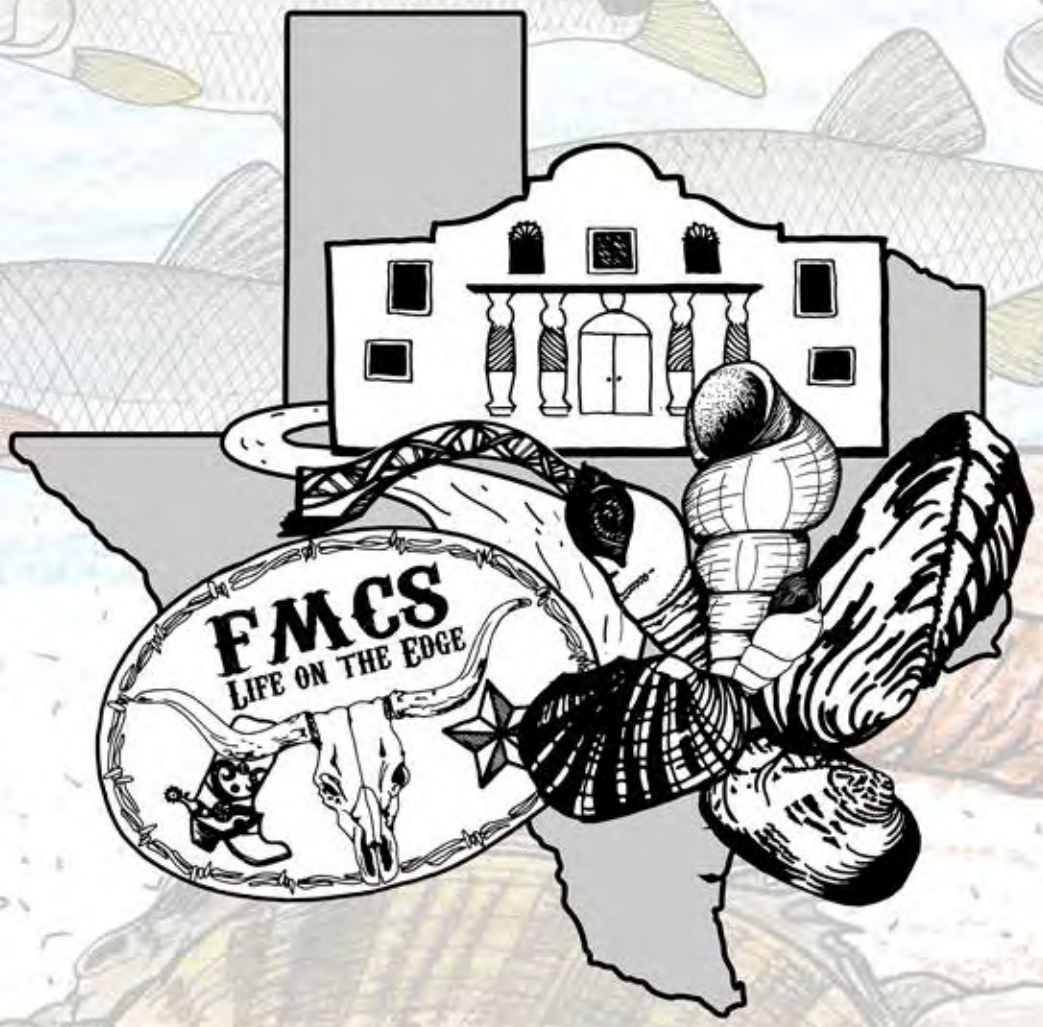
11th Biennial FMCS Symposium
San Antonio, TX



