) as a proxy for native topminnow, we explore the challenges of living in effluent-dominated streams, including (1) fluctuating water levels, (2) the potential for microplastics to impact diet, and (3) the effects of emerging contaminants on sexual maturation. Diurnal fluctuations in discharge of effluent create daily drying events in the lower reaches of the river, which can result in the stranding and death of fish. Furthermore, in drift samples we

have found microplastic concentrations as high as 5.56 particles/m3. However, in our diet analysis on a subset of 100 mosquitofish, we only documented one ingested plastic microfiber. Fish diets were otherwise comparable to natural systems and contained a variety of prey items with chironomid larvae, pupae, and adults dominating these taxa. Finally, our preliminary analysis has revealed a mosquitofish sex ratio heavily biased towards females (10.1:1), which is higher than ratios from published studies of natural systems (4.4:1). We hypothesize this pattern could be due to estrogen compounds, which can be common in effluent-dominated systems and can inhibit the sexual maturation of males. Faced with increasing human population growth and uncertainties of climate change, effluent systems will become increasingly important sources of aquatic habitat, but further studies are needed to assess their ability to support native fishes.

09:45 Endangered Species Recovery on a Landscape Scale - Leslie Canyon National Wildlife Refuge

William Radke (U.S. Fish & Wildlife Service, United States)

There are a multitude of innovative strategies available to land managers that can help facilitate landscape-level conservation and endangered species recovery in the face of expected changes in human population growth, increasing temperature, shifting rainfall patterns, and weather extremes. A good example involves Leslie Canyon National Wildlife Refuge in Cochise County, Arizona. Here, the U.S. Fish and Wildlife Service (Service) has worked effectively with others to expand protection, conservation, and species recovery activities beyond the 2,765-acre (1,119-ha) Refuge owned by the Service, extending those efforts onto an additional 20,471-acres (8,284-ha) of privately owned land. Strategies included a combination of: 1) originally delineating an adequate Refuge acquisition boundary to provide for conservation opportunities at a watershed scale; 2) monitoring and assessing the impacts of potential groundwater withdrawal within the watershed upstream from the Refuge; 3) acquiring, holding, and maintaining conservation easements on lands within that acquisition boundary; 4) formalizing a Safe Harbor Agreement with the neighboring landowners to help implement recovery activities for six federally-listed threatened and endangered species; and 5) seeking and providing funding opportunities that help enable landscape enhancement activities such as erosion control, grassland and wetland restoration, and fish and wildlife reintroductions. The success of these cost-effective efforts serves as a model by those who desire to collaborate in conserving similarly situated landscapes.

10:00 Trophic Ecology of Roundtail Chub, *Gila robusta*, Along a Gradient of Invasion

Jane Rogosch[1], Julian Olden[1] (1-University of Washington, United States)

Like many other species in the southwestern United States, Roundtail Chub, *Gila robusta*, is threatened by invasive species, water diversions and abstractions, and land-use change. Due to precipitous declines in range size and population number in recent decades, Roundtail Chub has been a candidate for listing under the Endangered Species Act (2009 USFWS: FWS–R2–ES–2009–0004; MO 92210530083– B2). Invasive species are likely the most significant threat to this species in the Bill Williams River basin, where the range of invasive species continues to expand while native species ranges contract. Using the gradient of invasive species prevalence as a natural experiment, our objective was to

determine how negative interactions with invasive fishes such as competition or predation affect the trophic status and quality of resource use for Roundtail Chub. We identified 12 sites in the upper Bill Williams watershed that support native only, invasive dominant, and mixed native and invasive fish assemblages (n = 4 sites per assemblage type). We collected fish fin tissues, macroinvertebrate primary consumers, and algal and detrital basal resources at each site. Carbon and Nitrogen stable isotope analysis of these tissues were used to establish isotopic trophic relationships along a gradient of invasion. We used Bayesian approaches to compare the three assemblage types and examine trophic overlap using niche metrics (R package SIBER) and to examine resource use and potential predation using isotope mixing models (R package mixSIAR). Trophic area, total food chain length (nitrogen range), and basal resource use (carbon range) did not differ among the three assemblage types: native, mixed, and invasive assemblages. However, our hypothesis that competition affected resource use of Roundtail Chub populations was supported by examining niche overlap and changes in resource use between Roundtail Chub and Green Sunfish, *Lepomis cyanellus*. When the two species co-occurred in mixed assemblages, Roundtail Chub and Green Sunfish had 59% niche overlap. Bayesian mixing models indicated both species shifted diets when they co-occurred. Roundtail Chub and Green Sunfish had an 18% and 13% shift, respectively, away from diets dominated by riffle invertebrates (e.g. Ephemeroptera). Furthermore, mixing models that included small Roundtail Chub (< 100 mm) as a potential resource for known predatory fishes in the community estimated that Roundtail Chub made up a quarter (0.25) of Black Bullhead, *Ameiurus melas,* diets (95% Credible Interval (CI): 0.01 – 0.60) and over a quarter (0.29) of Green Sunfish diets (95% CI: 0.05 – 0.65). Therefore, Green Sunfish could be significant intraguild predators on young-of-year Roundtail Chub. Indicators of competition and predation from stable isotope analysis along a gradient of invasion supports other research in the Colorado River Basin, namely that invasive fishes can reduce the fitness and long-term survival and persistence of native fishes, including Roundtail Chub. Invasive species removal efforts in the current range of Roundtail Chub or removal efforts before Roundtail Chub are reintroduced into former ranges should be prioritized in light of these findings.

10:15 Stream-Specific and Generalized Habitat Suitability Criteria for Four Native Desert Fishes

Zach Nemec[1], Scott Bonar[2] (1-Arizona Cooperative Fish and Wildlife Research Unit, University of Arizona, United States; 2-U.S. Geological Survey Arizona Cooperative Fish and Wildlife Research Unit, University of Arizona, United States)

Endemic fishes of the arid southwestern United States have rapidly declined due to anthropogenic stressors. Identifying the habitat conditions needed by these species is critical for their successful management. Habitat suitability criteria are commonly used to conserve species of interest. Therefore, developing habitat suitability criteria for native fish species across multiple rivers permits better understanding of how different environments are occupied under various circumstances. We developed stream-specific and generalized criteria for Longfin Dace, *Agosia chrysogaster*, Speckled Dace, *Rhinichthys osculus*, Desert Sucker, *Catostomus clarkii*, and Sonora Sucker, *Catostomus insignis* across four central Arizona streams. Over 1,200 sites were sampled using pre-positioned electrofishing devices during the 2017 summer low-flow period to identify

relationships among fish presence and habitat variables (depth, velocity, substrate class, capture temperature, and canopy cover). Optimal (central 50% of range used) and suitable (central 95% of range used) ranges within each habitat variable were calculated for each stream, based on the occurrence of each species. In general, Longfin Dace occupied depths of 9.00 – 54.75 cm (14.25 – 27.25 cm) velocities of 0.00 – 0.63 m/sec (0.11 – 0.31 m/sec), and substrate (modified Wentworth scale) of 0.5 – 4.3 (2.1 – 3.3). Speckled Dace occupied depths of 8.25 – 74.00 cm (17.00 – 34.25 cm) velocities of 0.00 – 0.74 m/sec (0.16 – 0.43 m/sec), and substrate of 0.0 – 4.5 (2.2 – 3.6). Desert Sucker occupied depths of 9.00 – 45.00 cm (15.25 – 25.00 cm) velocities of 0.09 – 0.72 m/sec (0.21 – 0.44 m/sec), and substrate of 1.0 – 4.6 (2.5 – 3.7). Sonora Sucker occupied depths of 9.20 – 61.40 cm (17.80 – 37.70 cm) velocities of 0.06 – 0.68 m/sec (0.15 – 0.28 m/sec), and substrate of 0.5 – 5.0 (2.4 – 3.2). Most of the generalized habitat suitability criteria for all four species did not transfer into study streams. Agencies should develop stream-specific habitat suitability criteria when managing species of interest for a certain stream.

10:30 How Old Is the Devils Hole Pupfish and Why Should We Care?

Christopher Martin (The University of North Carolina at Chapel Hill, United States)

The Devils Hole Pupfish (DHP) is a conservation icon; however, one outstanding question about this species remains unresolved: how long has it persisted in its hellish environment? Here I discuss recent estimates of the age of this species, gene flow out of Devils Hole since colonization, and future directions. We previously used RADseq data to infer the history of pupfishes in Death Valley. Instead of relicts isolated for millions of years, we found evidence for frequent gene flow among Death Valley and Amargosa National Wildlife Refuge pupfish populations and divergence coinciding with the last glacial maximum 15 kya. We estimated that Devils Hole was colonized by pupfish approximately 1 kya, followed by genetic assimilation of pelvic fin loss, and recent gene flow into neighboring spring systems. We also estimated that some pupfishes in Death Valley exhibit the lowest genetic diversity of any wild population and may display the highest mutation rates of any vertebrate, as suggested by the extreme environmental conditions and life history characteristics of DHP. These results provide a new perspective on an iconic endangered species using population genomic methods and support the idea that repeated cycles of gene flow and renewal are needed to sustain a network of small pupfish populations in the desert.

10:45 Observations on the Ecology, Distribution, and Status of the Inyo Mountains Salamander

Christopher Norment (Department of Environmental Science and Ecology, College at Brockport, SUNY, United States)

The Inyo Mountains Salamander, *Batrachoseps campi* (IMS), is one of only two salamanders in the world whose range is restricted to desert ecosystems. The IMS has been documented from 21 localities in the Inyo Mountains of California; all but one of these are in riparian habitat. In 2017 and 2018 I conducted intensive fieldwork on the species, to gather information for a status review by the U. S. Fish and Wildlife Service, which will determine if listing of the species under the federal Endangered Species Act is warranted. I visited 17 of the 21 documented IMS localities, and gathered data on its

abundance, distribution, and basic ecology, and evaluated possible threats to the species, including the chytrid fungus, *Batrachochytrium dendrobatidis*. My observations suggest that although the IMS population as a whole appears reasonably healthy and currently is chytrid-free, severe flash floods occurring after 2000 have negatively impacted at least five local populations. Ongoing climate change in the Southwest could exacerbate the frequency and/or severity of future flash floods, and damage or destroy additional IMS habitat.

11:00 Restoring the Terrestrial Connections of Devils Hole

Kerry A Gold[1], Ambre L Chaudoin[2], Jeffrey A Goldstein[2], Kevin P Wilson[2], Josh Hoines[2] (1-The Great Basin Institute, United States; 2-National Park Service, United States)

Devils Hole and its unique pupfish, *Cyprinodon diabolis*, have been historically managed in a species specific approach. Recently, more holistic, ecosystem based approaches have been used for conservation and recovery efforts for this critically endangered species. Investigations into energy flow and food web structure in Devils Hole found that carbon was limiting in winter. Stable isotope analyses indicated a year-round, fundamental source of carbon for the pupfish diet comes from allochthonous (outside sourced) plant and animal material (Wilson & Blinn, 2007, Western North American Naturalist 67(2):185-198). As late as 1950, the surrounding landscape of Devils Hole was bladed, removing the above ground and subterranean biomass encircling Devils Hole (USDOI General Land Office Report, Bureau of Land Management, 1950). Terrestrial restoration/revegetation of Devils Hole began May 2017 to increase the potential allochthonous carbon input into Devils Hole and reverse desertification. To assess the new vegetation's effectiveness in delivering organic matter to the system, a perennial shrub abscission (litter) study was devised. Monthly collections of the highest occurring shrubs have shown an average output of .03568 g/m²/day of organic matter. *Atriplex confertifolia* (Shadscale) has shown the highest average output with .00991 g/m²/day and *Larrea tridentata* (Creosote) has shown the lowest average output with .00047 g/m²/day. Data will be compared to allochthonous funnel traps that are deployed biannually over the water surface of Devils Hole.