April 14th - 18th, 2019

Program

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2019 FMCS Sympiosium Schedule Overview					
	Sunday 4/14	**Monday 4/15**	**Tuesday 4/16**	**Wednesday 4/17**	**Thursday 4/18**
	Registration 7:00 am - 8:00 am 12:00 pm - 6:00 pm	Registration 7:00 am - 6:00 pm	Registration 7:00 am - 6:00 pm	Registration 7:00 am - 1:00 pm	Optional Field Trips Central Texas Hill Country Mussel Sampling Trip Mission Reach Mussel Survivability Kayak Trip 9:00 - 5:00
		Breakfast on your own	Breakfast on your own	Breakfast on your own	
8:00 AM	Conservation Genetics & USFWS Species Status Assessments Workshops 8:00 - 5:00 Blanco Room	Welcome 8:00 - 8:15 Plenary Speakers Craig Bonds 8:15 - 8:45 Tim Birdsong: 8:50 - 9:50	Welcome 8:00 - 8:15 Plenary Speaker Fred Allendorf 8:15 - 9:15	Welcome 8:00 - 8:15 Plenary Speaker Jeanette Howard 8:15 - 9:16	
9:00 AM			Morning Break 9:20 - 9:40	Morning Break 9:20 - 9:40	
10:00 AM		Morning Break 10:00 - 10:20	Concurrent Sessions 9:40 - 12:00 SESSION 10: Surveys & Monitoring I SESSION 11: Southwestern Mollusks II SESSION 12: Genetics & Phylogeny IV	Concurrent Sessions 9:40 - 12:00 SESSION 19: Mussel Kills SESSION 20: Restoration Tools I SESSION 21: Gastropoda	
11:00 AM		Concurrent Sessions 10:20 - 12:00 SESSION 1: Anthropogenic Impacts I SESSION 2: Genetics & Phylogeny I SESSION 3: Contaminants & Ecotoxicology I			
12:00 PM - 2:00 PM		FMCS Committee Meetings (with lunch) or Lunch on your own 12:00 - 2:00	FMCS Committee Meetings (with lunch) or Lunch on your own 12:00 - 2:00	FMCS Buisness Lunch 12:00 - 2:00	
2:00 PM		Concurrent Sessions 2:00 - 3:20 SESSION 4: Anthropogenic Impacts II SESSION 5: Genetics & Phylogeny II SESSION 6: Contaminants & Ecotoxicology II	Concurrent Sessions 2:00 - 3:20 SESSION 13: Contaminants & Ecotoxicology IV SESSION 14: Propogation I SESSION 15: Surveys II	Diversity Speaker 2:00 - 2:30 Concurrent Sessions 2:40 - 3:40 SESSION 22: Invasive Species SESSION 23: Restoration Tools II SESSION 24: Management II	
3:00 PM	ExCom meeting 3:00 - 5:00 Frio Room	Afternoon Break 3:20 - 3:40	Afternoon Break 3:20 - 3:40	Afternoon Break 3:40 - 4:00	
4:00 PM		Concurrent Sessions 3:40 - 4:40 SESSION 7: Southwestern Mollusks I SESSION 8: Genetics & Phylogeny III SESSION 9: Contaminants & Ecotoxicology III	Concurrent Sessions 3:40 - 5:40 SESSION 16: Management I SESSION 17: Propogation II SESSION 18: Southwestern Mollusks III	Concurrent Sessions 4:00 - 5:00 SESSION 25: Management III SESSION 26: Restoration Tools III SESSION 27: Ecology	
5:00 PM		Dinner on your own 4:40 - 6:00	Evening Break 5:40 - 6:30	Dinner on your own 5:00 - 7:00	
6:00 PM	Student- Mentor Mixer 6:00 - 7:00 Chula Room	Poster Session 6:00 - 7:00	Plenary Speaker Wyman Meinzer 6:30 - 7:30		
7:00 PM	Welcome Reception 7:00 - 9:00 Garden Terrace	Social at Roadmap Brewing Company 7:00 - 10:00	Dinner & Auction 7:30 - 11:00	Mixer & Music 7:00 - 10:00	

Plenary, Poster Sessions, Dinner, and Wednesday Mixer are in Regency East
Sessions 1, 4, 7, 10, 13, 16, 19, 22, 25 in Rio Grande East
Sessions 2, 5, 8, 11, 14, 17, 20, 23, 26 in Rio Grande Center
Sessions 3, 6, 9, 12, 15, 18, 21, 24, 27 in Rio Grande West