11:15 Go with the Flow: Flow Regime and Fish Populations in Four Arizona Streams

Larissa Lee[1], Scott Bonar[2] (1-University of Arizona, School of Natural Resources and the Environment, United States; 2-U.S. Geological Survey Arizona Cooperative Fish and Wildlife Research Unit, University of Arizona, United States)

The extremities of desert flow regimes create unique environments for fish species throughout Arizona. This work aims to explore the relationship between the distributions of various fish species throughout time and space in four Arizona streams. We used flow statistics generated from USGS gage stations as well as USGS StreamStats estimates of flows in precise non-gaged locations to examine relationships between these flow statistics and the relative abundance of fish species in four Arizona streams. Data on fish distributions comes from an intensive summer field season (2017) as well as a 20-year dataset from collaboration with the Arizona Game and Fish Department. This research can

provide critical information to managers on how flow dynamics interact with different fish species in arid-land rivers.

11:30 Cryptic but Reel: Using Social Psychology Principles in Educational Videos to Acquaint the Public with Cryptic Fishes

Taylor Ulrich[1], Scott Bonar[2] (1-University of Arizona, United States; 2-U.S. Geological Survey Arizona Cooperative Fish and Wildlife Research Unit, University of Arizona, United States)

Desert fishes are cryptic, and infrequently seen by the public. Apathy of the public toward these fishes and their ecosystems hinders their conservation. Fortunately, advanced technological means to acquaint the public with these species is becoming increasingly common. High-definition underwater and aerial footage are now possible with affordable and user-friendly technology. We are creating low-cost, educational videography presentations featuring the unique and often rare desert fishes of Nevada and Death Valley. In these videos, we are testing the inclusion of various widely recognized social psychology principles to maximize presentation effectiveness. Low cost technology, especially when combined with the use of easy to include psychological principles, may provide spectacular visual results and could potentially serve as an effective tool to acquaint the public with rare desert fishes. After multiple rounds of testing, viewers' knowledge significantly improved after viewing such videos, $p < 0.001$. Here, we will present results from this research of testing the relationship between the inclusion of social psychology principles and their impact on viewers' learning outcomes and endorsement of a "pro-ecological" world view.

11:45 Differences in Aquatic Invertebrate Diversity and Community Composition in Perennial Systems of the Rio Sonoyta Basin, Arizona and Sonora

Kelsey Hollien[1], Michael Bogan[1] (1-University of Arizona, School of Natural Resources and the Environment, United States)

Quitobaquito spring and pond and the nearby Rio Sonoyta are some of the only perennial water bodies in the western Sonoran Desert, and support populations of endangered Sonoyta Mud Turtle and Pupfish. Quitobaquito is fed by a near constant flow from springs, while the Rio Sonoyta holds only a few perennial pools with intermittent flow after significant rainfall. We have started a comprehensive and comparative inventory of aquatic invertebrates in Quitobaquito and the Rio Sonoyta to understand how local food webs and, as a result, populations of mud turtles and pupfish, fluctuate through time. Since April 2017, we have had four seasonal sampling events at Quitobaquito and the Rio Sonoyta: April, June, October, and January. Each sampling event targeted the dominant microhabitat types present, including the headspring, pond, and spring channel riffles, runs, and pools at Quitobaquito and river pools and intermittent riffles at the Rio Sonoyta. Although Quitobaquito and the Rio Sonoyta are geographically adjacent, species richness and community composition differed between the locations. Quitobaquito was more taxonomically rich, with 124 species, whereas Rio Sonoyta only had 75 species. Species richness changed seasonally in the Rio Sonoyta, reaching its highest level during flowing periods in spring and lowest levels in the driest part of summer. In contrast, there appeared to be no predictable seasonal changes in species richness at Quitobaquito. Invertebrate

communities in the Rio Sonoyta tended to be fairly distinct from those at Quitobaquito. However, pond samples at Quitobaquito more closely resembled the community of Rio Sonoyta pools than those of the other microhabitat types at Quitobaquito. Understanding variability in invertebrate prey communities could help us better predict the needs of the imperiled species that depend on these perennial systems. Next steps in our research include stable isotope analyses to link potential prey items to pupfish and turtle populations.

12:00-13:30 Lunch (on your own)

13:30-17:00 Session 6: General Session III (Chair: David Rogowski)

13:30 Forgotten Secrets of Invasive Fish Eradication

David Ward (US Geological Survey, United States)

Prior to the widespread use of rotenone as a tool for eradication of invasive fishes, extensive research was conducted on other chemical methods for removal of aquatic nuisance species. Most of this 1950's to 1960's research was quickly forgotten by biologists and managers as rotenone became the tool of choice for use in fish renovation projects. I evaluated two of these forgotten methods (pH manipulation using soda ash and oxygen depletion using sodium sulfite) for their effectiveness at eradicating invasive Green Sunfish, *Lepomis cyanellus*. Effective dosages for both chemicals were quantified in the laboratory followed by field trials conducted in two small research ponds. Soda ash was dispensed at 0.95 g/L to rapidly increase pH to >10.5. This sudden change in pH was effective at removing all Green Sunfish from two small ponds with pH returning to baseline conditions within 4 days. Sodium sulfite dispensed at 0.8 g/L rapidly decreased dissolved oxygen to < 1 mg/L causing fish to gulp at the surface and allowing them to be captured with a hand net. These tools may have advantages over other fish removal methods in that water quality conditions quickly return to baseline conditions (<48 hours for sodium sulfite and <96 hours for soda ash) with no harmful residues or other negative environmental impacts. Additional tools for control of invasive aquatic species are sorely needed and although these particular tools may only be effective in small isolated bodies of water, the addition of any new tool for invasive fish management is helpful in the ongoing battle to prevent extinctions of southwestern native fishes.

13:45 Drought Cues Induce Dispersal in an Aquatic Beetle, *Haliplus punctatus* (Coleoptera: Haliplidae)

Natalie Constancio[1], Sophie Dunkelberger[1], Lauren Musial[1], Gaby Ortiz[1], Elizabeth von Ruden[1], Kate Boersma[1] (1-University of San Diego, United States)

Desert-dwelling aquatic invertebrates possess a wide array of behavioral adaptations that allow them to survive harsh and highly variable environmental conditions. Dispersal and burial are two opposing behaviors that have been observed during droughts, but it is unclear which of the many drought-associated environmental cues trigger these behaviors. We investigated this question in a little-studied species of crawling water beetle, *Haliplus punctatus*. These small beetles inhabit arid-land aquatic habitats with hydroperiods ranging from permanent ponds to temporary streams. They are able to bury and disperse

between sites, making them ideal model organisms for examining behavioral responses to extreme environmental conditions. We conducted a fully factorial experiment in which we recorded burial and dispersal behaviors in *H. punctatus* in response to three levels of three drought-associated environmental variables: temperature (8, 16, and 24°C), conductivity (111, 705, and 2868µS/cm), and evaporation (to 0.5, 1.5, and 2.5cm water depth), for a total of 27 treatments with 10 beetles in each treatment. We observed that neither conductivity nor evaporation affected beetle behavior. Temperature affected both burial and dispersal, although in opposite directions. Beetles were more likely to disperse at high temperature, and bury at low temperature. These observations suggest that beetles have multiple, opposing behavioral strategies that can both be triggered by changes in temperature. Given predictions of more extreme summer temperatures across the North American deserts, our results suggest that we may expect to see more dispersal of crawling water beetles in the future.

14:00 Biogeochemical Analyses of Airborne Deposition of Lead (Pb) Contamination in Aravaipa Creek, Arizona

Betsy Grube[1], Peter Reinthal[2], Jessica Gwinn[3], Elizabeth Arnold[4] (1-SNRE - University of Arizona, United States; 2-EEB - University Arizona, United States; 3-USFW, Phoenix Office, United States; 4-Plant Sciences, University of Arizona, United States)

The fish community of Aravaipa Creek, Arizona, with seven native species, is considered the foremost remnant assemblage of the imperiled Gila River basin fauna. In 2009, the Klondyke mine tailings were capped with a two-foot clean soil cover and installation of erosion protection on the upstream pile. Previous studies of lead isotopic ratios (208Pb, 207Pb, and 206Pb) of sediments, water and biota in pre-remediation and post-remediation of a mine tailing EPA Superfund site found remediation was effective in curtailing the inputs of contaminants into Aravaipa Creek from sediment and water. However, there was not an observed shift in the biota isotopic signatures of the lead sources. In this study we examine lead contamination in livers and muscles of native fish species, *Catostomus insignis*, *Pantosteus clarki* and *Gila robusta*, pre- and post-remediation with lead levels in livers much lower post-remediation. Muscle tissue was found to have lower levels of lead contamination than livers. However, given there is not a shift in fish lead isotope ratios suggests an alternative source of lead, such as airborne dust, impacting the creek. We assessed spatial patterns of airborne deposition in epilithic lichens in Upper Aravaipa Creek versus Lower Aravaipa Creek to determine spatial differences in airborne lead deposition. Mean lead found in lichens from Upper Aravaipa Creek (19.6 +/- 7.4 ppm dry), near mine tailings, was significantly greater than mean lead values from lower Aravaipa Creek (14.2 +/- 4.8 ppm dry). These data support the hypothesis that lead is entering the biotic food chain via airborne deposition via dust in Upper Aravaipa Creek that is near mine tailings but not in lower Aravaipa Creek, 15 miles downstream where mine tailings are not present.

14:15 Effect of Diurnal Flow Variability on Water Quality Dynamics in the Effluent-Dependent Santa Cruz River

Hamdhani[1], Drew Eppehimer[1], David Quanrud[1], Michael Bogan[1] (1-University of Arizona, United States)

The Santa Cruz River in Arizona is one of several river systems in Southwestern USA that have experienced loss of perennial flow due to groundwater pumping and drought. Along with the Gila and Salt Rivers, the Santa Cruz currently has perennial reaches that are supported by effluent discharge from wastewater reclamation facilities. The return of perennial reaches has brought back habitat for numerous aquatic and riparian taxa. Reliable flow rates are one of the crucial components that support healthy aquatic habitat. However, in the lower Santa Cruz, flow during a given 24-hour period fluctuates by more than a factor of two, dependent on timing of water use by Tucson-area residents, creating high and low flow "tides" each day. The effect of this daily flow variation on water quality conditions in this effluent-driven system is unknown. The objective of this study is to quantify physical and chemical water quality factors in the Santa Cruz River (1) temporally--during high and low flow periods and (2) spatially--along the river downstream from the effluent outfalls. Since September 2017 we have collected water quality data (DO, pH, conductivity, nutrient levels) monthly from six locations of the Santa Cruz River spaced ~2 miles apart during both high and low flow periods. Ammonia, which is potentially toxic to aquatic biota, was significantly higher during low flow than high flow conditions on average across the year. River water quality tended to improve with increasing distance from effluent outfalls. The findings of this study suggest we should sample effluent-driven systems during low flow periods in order to identify worst case water quality conditions. We hope that these results will also help us understand how effluent can be better used to restore perennial river habitats in arid climates, including habitat for native desert fishes.