2019 Symposium Organizers

Charles Randklev
Texas A&M, Agrilife
crandklev@ag.tamu.edu

Clint Robertson
Texas Parks and Wildlife
Clint.Robertson@tpwd.texas.gov

Susan Oetker
US Fish & Wildlife Service
oetker@fws.gov

Neil Ford
University of Texas at Tyler
nford@uttyler.edu

Symposium Planning Committee

Program: Kevin Cummings, Jeremy Tiemann, Neil Ford, and Charles Randklev
Keynote speakers: Charles Randklev and Kathryn Perez
Socials: Michael Hart and Gary Pandolfi
Registration: Emily Grossman, Susan Oetker, and Daelyn Woolnough
Auction: Lesie Kitchel and Greg Zimmerman
Sponsorships: Matt Johnson, Mark Fisher, Charles Randklev, and Jeremy Tiemann
AV/Communications: Marsha May, Nathan Johnson, and Charrish Stevens
Volunteers: Daelyn Woolnough and Susan Oetker
Fieldtrips: Astrid Schwalb, Clint Robertson, and Tom Miller
Workshops: Susan Oetker, Dave Smith, Nathan Allan, Gary Pandolfi, Sarah McRae, Dave Berg, Kevin Roe, Kentaro Inoue, and Fred Allendorf.
Local Arrangements: Roel Lopez
Live Music: Astrid Schwalb

Acknowledgements: Robert G. Howells, BioStudies, for the t-shirt design, Gabe Saldana, Texas AgriLife for the meeting logo, Amy T. Carroll, TAMU-NRI, for the abstract submission system, Sophie Binder, Sophie Binder Designs, for website support, Michael Hart, TAMU-NRI, help with freebies (i.e., t-shirts), Jennifer Khan, TAMU-NRI, for help collecting and organizing mussel sampling photos and printing, and Ashley Thomas, Hyatt Regency, hotel event coordinator.

FMCS Standing Officers

President: Heidi Dunn – EcoAnalysts, Inc.
***President Elect*:** Jeremy Tiemann – Illinois Natural History Survey
Secretary: Janet Clayton – West Virginia Division of Natural Resources
Past President: Teresa Newton – U.S. Geological Survey
Treasurer: Emily Robbins – EcoAnalysts, Inc.

FMCS Committees: Chairs, and Co-Chairs

Awards

Chair: Emy Monroe – USFWS, Midwest Fisheries Center, emy_monroe@fws.gov
Co-Chair: W. Gregory Cope – North Carolina State University, greg_cope@ncsu.edu
Teresa Newton – Upper Midwest Environ. Science Center, tnewton@usgs.gov

Environmental Quality & Affairs

Chairs: Steve McMurray – Missouri Department of Conservation, stephen.mcmurry@mdc.mo.gov
Braven Beaty – The Nature Conservancy, bbeaty@tnc.org

Gastropod Status and Distribution

Chair: Nathan Whelan – Auburn University, nwhelan@auburn.edu

Genetics

Chair: Kevin Roe – Iowa State University, kjroe@iastate.edu
Co-Chair: Dave Zanatta – Central Michigan University, zanat1d@cmich.edu

Guidelines and Techniques

Chair: Lisie Kitchel – Wisconsin Dept. Nat. Resources, lisie.kitchel@wisconsin.gov
Co-Chair: Ryan Schwegman – EnviroScience, Inc., RSchwegman@EnviroScienceInc.com

Information Exchange

Newsletter: John Jenkinson – Clinton, Tennessee, jjjenkinson@hotmail.com
Journal: W. Gregory Cope – North Carolina State University, greg_cope@ncsu.edu
Wendell R. Haag – U.S. Forest Service, whaag@fs.fed.us
Dave Berg – Department of Biology, Miami University, bergdj@miamioh.edu

Mussel Status and Distribution

Chairs: Arthur E. Bogan – N.C. State Museum of Natural Sciences, arthur.bogan@ncmail.net
John L. Harris – Arkansas State University, omibob1@gmail.com