14:30 Chichencanab, a Catastrophic Ecosystem?
Chichencanab, un Ecosistema Catastrófico?
Arcadio Valdes Gonzalez[1], Maria Elena Angeles Villeda[1] (1-Fac. de C. Biologicas UANL, Mexico)

The word "Chichenkanaab" in Yucatec Maya means "little sea" "short water" or more precisely "cut waters" as explained by local people. It consists of a very large body of water about 30 km long that is split into 8 sections in dry season. At about 30 m above sea level, it is a relatively new lacustrine ecosystem, with origins about 8,200 years BP with rapid filling related to sea level rise of the last glaciation. It experienced an extreme dry episode AD 800-1000 (Hodell, et al. 1995). It is the largest closed-basin lake in the Yucatan peninsula, with its main water body of 452 ha and 2600 to 3500 ha flooded in the rainy season. With salinity about 4 ppt and pH of 8 due to very high Calcium Carbonate and Calcium Sulfate in the form of tar and gypsum. Oxygen ranges from 3.6 to 9 ppm and conductivity is 4400 to 5500 mS/cm. Mean annual temperature is 25.4°C, and surface water ranges from 26-33°C. Yearly rainfall is 1,300 mm, usually with the rainy season May to September and dry season October to April. Native fishes are 7 *Cyprinodon* (*C. beltrani*, *C verecundus*, *C. maya*, *C. labiosus*, *C. simus*, *C. suavium*, and *C. esconditus*) and possibly two more undescribed, *Gambusia sexradiata*, plus introduced *Astyanax aeneus* and *Oreochromis mossambicus*. It is thus one of the most variable, but dependable, aquatic ecosystems, and its habitat fragmentation combined with rich benthic, planktonic, and detritic food resources were conducive to speciation. The same factors also make this habitat very difficult to analyze. It almost impossible to thoroughly sample, since most

areas are out of reach and the areas where fish can be sampled represent perhaps 3% of the total area. Despite the opinions of previous researchers, after four visits under different weather conditions, the abundance and distribution of the species of this lake's species flock are considered to be stable.

Hodell, D.A., J. H. Curtis & M. Brenner. (1995). Possible role of climate in collapse of classic Maya civilization. Nature Vol. 375 1 June 1995. pp 391-394.

La palabra "Chichenkanaab" en maya yucateco significa "mar pequeño" "agua corta" o más bien "aguas cortadas" según lo explicado por la población local, que consiste en un gran cuerpo de agua de unos 30 km de largo quedando dividido en 8 secciones en la estación seca. Aproximadamente a 30 metros sobre el nivel del mar es un ecosistema lacustre relativamente nuevo. Con sus orígenes en aproximadamente 8,200 años BP, desde el momento del rápido llenado de la depresión y relacionado con el aumento del nivel del mar de la última glaciación. Existiendo un episodio extremadamente seco para el año 800-1000 AC (Hodell, et al., 1995). También se considera este lago como la cuenca cerrada más grande de la península de Yucatán con 452 hectáreas en su masa de agua principal con 2600 y más de 3500 hectáreas de área inundable en época de lluvias. Con una salinidad de aproximadamente 4 ppt y un pH de ocho debido al muy alto contenido de sulfato de calcio y carbonato de calcio en forma de sarro y yeso. El oxígeno varía de 3.6 a 9 ppm, conductividad entre 4400 a 5500 mS / cm. La temperatura media anual es de 25.4 ° C y la temperatura del agua superficial varía entre 26 y 33 ° C. Lluvia anual de 1.300 mm con la temporada de lluvias de mayo a septiembre, y una estación seca de octubre a abril generalmente. Con siete especies de *Cyprinodon* coexistentes (*C. beltrani*, *C. verecunus*, *C. maya*, *C. labiosus*, *C. simus*, *C. suavium*, *C. esconditus*) y posiblemente otras dos formas no descritas, además de la coexistencia de *Gambusia sexradiata*, y se introdujeron *Astianax aeneus* y *Oreochromis mossambicus*. Haciendo de este uno de los ecosistemas acuáticos más variables, pero confiables que ha conducido a la especiación debido a su abundancia de presas bentónica, planctónica, detritus y alevines como recursos dietéticos y partición del ecosistema, el cual es muy difícil de analizar debido a su tamaño y complejidad, por lo que es casi imposible hacer un muestreo representativo ya que la mayoría está fuera de alcance, y las áreas para recolectar peces no representan ni siquiera un 3% de la misma. Después de cuatro visitas en diferentes condiciones climáticas, la abundancia y distribución de las especies de esta parvada se consideran estables en contraste a las opiniones de otros investigadores.

Hodell, D.A., J. H. Curtis & M. Brenner. (1995). Possible role of climate in collapse of classic Maya civilization. Nature Vol. 375 1 June 1995. pp 391-394.

14:45 Intraspecific Response of Sonora Suckers to Consecutive Wildfire Disturbances

Crosby Hedden[1], Skyler Hedden[1], Keith Gido[1], James Whitney[1] (1-Kansas State University, United States)

With the increasing size, frequency and intensity of wildfires across the American Southwest, assessment of wildfire effects on native fish populations is needed to better identify critical steps in recovery following these disturbances. Two large, contiguous

wildfires in consecutive years (2011 and 2012) burned >100 km^2 in the upper Gila River basin, New Mexico. Our objective was to quantify how occupancy and growth of juvenile and adult Sonora Suckers, *Catostomus insignis*, were influenced by these large fires to help develop a timetable of recovery for this species. Fish populations were sampled in June and October at five sites throughout the basin before fires (June 2008-June 2011), during the influence of fires (October 2011-June 2013), and post fires (October 2013-October 2015) to assess the response of juvenile and adult Sonora Suckers. Growth rates were measured for age-0 fish using length frequency analysis between June and October sampling events while growth for larger juveniles (>100mm) was based on recaptures of PIT tagged fish. Juvenile frequency of occurrence was high (>0.8) throughout the basin during all years in June but varied in October samples where occurrences before the fires were high (1.0), declined during years immediately following wildfire (0.4) and recovered in post fire years (0.73). Frequency of occurrence for adult fish was high (>0.6) during all years in October but varied in June samples where occurrences before and during the years of wildfire occurrence remained relatively high (>0.8) but were absent (0.0) in years following wildfires. Average body size of age-0 fish in June was smaller at upstream sites (mean = 31.2 and 36.7 mm) compared to the most downstream site (mean = 51.6 mm) (p-value=0.003 and 0.011), but juvenile body sizes did not differ among sites in October samples (p-value=0.885). Growth for adult fish differed among years with the highest growth occurring immediately following fires, lowest during pre-fire years, and highly variable growth post-fire years. Understanding the differing responses of multiple age-classes to disturbance events can aid managers to develop better management and conservation strategies.

15:00 Comparative Morphometrics Analysis Among Refuge and Wild Populations of Sonoyta Pupfish *Cyprinodon eremus* Miller & Fuiman, 1987 (Teleostei: Cyprinodontidae)

Análisis Morfométrico Comparativo de Poblaciones de Refugio y Silvestres del Pez Cachorrito del Sonoyta *Cyprinodon eremus* Miller y Fuiman, 1987 (Teleostei: Cyprinodontidae)

Alexsandre Gutiérrez-Barragán[1], Carlos Alonso Ballesteros-Córdova[2], Gorgonio Ruiz-Campos[3], José Manuel Grijalva-Chon[2], Alejandro Varela-Romero[2] (1-Universidad de Sonora, Licenciatura en Biología, Mexico; 2-Universidad de Sonora, DICTUS, Mexico; 3-Universidad Autónoma de Baja California, Facultad de Ciencias, Mexico)

The Sonoyta Pupfish, *Cyprinodon eremu*s Miller & Fuiman, 1987, is an Endangered freshwater fish. It is distributed in the Northwest of Mexico and Southwest of the USA in the Sonoyta River basin and in Quitobaquito Springs. Its wild populations are threatened by anthropogenic factors, so in 1986, a refuge population was successfully established in an artificial pond in the Centro Ecologico de Sonora to be used for future management and conservation of native populations. However, it is possible that individuals modified their morphology in response to changes in environmental conditions, which could be accompanied by genetic changes due to isolation. The objective of this work was to characterize and compare the morphology of Sonoyta Pupfish individuals from the refuge population with that of individuals from the wild populations. We used traditional morphometrics with measurements following the Box Truss protocol, and Discriminant

Function Analysis. Both males and females of the refuge population differed from the wild population in some characters, including having wider heads, decreased body width and depth, and lower caudal region depth. These changes could be related to the lentic environment and reproduction events. We recommend evaluating the genetic diversity and including this information in the design of management plans for the conservation of the species.

El pez cachorrito del Sonoyta *Cyprinodon eremus* Miller y Fuiman, 1987, es un pez en Peligro de Extinción. Se distribuye en el Noroeste de México y Suroeste de EUA en la cuenca del Río Sonoyta y en el manantial de Quitobaquito. Sus poblaciones se encuentran amenazadas por factores antropogénicos, por lo que en 1986 se creó exitosamente una población de refugio en un estanque en el Centro Ecológico de Sonora con fines de manejo futuro y conservación de sus poblaciones nativas. Sin embargo, es posible que los individuos modificaron su morfología como respuesta al cambio en las condiciones ambientales, lo que pudo estar acompañado de cambios genéticos como consecuencia del aislamiento reproductivo. El objetivo de este trabajo fue caracterizar y comparar la morfología de los individuos del pez cachorrito del Sonoyta de la población de refugio y de las poblaciones silvestres del Río Sonoyta. Se utilizó morfometría tradicional mediante el diseño de medidas siguiendo el protocolo de Box Truss y se analizaron los caracteres a partir de un análisis de función discriminante. Se encontró que la población de refugio presenta un morfotipo diferente a las poblaciones silvestres, tanto en machos como en hembras, con variaciones en algunos caracteres, como cabeza más ancha, cuerpo menos ancho y profundo y región caudal de menor profundidad. Estos cambios pueden estar relacionados al ambiente léntico en que se encuentran y a eventos de reproducción. Se recomienda evaluar la diversidad genética e incluir esta información en el diseño de planes de manejo para la conservación de la especie.

15:15 Effects of Body Size on Vulnerability to Predation in Juvenile Roundtail Chub Stocked in the Upper Verde River, Arizona

Laura Tennant[1], David Ward[1], Alice Gibb[2] (1-U.S. Geological Survey, Grand Canyon Monitoring and Research Center, Southwest Biological Science Center, United States; 2-Northern Arizona University, Department of Biological Sciences, United States)

In the upper Verde River in Arizona, Roundtail Chub, *Gila robusta*, populations have declined, while non-native fish populations, such as Smallmouth Bass, *Micropterus dolomieu*, have increased. As one effort toward population recovery, Roundtail Chub are cultured in hatcheries and then released into the upper Verde River. However, predators may target recently-released fish, thereby reducing the effectiveness of stocking programs. We used laboratory and field experiments to examine the influence of non-native Smallmouth Bass on the survival of Roundtail Chub. First, we conducted laboratory trials to determine if Smallmouth Bass gape size influenced consumption of Roundtail Chub of various sizes. Trials were initially conducted with 12 prey fish and four predators; a second set of trials was conducted using two prey fish and one predator. In these trials, Smallmouth Bass consumed chub that were as large as 64% of gape, with a mean of 39.6% gape. In a field experiment where 2,177 pit-tagged Roundtail Chub were released into the Verde River (December 2016), we used electrofishing-surveys 48 hours after release to evaluate predation on stocked fish. In this experiment, we captured and

measured the gape of Smallmouth Bass that consumed Roundtail Chub. Prior to stocking, the body depths of Roundtail were measured. Through these two measurements of predator and prey, we were able to quantify the relationship between predator gape and prey body depth when stocked Roundtail Chub were consumed by Smallmouth Bass in the field. From the field experiment, we infer Smallmouth Bass consumed prey that did not exceed 71.0% of gape, with a mean of 52.4% gape. A logistic regression model determines that, when prey body-depth exceeds 75% of predator gape, the probability of survival exceeds 95%. Based on these findings, we suggest that the size of both hatchery-reared fish and existing predators at stocking locations should be considered before native fish are released into the wild to reduce predator-related mortality.

15:30 Comparison of Aging Structures and Life History Aspects of an Historical Population of the Roundtail Chub, *Gila robusta* (Cyprinidae), in the Yampa River Canyon, Colorado

Stephen Ross[1], Tim Modde[2], Derek Ross[3] (1-Division of Fishes, Museum of Southwestern Biology, United States; 2-USFWS (retired), United States; 3-Auburn University, United States)

The *Gila robusta* complex includes three large, morphologically variable cyprinid species native to the Colorado River drainage. All three members of this complex, *G. cypha* , *G. elegans*, and *G. robusta*, historically occurred in the Yampa River Canyon of Colorado and Utah. Both *G. elegans* and *G. cypha* are federally listed as endangered, and *G. robusta* (Roundtail Chub) is considered either imperiled or vulnerable to extinction by all state management agencies in the Colorado River basin. In July of 1998, 1999, 2001, and 2002, we opportunistically collected Roundtail Chubs on USFWS nonnative fish removal trips on the Yampa River in Dinosaur National Park. Roundtail Chubs were still abundant at this time. Our objectives were to determine the efficacy of scales, opercular bones, and otoliths as aging structures and to describe age, growth, ages at first reproduction, and tuberculation patterns relative to reproductive stages. Based on all four years of data, we obtained interpretable annuli for 111 fish using otoliths, 91 fish using opercles, and 111 fish using scales. Scale annuli generally agreed with otolith annuli up to approximately eight years, after which scale annuli consistently underestimated opercular annuli. Opercular annuli closely agreed with otolith annuli up to 15 years before underestimating otolith annuli. Based on otoliths, the oldest fish was aged at 22+, with 7 fish exceeding 15 years. Using a linearized catch-curve, Roundtail Chub had an instantaneous mortality rate of - 0.158, corresponding to 85% survivorship. Both sexes have similar ages at first reproduction, with females showing early maturing gonadal stages at five years, and late maturing or mature gonadal stages from 8-20 years. Our July sampling likely preceded actual spawning dates given that we did not collect females with later developmental stages of ovaries (e.g., MR or RE) stages. Males showed testicular development beginning at 6 years, with mature or running ripe testes from 6 to 22 years. Both sexes develop tubercles, with the intensity and extent of tubercles on the body related to gonadal stages. The greatest tubercle development occurred in males with maturing or running ripe testes, and in females with maturing ovaries.

15:45 A New Las Vegas Home for the Pahrump Poolfish, *Empetrichthys latos*

Aaron Ambos[1], Raymond Saumure[1], Thomas O'Toole[2] , Zane Marshall[1] (1-Southern

Nevada Water Authority, United States; 2-Las Vegas Springs Preserve, United States)

In May 2018, two-hundred and fifty adult Pahrump Poolfish, *Empetrichthys latos*, were released into two constructed ponds at the Las Vegas Springs Preserve in Las Vegas, Nevada. This introduction marks the first time in over fifty years that a Nevada endemic fish swims at the site of the historic Las Vegas springs. Once a lush oasis within an arid Mojave Desert landscape, the Las Vegas spring complex ceased flowing prior to 1962 due to increasing groundwater usage. Endemic to the spring complex, the Las Vegas Dace, *Rhinichthys deaconi*, disappeared from the system around 1957, but was not officially declared extinct until after its formal description by Miller in 1984. In the following decades, the site existed solely as a well field, providing water for the growing Las Vegas community. In 1997, however, the Las Vegas Valley Water District Board of Directors approved a plan to develop a 180-acre preserve to protect and manage the natural, cultural, and water resources of the site. The Springs Preserve opened in June 2007, and by 2010 plans were made to restore some surface water habitat within the original creek channels. The federally endangered Pahrump Poolfish was identified as a possible candidate to inhabit these ponds as it is a Nevada native species, tolerant of a broad range of water conditions, and in need of an additional refuge population. Permits for the Pahrump Poolfish were obtained in 2017 and included a Nevada Department of Wildlife Scientific Collection Permit, a U.S. Fish and Wildlife Enhancement of Survival permit, and a U.S. Fish and Wildlife Safe Harbor Agreement. The initial two ponds were completed in early 2018 and Pahrump Poolfish from an existing refuge population were introduced on May 29. By June 18, dozens of ~5-mm long larval Poolfish were observed in the shallows, and by August multiple age-classes were observed throughout the ponds. Pahrump Poolfish may eventually be introduced to an additional eight ponds on the Springs Preserve property.

16:00 **Does Increasing Food-Web Stability Mediate the Effects of Cattle Grazing in Aquatic Desert Ecosystems?**

Hannah Moore[1], Howard Whiteman[1] (1-Murray State University, United States)

Anthropogenic activities have led to habitat degradation in streams throughout much of Western North America. In particular, cattle grazing has caused a loss of riparian vegetation resulting in higher water temperatures and an increase in nutrient runoff. The effects of habitat degradation on food quality and quantity for aquatic consumers could have large implications for stream communities. Since omnivores feed at multiple trophic levels, they increase community complexity and may be resilient to altered food webs. Theoretically, this would allow them to stabilize communities in degraded habitats where resources have been reduced. To test the hypothesis that omnivores positively impact community stability in degraded habitats, I established artificial mesocosms using 1000L cattle tanks with varying levels of two disturbance factors: shade (loss of shade mimicking a degraded riparian zone) and nutrients (increased nutrients representing agricultural fertilizer inputs), and the presence or absence of the omnivorous Speckled Dace (*Rhinichthys osculus*). I compared the rate of change of community structure and ecosystem function by analyzing invertebrate biodiversity and biomass, algal biomass, and water chemistry in order to determine if dace play a stabilizing role in degraded streams.

By understanding the role omnivory plays in degraded aquatic systems, we can gain insight into both the management and restoration of these ubiquitous habitats.

16:15 **Developing YY Males to Control Nuisance Fish Populations in the Southwest**
Chad Teal[1], Scott Bonar[1], Dan Schill[2] (1-University of Arizona, United States; 2-Fisheries Management Solutions, Inc., United States)

Competition and predation from nonnative fishes have had a substantial impact on native fish species in the Southwestern United States. Nonnative fish introductions have been implicated in nearly 50% of endangered species listings, second only to habitat loss. The Red Shiner (*Cyprinella lutrensis*) has been shown to compete with native cyprinids and other small bodied species. Green Sunfish (*Lepomis cyanellus*) are generalists that compete with more desirable game species and prey upon native fishes. Traditional removal efforts are usually not species specific and these efforts are rarely 100% effective. Trojan sex chromosome eradication strategies have been modeled and show the collapse of target species' populations. Efforts have begun at the University of Arizona to examine the feasibility of producing Trojan sex chromosome carrier (YY male or supermale) red shiner and green sunfish. To date, breeding and larval rearing techniques have been developed at the University of Arizona Propagation Lab. Sex reversal methods and genetic marker development have also begun. The development of trojan sex chromosome carriers (YY males) for common nuisance fish species could be useful for fisheries management.

16:30 **Ecological Traits of Non-Native *Fundulus grandis* in the Pecos River: Implications for Impacts on Native Species**
Kelbi Delaune-Trotter[1], Allison Pease[1] (1-Texas Tech University, United States)

Non-native inland populations of Gulf Killifish, *Fundulus grandis*, potentially threaten native fishes in the Lower Pecos River. Recent studies of *F. grandis* in the Pecos have shown them to be highly piscivorous compared to coastal populations, consuming native species such as the imperiled Pecos Pupfish. Otherwise, little is known about the ecology of this species in inland systems and the potential effects on native fishes. In this study we examined reproductive characteristics, size, and age of *F. grandis* in the Pecos River, Texas. Fish were collected from the Pecos River near Iraan, Texas twice per month in the spring, summer, and fall. Preliminary results indicate that reproduction takes place approximately between March through August, with gonadosomatic index (GSI) of females peaking in March. This suggests that the Pecos population may have a different spawning period than that described for native *F. grandis* in Texas coastal habitats. However, timing of peak GSI measurements is similar to that of coastal populations. Fish collected from the Pecos ranged in size between 25.7- 143.3 (mm) total length (TL) for males and 32.3 - 148.8 (mm) TL for females. Size structure of the Pecos River population suggests that there is a higher proportion of larger individuals in the invaded system. The relatively large size and piscivorous nature of *F. grandis* along with the degradation of the mainstem of the Pecos River, are attributes hypothesized to promote replacement of native species by non-native invaders. Thus, this study provides a foundation for understanding the potential impacts of *F. grandis* in this invaded, inland system.

16:45 **Bonytail, the Arizona Tuna? Convergence in Muscle and Tendon Anatomy in Scombrids and *Gila cypha***

Daniel Kimball[1], Owen Kyle[1], Michael Minicozzi[1], Alice Gibb[1] (1-Northern Arizona University, United States)

Bonytail (*Gila elegans*) is an Arizona native endangered species that has an unusual locomotor morphology with a shallow peduncle and crescent shaped tail. This morphology appears to have evolved as an adaptation to high flow, riverine environments and may reduce drag and increase swimming efficiency. We describe the anatomical features associated with the bones and soft tissues of the caudal peduncle region. We compared the morphology of two closely related native species, Roundtail (*Gila robusta*) and Humpback Chub (*Gila cypha*), to that of the Bonytail. We cleared and stained ten individuals from each species to measure the neural and hemal vertebral spine angles (angle the spine creates with the vertebral centra) and normalized spine lengths (spine length/standard length of fish) of the twelve vertebrae proximal to the tail. Bonytail have more acute spine angles in the caudal peduncle region when compared to Humpback and Roundtail. In the soft tissues (muscle and tendon) of the caudal peduncle, we found evidence for two (paired) lateral tendons originating at the anterior axial musculature and inserting along the hypural plates of the tail in Bonytail, which appear to be absent in the other Gila species. The volume of muscle in the peduncle region of Bonytail appears to be reduced when compared to Humpback and Roundtail. Reduced musculature and novel tendons are also seen in scombrid (tunas) fishes, where their long lateral tendons transmit force from the anterior musculature to the tail. For Bonytail, this morphology may be beneficial during historic seasonal flooding events, where a more effective swimming behavior allows them to maintain position in the current with relatively low energy expenditure.