Outreach

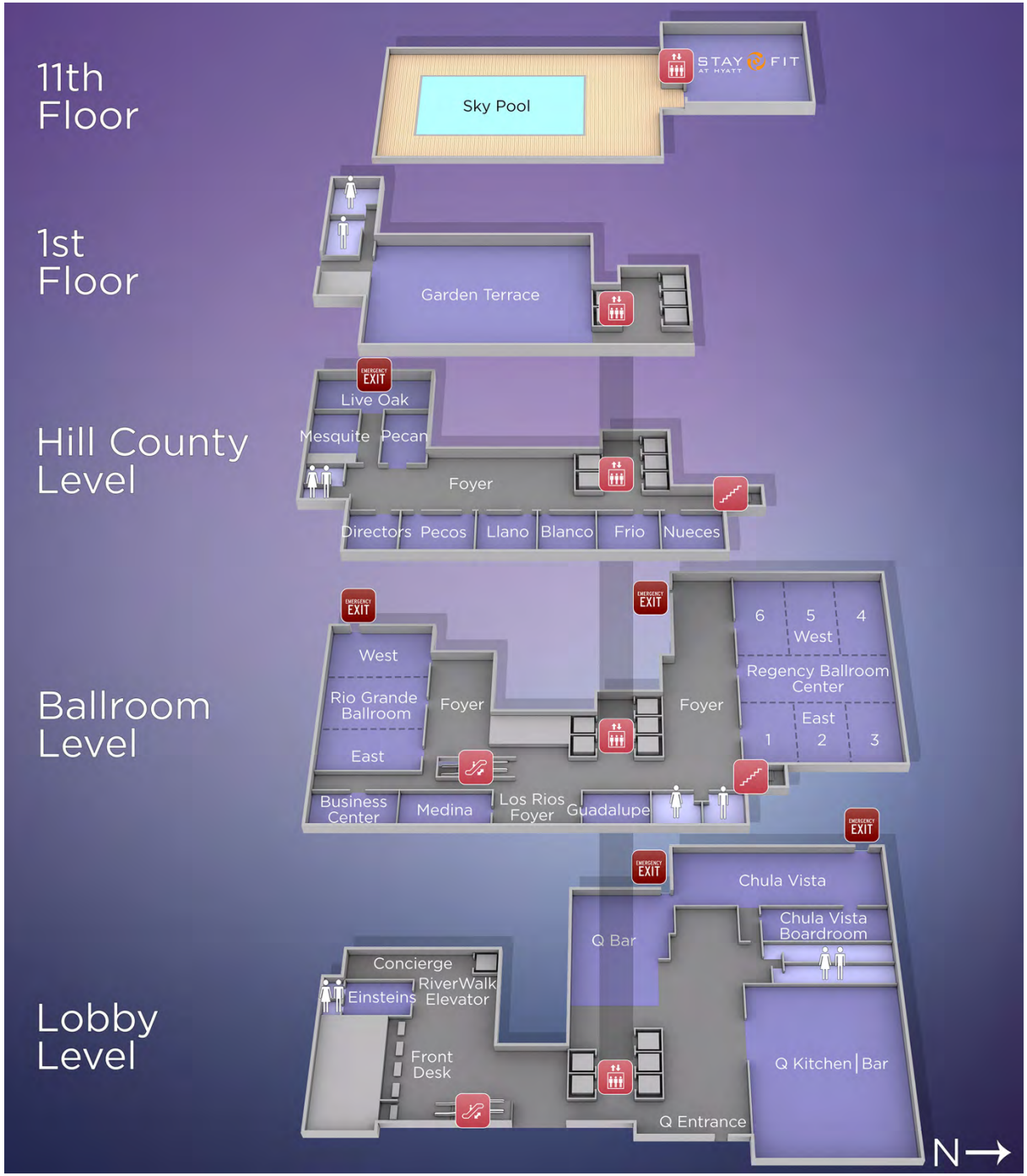
Chair: Meghan Bradley – Virginia Tech, mebradl1@vt.edu
Co-Chair: Jennifer Archambault – North Carolina State University, jmarcham@ncsu.edu