17:15-18:15 Business Meeting (Chair: Krissy Wilson)

19:15-21:15 Banquet (Location: The Date Grove)

Saturday, November 17th

08:30-12:00 Session 7: General Session IV (Chair: Pilar Wolters)

08:30 The Conservation Landscape: Finding Success at the Intersection of Ecological, Social, and Institutional Dimensions

Rollie White[1], Jason Dunham[2], Chris Allen[3], Bruce Marcot[4], Dan Shively[4] (1-U.S. Fish and Wildlife Service, Region One, United States; 2-U.S. Geological Survey, United States; 3-U.S. Fish and Wildlife Service, Oregon Fish & Wildlife Office, United States; 4-U.S. Forest Service, United States)

The recent book Reintroduction of Fish and Wildlife Populations (Jachowski et al. 2016), included a chapter titled The Reintroduction Landscape: Finding Success at the Intersection of Ecological, Social and Institutional Dimensions. The authors of the chapter, representing the U.S. Geological Survey, U.S. Forest Service, and the U.S. Fish and Wildlife Service, coin a new phrase - the reintroduction landscape - that encompasses the integration of human and ecological factors. The chapter authors submit that it is these factors, expressed as ecological, social and institutional dimensions, and the interactions

among them, that determine the relative success of species reintroductions. We will examine the various factors within the ecological, social and institutional dimensions and demonstrate the importance of meeting these factors to achieve an appropriate reintroduction landscape. We also note that such considerations can be useful beyond species reintroductions, and apply broadly to important conservation and species recovery actions as a whole.

08:45 Long-Term Patterns of Fish Community Structure in Lake Mohave, Arizona-Nevada

Aaron Burgad[1], Brian Kesner[1], Paul Marsh[1] (1-Marsh & Associates, United States)

The Colorado River has undergone significant anthropogenic modifications, consequently native fish communities are severely imperiled. We examined temporal patterns in fish community structure over 37 years in Lake Mohave using bi-annual trammel net surveys (spring and autumn) that were initiated by W. L. Minckley in 1974. Specifically, we examined 1) historical changes in fish community structure to determine stability and persistence and 2) long-term abundance trends. Non-native fishes were established prior to surveys, precluding the ability to determine a "normal bounds" of historical fish community structure. The two remaining native fishes, Razorback Sucker, *Xyrauchen texanus* and Bonytail, *Gila elegans*, declined precipitously in abundance through time. However, a repatriation program initiated in 1991 prevented Razorback Sucker from extirpation, while reintroduction efforts for Bonytail have failed; wild populations of both species are gone. Total catch per unit effort (CPUE) averaged across seasons (range = 1.77 to 39.57) and species richness ($\overline{x}$ = 8.08, SD = 1.38) showed a negative relationship with time. Long-term abundance trends indicated three non-native taxa (i.e., Gizzard Shad, *Dorosoma cepedianum*, Yellow Bullhead, *Ameiurus natalis*, and Smallmouth Bass, *Micropterus dolomieu*) increased, eight decreased, and six showed no relationship. Fish community composition shifted directionally through time in multivariate space, with the formation of four significant clusters indicating alternative states and low stability. The native fish community vanished shortly after the introduction of a suite of non-native taxa and razorback sucker persists in Lake Mohave only because of continued stocking. The contemporary population of razorback sucker is stable albeit less abundant than historically, thus continued adaptive management will be required to preserve the most genetically diverse population in the Colorado River system.

09:00 Limiting Factors and Recovery of Woundfin in the Virgin River

Melinda Bennion[1], Richard Fridell[1] (1-Utah Division of Wildlife Resources, United States)

Woundfin, *Plagopterus argentissimus*, has been federally listed as an endangered species since 1970. Successful reproduction and recruitment of Woundfin is limited to a 16.3 mile reach in the upper Virgin River in Utah. Currently, only a small portion of Woundfin live to be greater than 1-year old in the wild; the persistence of Woundfin is dependent on the survival and reproductive success of these young fish. Woundfin abundance and distribution has been limited by multiple factors including non-native fish, drought, altered streamflow regimes, diversions, elevated water temperature, decreased turbidity, water management events, and a decline of spawning and rearing habitat.

Since 2000, the Utah Division of Wildlife Resources has worked through the collaborative Virgin River Program to identify and evaluate these factors limiting Woundfin persistence and recruitment. This presentation will highlight the creative ways we have addressed these factors and enhanced Woundfin populations and habitat recovery in the Virgin River.

09:15 An Evaluation of Three Artificial Structures to Reduce Predation on Hatchery-Reared Bonytail and Razorback Suckers

Kristopher Stahr (Arizona Game and Fish Department, United States)

Bonytail, *Gila elegans*, and Razorback Sucker, *Xyrauchen texanus*, are two endangered fishes endemic to the Colorado River Basin. Population declines of both species are attributed to the introduction of non-native fish species and alteration to flow. Each year hatchery-reared Bonytail and Razorback Sucker are reintroduced back into the wild. However post-stocking survival is often poor as offspring are naïve to predation. Artificial structures have been discussed as a potential strategy to improve post-stocking survival but have yet to be evaluated. Therefore the objective of this study was to evaluate three different artificial structures to improve survival of hatchery-reared Bonytail and Razorback Sucker when exposed to predation. Three different structures (artificial macrophytes, large diameter vertical PVC, and small diameter horizontal PVC) and a control treatment (void of any structure) were used in the experiment. A repeated measures design experiment was conducted using Largemouth Bass, *Micropterus salmoides*, as a model predator and naïve hatchery-reared Bonytail and Razorback Suckers were used as prey. Experiments were conducted within one meter diameter circular tanks for one hour periods. Small diameter horizontal PVC and artificial macrophytes resulted in significantly higher survival for Bonytail compared to both the control treatment and large diameter vertical PVC. There was no significant difference in survival for Razorback Suckers between all treatments. Therefore it appears that artificial structure may play a larger role in post-stocking survival for Bonytail than Razorback Sucker, but future research is needed to confirm these results at a larger scale.

09:30 Quantifying the Predatory Threat of a Nonnative Fish on Native Fishes in the San Juan River

Skyler Hedden[1], Keith Gido[1], Bobby Duran[2], Scott Durst[2], Nathan Franssen[2], Eliza Gilbert[2], Crosby Hedden[1], Brian Hines[3], Mark McKinstry[4], Casey Pennock[1] (1-Kansas State University, United States; 2-USFWS, United States; 3-UDWR, United States; 4-BOR, United States)

Nonnative fishes, such as Channel Catfish, *Ictalurus punctatus*, potentially have negative impacts on native fishes, but their effects on native communities can be difficult to quantify. Specifically, predation on native fishes will likely vary spatially and temporally based upon prey availability and abiotic conditions, thus quantifying a predator's ability to diminish native fishes needs to incorporate multiple spatial and temporal scales. To quantify the predatory threat of Channel Catfish on native fishes, stomach fullness, stomach evacuation rates, and diets were quantified throughout the San Juan River, NM, CO, and UT over both fine (24 hour) and broad (seasonally) temporal scales. Stomach fullness varied both spatially and seasonally but contrary to our expectations, no diel

differences in fullness were observed. Stomach evacuation rates, measured in a laboratory setting, increased with water temperatures and fish prey items took 7-75 hours to digest to 50% of their initial wet weight. Lastly, diets were composed of both aquatic (~60%) and terrestrial (~40%) materials, of which fish remains were in a relatively low frequency (0-0.25) of stomachs and native fishes represented 52% of the total fish prey consumed by Channel Catfish. Identifying nonnative predator impacts on native species across multiple scales may help develop management strategies to minimize negative interactions between native and nonnative fishes.

09:45 Spatial and Temporal Variation of Aquatic Macroinvertebrates in the Upper Gila River, New Mexico and Response to Drought, Wildfire and Monsoonal Flooding
Keith Gido[1], Webster Jordan[1], Sky Hedden[1], James Whitney[2] , David Propst[3] (1-Kansas State University, United States; 2-Pittsburgh State University, United States; 3-University of New Mexico, United States)

Characterizing spatial and temporal variation in communities can provide insight into main factors driving community structure. Samples across space can capture variation attributed to environmental gradients, such as stream size, and samples across time can capture responses to variation in hydrologic conditions, including extreme events such as flooding and drought. Because disturbance is often unpredictable by nature, capturing the effects of a natural disturbance can be quite difficult, unless a study is already in progress. Two wildfires and an extreme monsoon occurred mid-way through a 2008-2016 study on the spatial and temporal variation in aquatic communities in the Gila River of New Mexico, providing an opportunity to witness how these events might structure macroinvertebrate communities. Aquatic macroinvertebrate community structure varied spatially along an elevational gradient with high elevation sites distinguished with higher abundance of two caddisfly families Polycentropodidae and Philopotamidae and low elevation sites characterized by higher abundance of the dragonfly family Libellulidae. Overall insect diversity decreased following the wildfires, although a few families, such as Chironomidae, were unaffected or increased in total biomass. Variable discharge over the 8-year study also had an effect, with Empididae, Nemouridae, and Taeniopterygidae becoming more abundant in flood years relative to other macroinvertebrate taxa. Responses of macroinvertebrate taxa was concordant with general patterns of habitat use; some riffle dwelling species performed well in wet years and some pool dwelling species performed well in dry years. Collectively, these patterns of variation might be used to predict benthic macroinvertebrate community response to spatial and temporal variation in environmental conditions.

10:00 Oregon / Northern California Area Report, November 2018
Alan Mauer[1], Brian Sidlauskas[2], Marci Schreder[3], Paul Divine[4], Justin Miles[5] (1-US Fish and Wildlife Service, Bend Field Office, United States; 2-Oregon State University, United States; 3-Lake County Umbrella Watershed Council, United States; 4-California Dept. of Fish and Wildlife, United States; 5-Oregon Dept. of Fish and Wildlife, United States)

The northwestern extreme of the desert region includes several endorheic or terminal lake basins in Oregon, northeastern California, and northwestern Nevada (Fort Rock, Chewaucan, Goose, Warner, Catlow, Alvord, Malheur, Coyote lakes, and Quinn River).

This region supports remnant fish faunas that once inhabited extensive pluvial Pleistocene lakes.

Oregon State University is re-evaluating the taxonomy of the Torrent Sculpin (*Cottus rhotheus*) in Oregon, Washington, Idaho and Montana. Results suggest that there are two or three species subsumed under the one current name separated along molecular, morphological and geographic lines. The lab is testing whether the very similar *Cottus gulosus* and *Cottus perplexus* are actually distinct species in Oregon, and working on a review paper that will highlight and summarize taxonomic needs for the fishes of Oregon.

Lake County Umbrella Watershed Council (LCUWC) has designed and planned three conservation projects benefitting Warner Sucker and Redband Trout in the Warner basin, and three fish passage projects in the Goose Lake Basin that will benefit nine native Goose lake fishes. Several partner organizations and agencies have formed a "Warner Basin Aquatic Habitat Partnership" with the council to develop fish passage solutions for Warner Suckers, Redband Trout, and other aquatic life. The Western Native Trout Initiative has developed a portfolio of projects, including Warner basin projects, to use in advocating conservation to potential supporters.

California Department of Fish and Wildlife (CDFW) completed projects in Pine Creek and Eagle Lake of northeast California for the conservation and management of Eagle Lake Rainbow Trout (ELRT), a native rainbow trout subspecies. Currently, CDFW is reestablishing natural production and assessing genetic integrity, while supplementing with hatchery reared rainbow trout. CDFW also collected genetic samples for genetic analysis and inbreeding within ELRT and evaluation of the level of genetic distinctiveness of extant populations. CDFW used video to document upstream spawning migrations in Pine Creek. CDFW assessed Brook Trout distribution in Pine Creek to plan Brook Trout removal.

Oregon Department of Fish and Wildlife (ODFW) provided updated information on Redband Trout surveys conducted in the Warner and Abert lakes basins. ODFW also facilitated the capture and transfer of several Foskett Speckled Dace to the High Desert Museum for an educational display. These fish are in addition to eleven Warner Suckers that ODFW provided to the museum in 2016.

BLM conducted a habitat enhancement project at Foskett Spring. Management actions and a commitment to conservation were conducive to the US Fish and Wildlife Service's decision to propose delisting the Foskett Speckled Dace from the ESA list. The public comment period for the proposed delisting has concluded and a final decision will be published December to early January. ODFW conducted population estimate of Borax Lake Chub in 2016 and 2017 and observed a rather large population change (low of 1,200 fish in 2016 to 78,000 fish in 2017). The US Fish and Wildlife Service is also proposing to delist the Borax Lake Chub, from the ESA list. The proposal will publish with an open public comment period mid-October.

10:15 Factors Influencing Successful Mechanical Removal of Green Sunfish

Brian Hickerson[1], Anthony Robinson[1], David Partridge[1], Matthew Rinker[1] (1-Arizona

Game and Fish Department, United States)

Green Sunfish *Lepomis cyanellus* are exceptional invaders and have become widespread throughout watersheds of the Southwest, largely due to their ability to tolerate the extreme physical and biological conditions characteristic of desert aquatic systems. Green Sunfish are frequently linked to declining native fish populations as a result of competitive and predatory interactions. Consequently, managers of desert fishes have put substantial resources into mechanical removal efforts intended to eradicate nonnative Green Sunfish, with varying degrees of success. We sought to evaluate factors that contributed to the success of mechanical removal of Green Sunfish across eradication efforts in Arizona. We compared six Green Sunfish removal efforts in Arizona that occurred between 2012 and 2018. We considered a number of factors that likely influence success of removal efforts including whether removal reaches were isolated from invasion, watershed size, removal reach length, and initial relative abundance. We used logistic regression to evaluate which factors contributed to removal success. We found that successful removals were characterized by low initial relative abundance and isolation from an invasion source. By identifying factors contributing to successful outcomes for removal efforts, we can focus our limited resources for nonnative fish control on systems where mechanical removals are likely to be successful.

10:30 Potential for a Multi-Species Refuge: Investigating Competition Between Historically Co-Occurring Cyprinids

Christi Kruse[1], Jon Shurin[2], Jeff Holmquist[3], Natalie Jones[4], Steve Parmenter[5], Nick Buckmaster[5] (1-California Department of Fish and Wildlife, Bishop Office and Oregon State University, United States; 2-University of California San Diego, United States; 3-University of California, Los Angeles, United States; 4-UC San Diego and the University of Queensland, Australia, Australia; 5-California Department of Fish and Wildlife, Bishop Office, United States)

In the Owens Valley, native fish conservation is limited by suitable habitat; open waters are invaded by non-native species and refuge habitats are scarce. We investigated the potential for success of a multi-species native fish refuge using a mesocosm experiment to assess interactions between Owens Speckled Dace, *Rhinichthys osculus* ssp., and two size classes of hybridized Owens Tui Chub, *Siphateles bicolor snyderi* X *S. obesa,* (a surrogate for the listed subspecies). We tested the effects of interspecific interactions (e.g. competition and predation) on body condition, growth, and survivorship using five different combinations of species and sizes with a control treatment, each replicated 8 times. Mesocosms were inoculated with benthic substrate and invertebrates from the proposed refuge habitat. Two hypotheses were evaluated, (1) that the large size class of chub would prey upon dace, and (2) that interspecific competition between smaller size classes of fish would negatively affect body condition for both species. We did not find support for our first hypothesis, of predation by chub on dace, however, Dace body condition was negatively affected by competition with small chub which partially supported our second hypothesis. Growth and body condition of large and small chubs were not affected by the presence of dace. Our results suggest that competition with small chub is more important than predation by large chub for dace growth and survival. Restoring sympatric populations of the two species may be possible if the habitat

complexity allows for the rapid growth of chubs or if habitat complexity reduces the potential for interactions.

10:45 A Resurvey of Springsnails in and near Ash Meadows National Wildlife Refuge 31 Years Later

Geoff Moret[1]; Erin Orozco[1], Michael Schwemm[2] (1-United States Geological Survey, United States; 2-United States Fish and Wildlife Service, United States)

In 1985 and 1986, Robert Hershler and Don Sada conducted a comprehensive survey for springsnails on and near the newly-established Ash Meadows National Wildlife Refuge. They documented the distribution of 11 species of springsnails, including nine newly-described species, and included field water quality data and a brief description of the habitat at each spring. In the previously surveyed 47 springs, one spring was dry (Mexican Spring), and springsnails occurred in 36. The relatively widespread *Pyrgulopsis micrococcus* was the only springsnail found in 9 springs. One or more of the remaining ten species (*Tryonia variegata, Tryonia angulata, Tryonia ericae, Tryonia elata, Pyrgulopsis erythropoma, Pyrgulopsis crystalis, Pyrgulopsis nanus, Pyrgulopsis isolatus, Pyrgulopsis fairbanksensis,* and *Pyrgulopsis pisteri*) were found in 27 springs. Here, we present a 2017 resurvey of 26 springs with endemic springsnails previously visited by Hershler and Sada (the 27th spring is Devils Hole, which has regular surveys of all invertebrates). Our methods include the enumeration of individuals by genus (*Tryonia* or *Pyrgulopsis*), basic field water quality measurements, habitat description and the observation of potential environmental stressors. Samples were also collected for future genetic analysis. Seven of the 26 resurveyed springs were dry. Two species (*T. elata* and *P. isolatus*) were not found in the springs where previously reported as endemic. In addition, *Tryonia* occurred in only one of the two springs where *T. ericae* was found in the original survey, and only a single individual *Pyrgulopsis* was found is the spring where *P. crystalis* previously occurred. Our results show that springsnail presence is generally robust geographically over approximately 30 years, however, the distribution of some species can change significantly over that time, even within a protected area. More surveys and species-level identification are needed to verify non-detections reported in the 2017 survey.

11:00 Do "Designer Flows" for Native Fish Also Protect Aquatic Insects and Riparian Plants?

David Lytle[1], Jonathan Tonkin[1], Julian Olden[2], David Merritt[3], Lindsay Reynolds[3], Jane Rogosch[4] (1-Oregon State University, United States; 2-University of Washington, United States; 3-Forest Service, United States; 4-University of Washington, United States)

Designer flow optimization for dammed rivers is a powerful approach for balancing ecological objectives and competing societal demands for water. How designer flows, which use flow events to target select species of interest, affect non-target ecosystem components has been largely overlooked. Using empirically-parameterized population models based on the Verde River, Arizona ecosystem, we found tradeoffs associated with designer flow regimes targeting riparian vegetation, fishes, and invertebrates. The different event frequencies associated with each designer flow regime resulted in some nontarget ecosystem components becoming functionally extinct in as little as 50 years. By incorporating multiple flow frequencies, the natural flow regime enabled a balanced

response of the three components. Although returning to a natural flow regime may no longer be viable in highly managed rivers, designing river flows to support entire ecosystems must begin from natural flow regime principles.

11:15 A Post-Stocking Survival and Movement Analysis of Razorback Sucker and Bonytail in the Lower Colorado River

Taylor Haas[1], Brian Kesner[1], Paul Marsh[1] (1-Marsh & Associates, United States)

Bonytail *Gila elegans* and Razorback Sucker *Xyrauchen texanus* are both listed as endangered by the United State Fish and Wildlife Service. A stocking initiative by the Bureau of Reclamation, Lower Colorado River Multi-Species Conservation Program has maintained these native species in parts of their historic range, including below Palo Verde Dam in the area around Blythe, CA. Since 2007, 21,749 Razorback Sucker and 18,475 Bonytail have been stocked in the area with passive integrated transponder (PIT) tags implanted in them. The focus of stockings has been 5 primary "backwaters". These backwater habitats are connected to the main river channel, allowing stocked fish to disperse into the main channel of the Colorado River. Since 2016, 38 subadults of each species and 20 adult Razorback Sucker were surgically implanted with acoustic telemetry tags so manual and passive tracking of movement could take place. Biologists from Marsh & Associates have monitored the movements of the stocked fish via PIT tag scanners, Submersible Ultrasonic Receiver, and an acoustic hydrophone and receiver. Collection efforts from this year resulted in contacting 1,234 unique Razorback Sucker (5.6%) and 535 Bonytail (2.8%). 103 Razorback Sucker contacted this year were stocked prior to this year, whereas there were no Bonytail contacted that were released prior to this year. PIT scanning effort in the main stem was increased this past year which resulted in 9 Razorback Sucker and 6 Bonytail contacts. Mean days at large was 156.5 for Razorback Sucker and 27.8 for Bonytail.

11:30 Assessment of Razorback Sucker Monitoring in the Lower Colorado River Basin

Brian Kesner[1], Aaron Burgad[1], Paul Marsh[1] (1-Marsh & Associates, United States)

Stocking of hatchery-raised fish or repatriation has been the primary means of maintaining populations of the endangered Razorback Sucker *Xyrauchen texanus* throughout its historic range. In the lower Colorado River basin, populations in the thousands have been established and maintained in Lake Havasu and Lake Mohave by stocking over a half million subadult to adult Razorback Sucker over the last three decades. Since 2006 all Razorback Sucker released in these reservoirs are injected with a 134.2 kHz passive integrated transponder (PIT) tag. These fish are monitored using traditional capture methods (e.g. annual netting activities) and remote sensing via deployment of remote PIT tag scanning units. Remote PIT tag scanning has resulted in orders of magnitude more contact data than traditional methods. To date, 19,713 Razorback Sucker have been contacted via remote PIT scanning in the lower Colorado River basin. These data have been used to refine estimates of population size and post-stocking and adult survival using mark-recapture models. However, there has been little formal assessment of how these estimates correlate to results from traditional capture methods. A discrete time population model was developed to compare estimates of post-stocking and adult survival and frequency distributions of annual Razorback Sucker stockings in Lake Havasu and Lake

Mohave with single-census estimates of abundance. We also extend the population model to include tag loss and compared ratios of tagged to untagged fish calculated from netting events to determine if natural recruitment at low levels was likely occurring without detection. The results were then compared to model results for Lake Mead, the third reservoir in the lower Colorado River basin which has no formal stocking program and limited natural recruitment.