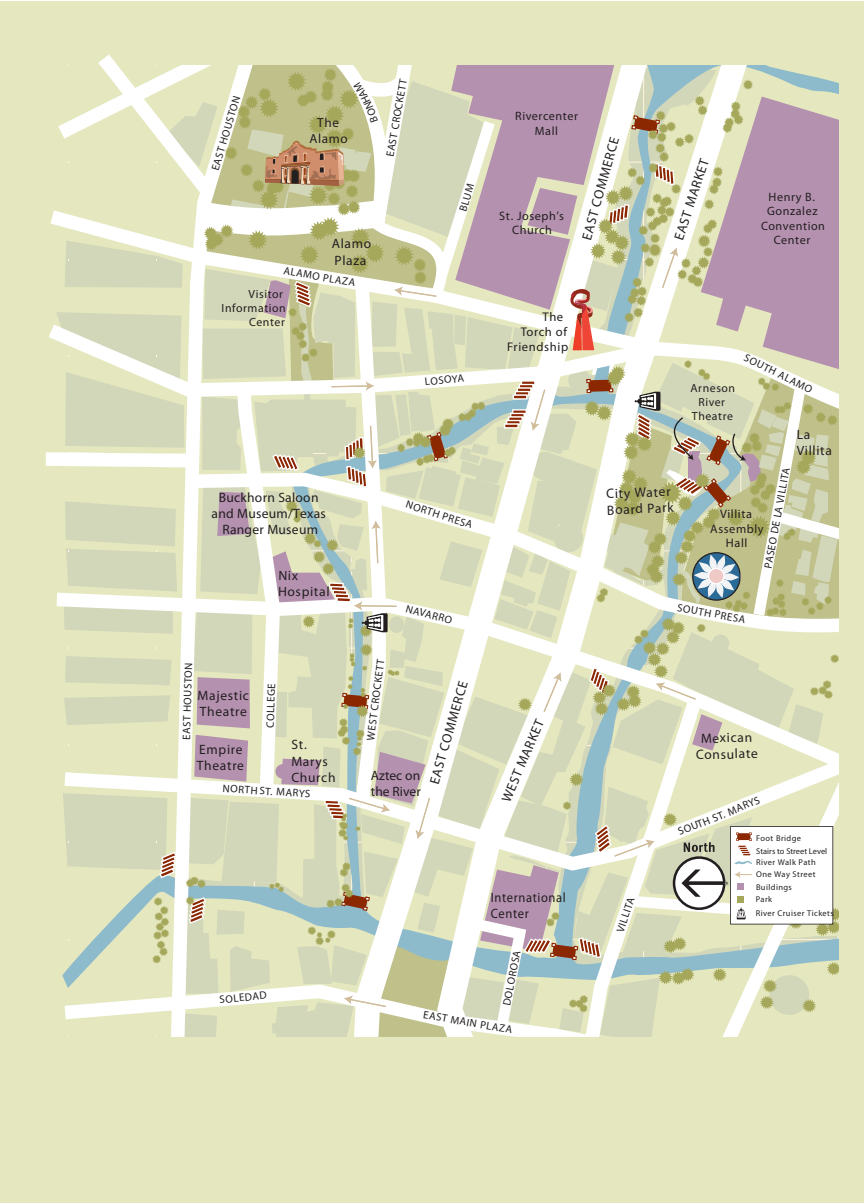
Propagation, Restoration & Introduction

Chairs: Rachael Hoch – North Carolina Wildlife Resources Comm., rachael.hoch@ncwildlife.org
Tim Lane – Virginia Dept. of Game & Inland Fisheries, tim.lane@dgif.virginia.gov