11:45 Age, Growth, and Age at Maturity of Bonefish (*Albula* Species) Among Cuban Habitats

Jacob Rennert[1], Jon Shenker[2], Aaron Adams[3], Jorge Angulo-Valdez[4] (1-Marsh & Associates, United States; 2-Florida Institute of Technology, United States; 3-Bonefish and Tarpon Trust, United States; 4-Eckerd College, United States)

Bonefish (*Albula* spp.) are a prized sportfish among avid anglers worldwide. Two morphologically indistinguishable species of bonefish (*Albula vulpes* and *Albula goreensis*) occur in coastal areas of the tropical western Atlantic. Growth rates of *A. vulpes*, which supports an economically important sport fishery, differ among locations where they have been studied, but many locations have not yet been examined. To investigate bonefish growth in Cuba, specimens were obtained from 3 regions around the periphery of the island from November 2016 to January 2017. Sagittal otoliths (for aging) and fin clips (for genetics) were collected from each fish, and sex was determined by examining gonads. A total of 222 bonefish were collected for this study. Comparisons of distribution patterns, von Bertalanffy growth curves and age at maturity of different species in different regions will be presented. The insight of different growth patterns between *A. vulpes* and *A. goreensis* allows for better management of the species, and further distinguishes differences in the biology of *A. vulpes* and *A. goreensis*.

12:00-13:30 Lunch (on your own)

13:30-17:00 Session 8: General Session V (Chair: Julie Carter)

13:30 Distribution of Fishes and Fish Assemblages in the Northern Owens Valley

Nicholas Buckmaster[1], Rosa Cox[1], Leah Botelho[1], Christi Kruse[2], Steve Parmenter[1] (1-California Department of Fish and Wildlife, United States; 2-Oregon State University, United States)

Here we report the results of over 100 kilometers of electrofishing stream surveys to assess the distributions of Owens Valley fishes, including Owens Sucker (*Catostomus fumeiventris*), and Owens Speckled Dace (*Rhinichthys osculus* ssp.). Surveys were conducted in valley-bottom streams and ditches from Round Valley (north of Bishop, CA) to Tinnemaha Reservoir (south of Big Pine, CA). Hierarchical clustering was used to identify five species assemblages comprised of native+nonnative, and wholly nonnative, fish communities. Fish assemblages were compared with water quality, geomorphic, and land-use data to better understand species distribution within the watershed. Comparing the historic site record with the current distribution survey, we conclude the two native species remain widespread. However, Owens Speckled Dace appear to have undergone a substantial range contraction, whereas Owens Sucker distribution has remained stable. The

persistence of Owens Suckers is likely due to the presence of large adults which exceed the gape-limit of sympatric, co-occurring brown trout.

13:45 Comparisons of the Age Structure of Several Populations of Bonneville Bluehead Sucker
Chance Broderius (Utah Division of Wildlife Resources, United States)

Bluehead Sucker occurring in the Bonneville Basin and Snake River Basin have been determined to be genetically distinct from those occurring in the Colorado River drainage. As such, the few disjunct populations that occur across parts of Utah, Idaho, Nevada, and Wyoming have become increasingly necessary to protect. This study aged Bonneville Bluehead Sucker from fin ray samples taken in five disjunct sections of the Weber River (Weber, Davis, Morgan, and Summit counties UT) as well as Snake River Bluehead Sucker from the Raft River (Box Elder County, UT). Age structure information from this study will allow managers to make better informed decisions related to the effects of missing age classes, max age, growth, and reproductive maturity which differs within each population due to differing habitat characteristics.

14:00 Challenges in Desert Pupfish Management in Salt Creek and San Felipe Creek, Riverside and Imperial Counties of California
Sharon Keeney (California Department of Fish and Wildlife, United States)

Salt Creek and San Felipe Creek are two drainages that constitute much of the existing habitat for Desert Pupfish (*Cyprinodon macularius*) outside of their occurrence in agricultural irrigation systems and refuges. Salt Creek is a natural drainage supplemented by mitigation water. San Felipe Creek is an entirely natural drainage that includes the only designated Critical Habitat for the species. Management challenges have been changing during the past five years in these watersheds, and this talk discusses these changes and CDFW's responses to them. As the Salton Sea ecosystem increases in salinity, the Sea will soon become unsuitable for the species, thereby isolating the two watersheds that will be discussed.

14:15 Post-Stocking Fate of Razorback Sucker in Topock Marsh, AZ
Chase Ehlo (U.S. Fish and Wildlife Service, United States)

Razorback Sucker *Xyrauchen texanus* is an endangered species endemic to the Colorado River Basin. In the lower Colorado River, recruitment in the wild is nonexistent and adult survival is low due to habitat alterations and negative interactions with nonnative species. Topock Marsh is a large (1618 hectares) backwater adjacent to the Colorado River. Preliminary Remote PIT scanning in 2016 determined that 551 Razorback Sucker of the original 3244 stocked in 2010 still persist in the Marsh. Due to this persistence, a telemetry study was implemented in the Winter of 2016. A total of 20 wild fish captured in Topock Marsh and 20 hatchery fish were implanted with acoustic telemetry tags and tracked for one year post release to determine survival and utilization of the Marsh. A combination of active tracking with directional and omnidirectional hydrophones and passive tracking with Submersible Ultrasonic Receivers (SUR) determined that a total of 2 hatchery fish and 8 wild fish survived to the end of the study. Kaplan-Meier survival estimates (95% CI) were 0.62 (0.38-0.82) and 0.51 (0.29-0.73) for hatchery fish and wild fish respectively.

Although survival was not significantly different between hatchery and wild fish, several of the hatchery fish were lost to the study therefore inflating their survival estimates. The SUR network determined that fish utilized the whole Marsh during the winter months, and in the summer months concentrated where cool fresh water is delivered into the Marsh from the Colorado River. Given the relatively high survival of fish in Topock Marsh, particularly the 2010 stocking cohort, it has the potential to be an important recovery habitat. Using the information that was learned from the telemetry study, the population in Topock Marsh will continue to be monitored and information will be used to aid in the recovery of Razorback Sucker.

14:30 Use of the Lower Dolores River by Endangered Fishes, 2013-2017

Dave Speas[1], Peter MacKinnon[2], Jim White[3], Dan Keller[4], Zane Olsen[4] (1-U.S. Bureau of Reclamation, United States; 2-Utah State University, United States; 3-Colorado Parks and Wildlife, United States; 4-Utah Division of Wildlife Resources, United States)

The Dolores River (southwestern Colorado, southeastern Utah) is an important source of water for agricultural, municipal/industrial, recreational and ecological interests both within and beyond its watershed. It supports an assemblage of endangered, non-listed native and non-native fish species which varies in composition along its longitudinal gradient. Hydrology of the Dolores River is heavily regulated by McPhee Dam although inputs from the San Miguel River provide a relatively dynamic hydrograph in the Dolores River near and downstream of the Colorado/Utah state line. In 2013, a passive interrogation array was installed in the Dolores River about 13 km above its confluence with the Colorado River to monitor use of the tributary by PIT-tagged non-listed native and endangered fishes. As of October 2017, the facility has detected 1,013 individual PIT-tagged fish consisting of 658 Bonytail *Gila elegans*, 134 Bluehead Sucker *Catostomus discobolus*, 74 Flannelmouth Sucker *Catostomus latipinnis*, 30 Razorback Sucker *Xyrauchen texanus*, 26 Colorado Pikeminnow *Ptychocheilus lucius*, 16 Roundtail Chub *Gila robusta* and 8 Flannelmouth/Razorback sucker hybrids. An additional 67 unidentified fish were also detected. Colorado Pikeminnow were detected in the Dolores River primarily during the months of June through September, whereas Razorback Sucker tended to appear in the river during the months of March through May. Except for anecdotal observations, detections of Colorado Pikeminnow during 2015-2017 represent the first substantiated evidence of this species occurring in the Dolores River since 1991. Colorado Pikeminnow and Razorback Sucker capture histories prior to recent detections are complex and geographically extensive. Bonytail detections appeared to be most frequent immediately following stocking events in the Dolores River, however there were a few examples of individual fish detected in the tributary up to three years after stocking. Flow targets intended to maintain and enhance geomorphology of the Dolores River channel went into effect in 2012, but response of the fish community to these flows is very difficult to discern based on available information.

14:45 Response of Macroinvertebrate Communities to High Flows in the Owens River Gorge

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This study compares macroinvertebrate communities before and after a sustained high flow event in the Owens River Gorge (ORG). Since the construction of the Long Valley dam in the 1940s, the ORG has experienced dramatically reduced flows, averaging about 0 cfs from 1953 to 1991, and less than 40 cfs annually from 1991 to 2018. From July 2018 to September 2018 the lower six miles of river experienced a moderately high flow of 400 cfs. Replicated samples were collected during spring and summer of 2018 using a Surber sampler at six locations (two above the reach subject to high flows and four within the reach). We detected a significant decline in invertebrate abundance ($p<0.05$) and species richness between the pre- and post- high-flow invertebrate communities within the lower reach, with varying levels of decline among common taxa. While we observed an initial decline in invertebrate communities immediately following the pulse flow, we believe scouring effects will likely provide increased interstitial habitat for future invertebrate populations. Monitoring the invertebrate communities in ORG will continue throughout the next few years. Ultimately, we hope to see managed high flows imitate a more natural flow regime than the ORG has seen in the past few decades. Monitoring invertebrate and fish communities' response throughout this process will be crucial for informing the success of varying flow regimes.

15:00 A Multi-Disciplinary Approach to Protecting Instream Flows and Endemic Species in the Devils River, Texas

Sarah Robertson (Texas Parks and Wildlife Department, United States)

The Devils River is a groundwater-dominated, semi-arid river in southwest Texas and is considered one of the most pristine rivers in the state. It is one of the last strongholds for multiple species of regionally endemic freshwater fauna including the federally-listed Devils River Minnow and Texas Hornshell. However, the potential for large-scale groundwater pumping in the watershed and prolonged droughts pose threats to groundwater availability and the springflows that sustain river baseflows. Development of a comprehensive basin-wide fish and mussel conservation plan including instream flow recommendations is ideal due to the relatively small size of the watershed. However, challenges include the isolated location of the river and the low proportion of publicly held lands for implementing on-the-ground conservation measures. To best determine science needs, focus resources, and increase informed stewardship of the river, Texas Parks and Wildlife Department has partnered with governmental agencies, universities, non-profit organizations, and landowners interested in preserving this unique resource. Through collaborative research aimed at a better understanding of groundwater-surface water interactions and instream flow needs of endemic species, and by building cooperative partnerships, steps are underway to preserve the aesthetic, ecological, and recreational values of the Devils River.