Symposium

Jeremy Tiemann – Illinois Natural History Survey, jtiemann@illinois.edu


11th Floor
Sky Pool
STAY FIT AT HYATT
1st Floor
Garden Terrace
Hill County Level
EMERGENCY EXIT
Live Oak
Mesquite
Pecan
Foyer
Directors
Pecos
Llano
Blanco
Frio
Nueces
Ballroom Level
EMERGENCY EXIT
West
Rio Grande Ballroom
East
Foyer
Business Center
Medina
Los Rios Foyer
Guadalupe
EMERGENCY EXIT
Foyer
6
5
4
West
Regency Ballroom
Center
East
1
2
3
EMERGENCY EXIT
Lobby Level
EMERGENCY EXIT
Chula Vista
Chula Vista Boardroom
Q Bar
Concierge
Einsteins
RiverWalk Elevator
Front Desk
Q Kitchen
Bar
Q Entrance
N



GETTING AROUND TOWN

VIVA is a new service line from VIA Metropolitan Transit that takes you to the most visited sites and attractions in the heart of San Antonio.
The three distinct VIVA routes below connect riders with historic places, opportunities to learn and discover, classic and contemporary art, and popular dining and entertainment spots.

11 VIVA culture - VIVA culture route provides direct connections to Southtown, King William, Downtown, Pearl, and Broadway Reach cultural attractions. The route will provide more frequent service and will run longer hours along some segments.

40 VIVA missions - VIVA Missions provides direct connections between the Alamo and the San Antonio Missions World Heritage Site, which includes Missions Concepción, San José, and San Juan. Route will run daily from 8:30 a.m. to 5 p.m. Service to Mission Espada will be added at a later date.
301 VIVA centro - VIVA centro provides convenient connections between Centro Plaza and St. Paul Square. Traveling eastbound from Centro Plaza, the route will use Houston, Alamo, and Market streets to reach St. Paul Square. It will return westbound using Commerce, Alamo, and Travis streets before resuming on Commerce to Centro Plaza.

The best value for VIVA is with a $2.75 Day Pass, which gives you unlimited rides all day (available on the bus). A single trip is just $1.30. Or get a 7-Day Pass for only $12 and take the time to plan your next adventure with VIVA.
Free Mobile App – "Go VIA VIA" is the official VIA Metropolitan Transit free mobile app. This app is a convenient and time saving tool for VIA bus riders with iPhone and Android smartphones. Riders can view transit stops in the area and get real time arrivals for routes. Or just set an alert and the app will let you know when your bus is minutes away. You can also use the app to plan your trip, view routes and look up schedules. "Go VIA VIA" provides easy connections to VIA's online store, rider alerts, Facebook page and Twitter feeds. If you are riding VIA you have to "Go VIA VIA".
Go Rio Shuttle Service – Just trying to get from place to place? Flag down a Go Rio shuttle! Look for the Go Rio Shuttle signs that are located throughout the River Walk downtown and on the Museum Reach. Boats are labeled with Go Rio Shuttle signs. Shuttle service begins at 10am. There are no scheduled pick-ups or drop offs at this time. Shuttles run approximately every 45 minutes.

Taxi – Travel within the downtown area, there is a minimum charge of $5 from 7 am-7 pm and $6 from 7 pm-7 am. Two - six people ride for the price of one.

Yellow Cab App – zTrip™ is the fastest way to catch a cab! With just a few taps on your smartphone, a licensed taxi driver in a city regulated vehicle will be on its way to your location. Features include: locate and track your cab in real time, find the closest cab to your current location or pick-up address and schedule future pick-ups. The app is available for iOS and Android devices and is free and secure. Download the zTrip™ app from your mobile app store or by visiting www.yellowcabsa.com.
Directions & Parking for the Convention Center – The Convention Center is an easy walk from most hotels in the downtown area. Need directions to the Henry B. González Convention Center - www.sahbgcc.com/Visit-Us/Location-Directions-Parking

FIELD TRIPS

CENTRAL TEXAS HILL COUNTRY
San Antonio is just southeast of the Texas Hill Country, one of the most beautiful regions in Texas, famous for its wildflower-lined roadways and beautiful small towns. Start the day with climbing Enchanted Rock, a dome of pink granite rising 425ft above ground and one of the largest batholiths in the US, offering a great view of the surrounding rolling hills. Then stroll along Main Street in Fredericksburg and enjoy your lunch in a beer garden. Visit the nearby LBJ Ranch at the Pedernales River, where Lyndon B Johnson, the 36th President of the United States, lived and died. End the day listening to live-music in legendary Luckenbach, which was made famous in a country song by Waylon Jennings.
https://tpwd.texas.gov/state-parks/enchanted-rock
https://www.nps.gov/lyjo/planyourvisit/visitlbjranch.htm
http://www.luckenbachtexas.com/home.htm