15:15 Captive Propagation of the Devils Hole Pupfish at the Ash Meadows Fish Conservation Facility

Olin G. Feuerbacher[1], Jennifer M. Gumm[1], Corey W. Lee[1], Michael R. Schwemm[1], Mitchell R. Stanton[2], Kevin P. Wilson[3], Jeffry A. Goldstein[3], Ambre L. Chaudoin[3], Brandon L. Senger[4], Javier Linares-Casenave[1], John G. Wullschleger[5], Jon C. Sjoberg[4] (1-US Fish and Wildlife Service, United States; 2-Great Basin Institute, United States; 3-

Death Valley National Park, United States; 4-Nevada Department of Wildlife, United States; 5-Water Resources Division, National Park Service, United States)

The endangered Devils Hole Pupfish, *Cyprinodon diabolis*, whose wild population is limited to a single geothermal pool in the Mojave Desert, has been the subject of conservation and management for more than 50 years. Historically, the establishment of quasi-natural, outdoor refuge populations met only marginal and temporary successes, and ultimately failed due to various logistical and biological reasons. Further, despite decades of attempts, traditional propagation via aquaria has never been fully successful. Here, we report the status of the captive population at the Ash Meadows Fish Conservation Facility (AMFCF), a state-of-the-art aquaculture facility that combines aquaria propagation with a simulated natural refuge habitat. Utilizing eggs collected from Devils Hole, we achieved a greater than 80% larval survival to adulthood. At appropriate size, juveniles and young adults are stocked into a 100,000 gallon refuge tank designed to simulate the challenging conditions of Devils Hole. All life stages, including eggs, larvae, and multiple generations of adults occur in the tank. Although the captive population has produced successive generations, the explosive population growth that was hoped for has not yet been realized, and challenges to successful breeding in aquaria remain. In one example, control of predacious diving beetles in the refuge tank has increased egg recovery significantly. Recovered eggs proved more difficult to rear in laboratory conditions compared to wild-collected eggs, due in part to rapid colonization of eggs and aquaria by microbes, resulting in egg and larval death. New rearing methods were subsequently developed and have been successful in controlling deleterious microbes, resulting in a laboratory population from captive-spawned eggs which will be utilized in captive-breeding trials.

15:30 Waterfall Formation at a Desert River-Reservoir Delta Isolates Endangered Fishes
Charles Nate Cathcart[1], Casey Pennock[2], Christopher Cheek[3], Mark McKinstry[4], Peter MacKinnon[5], Mary Conner[5], Keith Gido[2] (1-Alaska Department of Fish & Game, United States; 2-Kansas State University, United States; 3-Purdue University, United States; 4-Bureau of Reclamation, United States; 5-Utah State University, United States)

Unforeseen interactions of dams and declining water availability have formed new obstacles to recovering endemic and endangered big-river fishes. During a recent trend of drying climate and declining reservoir water levels in the Southwestern United States, a large waterfall has formed on two separate occasions (1989–1995 and 2001–present) in the transition zone between the San Juan River and Lake Powell reservoir because of deposited sediments. Since recovery plans for two large-bodied endangered fish species, Razorback Sucker (*Xyrauchen texanus*) and Colorado Pikeminnow (*Ptychocheilus lucius*) include annual stockings in the San Juan River, this waterfall potentially blocks upstream movement of individuals that moved downstream from the river into the reservoir. To quantify the temporal variation in abundance of endangered fishes aggregating downstream of the waterfall and determine population demographics, we remotely monitored and sampled in spring 2015, 2016, and 2017 when these fish were thought to move upstream to spawn. Additionally, we used an open population model applied to tagged fish detected in 2017 to estimate population sizes. Colorado Pikeminnow were so infrequently encountered (<30 individuals) that population estimates were not performed. Razorback Sucker captures from sampling (335), and detections from remote monitoring

(943) showed high abundance across all 3 years. The Razorback Sucker population estimate for 2017 alone was 755 individuals and, relative to recent population estimates ranging from ~2,000 to ~4,000 individuals, suggests that a substantial population exists seasonally downstream of this barrier. Barriers to fish movement in rivers above reservoirs are not unique; thus, the formation of this waterfall exemplifies how water development and hydrology can interact to cause unforeseen changes to a riverscape.

15:45 Prescribed Fire as a Tool to for Sensitive Species Conservation

Cassie Mellon[1], Kevin Wheeler[2] (1-Bureau of Land Management, United States; 2-Utah Division of Wildlife Resources, United States)

Least Chub, *Iotichthys phlegethontis*, is endemic to the Bonneville Basin of Utah with only six isolated extant populations. One of these populations occurs at Gandy Marsh which is a complex of approximately 50 springheads located in the Snake Valley of Utah. Gandy Marsh provides habitat for Least Chub as well as Utah Chub, *Gila atraria*, Speckled Dace, *Rhinichthys osculus*, Columbia Spotted Frog, *Rana lueteventris*, and Northern Leopard Frog, *Rana pipiens*. Portions of this spring complex have been protected as a Bureau of Land Management Area of Critical Environmental Concern since 1992. Two livestock grazing exclosures (12 and 50 acres), which encompass 25 springheads, were built in the early 1990's to protect the unique ecosystem and habitat of Gandy Marsh. The discharge of these springheads varies seasonally. Open water is primarily restricted to springheads in the summer. In the spring and fall water flows through springbrooks to seasonally flooded basins. Occupancy surveys for Least Chub at the springheads have been conducted every 1 to 3 years in August since the early 1990's. Declines in Least Chub occupancy at springheads within the exclosures were documented beginning in 2010, while occupancy at springheads outside the exclosures remained unchanged. This decline was attributed to a buildup of decadent vegetation within the exclosures which clogged the channels, limited open water, and prevented Least Chub from leaving or returning to the springheads during high water periods. We believed that Least Chub needed to leave the springheads to reach the seasonally flooded basins to spawn and then return to the springheads to overwinter and oversummer. With the buildup of vegetation, the channels were too clogged for Least Chub to complete this portion of their life cycle which led to a loss of Least Chub inside springheads in the exclosures. A prescribed burn was conducted inside both exclosures in October 2017 with the goal of removing vegetation and increasing open water habitat to allow Least Chub to return to the springheads in the exclosures. In monitoring from 2010 to 2016, Least Chub were only found in one exclosure in one year. During monitoring in August 2018, Least Chub were documented in five springheads inside the exclosures. This increase in occupancy indicates that prescribed fire can be an effective tool to remove vegetation, maintain open water, and allow Least Chub to naturally recolonize springheads. We will continue to monitor Least Chub occupancy and vegetation response to determine frequency of future burns or other management efforts needed to help maintain this population.

16:00 Submersible PIT Antennas Document a New Spawning Location for Colorado Pikeminnow, *Ptychocheilus lucius*, in the Green River, Utah

Michael Partlow[1], Matthew Breen[1], Garrett Tournear[1] (1-Utah Division of Wildlife

Resources, United States)

Colorado Pikeminnow, *Ptychocheilus lucius*, is a long-lived, potamodromous fish that exhibit spawning site fidelity. Following decades of research in the Green River sub-basin, two primary spawning sites have been identified, one in Yampa Canyon (Yampa River) and the other in Gray Canyon (Green River). In July 2018, a suspected spawning aggregation of Colorado Pikeminnow was encountered during non-native fish removal electrofishing in Dinosaur National Monument near the Chew Bridge (river km 508) downstream of Split Mountain Canyon. In response, a remote submersible PIT antenna (Biomark, Inc., Boise, ID) was promptly deployed at this location from 10–30 July 2018. During this time, 50 unique PIT tags were detected, 42 of which were implanted into Colorado Pikeminnow; three were implanted into Razorback Suckers, *Xyrauchen texanus*, and five remaining tags have not yet been reconciled with an existing record of implantation. Remote submersible PIT antennas may be a valuable tool for investigating life history traits of endangered fishes in place of more intrusive sampling techniques, such as netting and electrofishing, that potentially disrupt spawning behaviors. Future monitoring of this site with submersible PIT antennas should continue in subsequent years and additional research should be conducted to determine when passive detection of PIT tags can be positively attributed to spawning activity.

16:15 Critical Rearing Grounds for the Endangered Colorado Pikeminnow (*Ptychocheilus lucius*): Management Challenges in a Rapidly Changing Ecosystem
Christopher Michaud (Utah Division of Wildlife Resources, United States)

The placid waters of the canyon-bound and alluvial reaches of both the Colorado and Green Rivers immediately upstream of their confluence form a large proportion of the remnant nursery habitat critical to the survival of the endangered Colorado Pikeminnow. This big river fish, endemic to the Colorado River Basin, uses 120 miles of the lower Green River and 110 miles Colorado River for rearing and recruitment of early life stages. The low-velocity habitats selected by these fish exhibit a low level of stability through time. Discharge has a large impact on quality and abundance of low-velocity habitats. Spring runoff frequently inundates these habitats, whereas extreme low water has the tendency to drain habitats or isolate them from the main channel. Monsoonal activity with consequent flow spikes will inundate habitats with fine sediments reducing their value. Complementing natural stochastic events are a suite of anthropogenic influences. Over the past 130 years, human activity has added multiple factors influencing critical rearing habitat. These include water development, establishment of exotic invasive plant and fish species and global climate change.

16:30 Genetic and Morphological Analysis of Hybridization Between Native and Invasive Pupfishes (*Cyprinodon*)
Jennifer Gumm[1], Kristina Ayers[2], Vance Imhoff[2] , Gene Wilde[3] (1-Ash Meadows Fish Conservation Facility, US Fish and Wildlife Service, United States; 2-Stephen F. Austin State University, United States; 3-Texas Tech University, United States)

Invasive species can devastate native species and a main threat to endemic biodiversity is hybridization with introduced species. *Cyprinodon variegatus* is an invasive species that

has impacted several other *Cyprinodon* species through rapid hybridization and genetic introgression. *Cyprinodon rubrofluviatilis* is native to the Brazos, Wichita and Red Rivers but collections between 2006-2012 showed intermediate morphological traits suggesting hybridization had occurred in the Brazos River. We investigated if *C. variegatus* was present and hybridizing in the Brazos River and identify the extent of introgression between the two species. We used molecular and morphological approaches to analyze specimens collected between 2013-2017 from the Brazos, Wichita, and Red Rivers and the Gulf of Mexico. In 2014-2015, low levels of introgression were evident, but hybridization was not widespread in the Brazos. In more recent sampling (2016-2017), genetic structure differed from previous years and there were no longer signs genetic signs of hybridization. Morphological analysis showed clear differences between species with little evidence of intermediate phenotypes. Although hybridization between *C. variegatus* and *C. rubrofluviatilis* is not currently widespread, there has been a complex pattern of hybridization in the past and it remains a threat to native *Cyprinodon* in this region.

Sunday, November 18th

08:00-13:00 Field Trip: Amargosa River (led by Mike Schwemm)