MUSSEL SAMPLING TRIP
Come and find hidden gems in the most flash-flood prone area in the United States, Central Texas. Our gems include several endemic species in the Guadalupe River basin, you don't want to miss. Lunch will be BBQ in Lockhart, the BBQ capital of Texas.
http://www.lockhartchamber.com/pages/BBQCapitalofTexas

MISSION REACH MUSSEL SURVIVABILITY KAYAK TRIP
Join us to kayak a section of the San Antonio River Mission Reach. Take in the sights and sounds of this recently restored section of urban stream just downstream of bustling San Antonio. Topics of discussion will include the massive ecosystem restoration which has given rise to a few projects set out to explore the ecological lift of the area as well as the ongoing Mission Reach Mussel Survivability Study being conducted by the San Antonio River Authority. Visit one of the mussel study sites and have a hands on look at the gear and the mussels used in the study. This trip is being completely furnished by the San Antonio River Authority and will include transportation to and from the conference hotel as well as a kayak, paddle and lifejacket.

For more information, contact Christopher Vaughn

Code of Conduct

The Freshwater Mollusk Conservation Society

Approved 15 November 2018

The Freshwater Mollusk Conservation Society (FMCS) is an international scientific organization whose purpose is to conserve and advocate for freshwater mollusks. FMCS members and attendees of FMCS-sponsored symposia, workshops, meetings, or other FMCS activities (events) are expected to adhere to this Code of Conduct. FMCS is committed to providing a safe, productive, and welcoming environment for all participants and staff. All participants including, but not limited to, members, guests, attendees, speakers, volunteers, exhibitors, service providers, and others are expected to abide by this Code of Conduct. This Code of Conduct applies to in-person, electronic (text, email, social media), and written communications.

The FMCS leadership encourages anyone to contact FMCS Executive Committee regarding ways in which the Society can improve inclusion and diversity and encourage a stimulating and supporting atmosphere.

Expected Behavior

- Communicate openly with respect and consideration for others, valuing a diversity of views and opinions.
- Avoid personal attacks directed toward other attendees, participants, suppliers, or vendors.
- Be mindful of your surroundings and of your fellow participants.
- Speak up, intervene, or alert an FMCS board member if discriminatory or inappropriate behavior directed at others is observed or you notice a dangerous situation or someone in distress.
- Abide by the rules and policies of the event venue, hotels, FMCS-contracted facility, or any other venue.
- Request permission from speakers before recording or taking photographs during their presentations. Turn off any ringers or other disrupting devices during oral and poster sessions.

Unacceptable Behavior

It is important that our events be places where no attendee or staff is ever belittled, harassed, or made to feel unsafe. The following behaviors will not be tolerated:

- Harassment, intimidation, or discrimination in any form.
- Physical, written, or verbal abuse of any attendee, speaker, volunteer, exhibitor, service provider, or other event participant.

Examples of unacceptable behavior include, but are not limited to, unwelcomed physical contact; verbal comments related to gender, sexual orientation, disability, physical appearance, body size, race, religion, or national origin; inappropriate use of nudity and/or sexual images in public spaces or in presentations; and threatening or stalking any attendee, speaker, volunteer, exhibitor, service provider, or other event participant.

Reporting Unacceptable Behavior & Consequences

All members, event attendees, and event staff are expected to abide by the FMCS Code of Conduct. Anyone experiencing or witnessing behavior that constitutes an immediate or serious threat to public or personal safety should locate a house phone and ask for security. If a security officer is not available contact 911. Once the person is out of danger, contact an FMCS executive officer. Anyone requested to stop unacceptable behavior is expected to comply immediately. If you are the victim of unacceptable behavior or have witnessed any such behavior, please immediately notify an FMCS executive officer.

Notification can occur by emailing, calling, or texting your concern to the FMCS President or the event services representative. After receiving a report of inappropriate behavior, the FMCS President, Executive Committee, and event services representative will assess the report and work with the complainant to determine the relevant facts, evidence, and most appropriate response.

Anyone filing a complaint concerning a suspected violation of the Code of Conduct must be acting in good faith and have reasonable grounds for believing the information disclosed indicated a violation of the Code of Conduct. Any allegation made with a malicious intent will be viewed as a Code of Conduct violation.

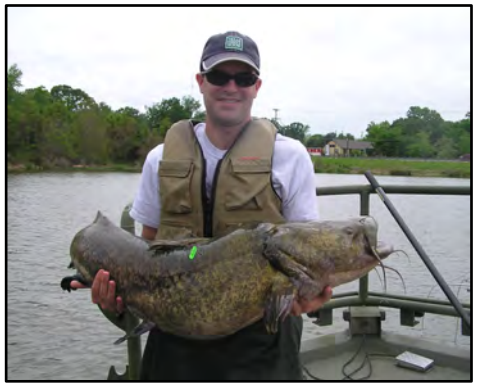
FMCS is committed to protecting the privacy of all individuals involved in the incident to the greatest extent practicable.

The FMCS Executive Committee reserves the right to take any lawful action deemed necessary in response to a violation of this Code of Conduct. This includes, but is not limited to, the immediate removal of the violator from the event without warning or refund. The FMCS Executive Committee may also elect to suspend the violator from future events. Repeated violations could result in loss of FMCS membership and a permanent ban on attendance at FMCS events.

Failure to adhere to the Code of Conduct is cause for removal from an event and/or suspension from membership in FMCS at the discretion of the Executive Committee. A Member may be suspended or removed from FMCS membership with cause by vote of two-thirds of the Board of Directors only after reasonable notice and an opportunity to be heard.

Keynote and Plenary Session Speakers

Monday, 8:15 a.m. – 8:45 a.m., Regency East – *Craig Bonds*

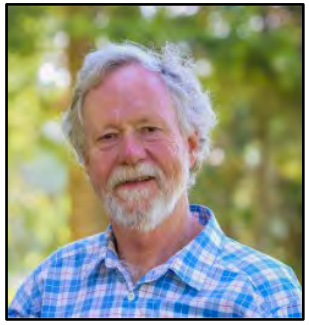


Craig Bonds is a native of Central Texas and holds a B.S. from Texas A&M University and a M.S. from Virginia Tech. He is a 20-year veteran of TPWD, including prior service as a fisheries biologist at various levels and locations throughout Texas, including San Marcos San Angelo, and Tyler, promoting to Austin as Division Director in 2015. Craig is a Certified Fisheries Professional with the American Fisheries Society (AFS). He has held numerous positions within the Texas Chapter of the AFS, including President. He has served as President of the Southern Division of the AFS and on that international Society's Governing Board. Craig also serves on the Board of the Recreational Boating and Fishing Foundation.

Monday, 8:50 a.m. – 9:50 a.m., Regency East – *Tim Birdsong*

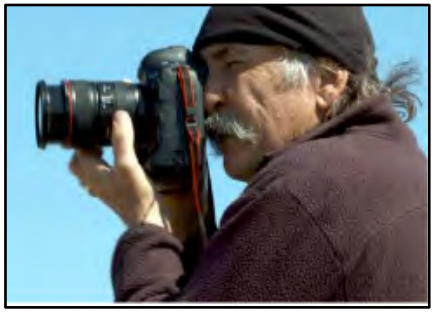
Tim Birdsong is Chief of Habitat Conservation for the Inland Fisheries Division of Texas Parks and Wildlife Department, where he leads efforts to restore and preserve the diversity of Texas freshwater habitats and species. Tim's presentation will reflect on the importance of collaborative stewardship, and public-private partnerships and profile case studies in connecting and empowering local communities and river users to take action to conserve aquatic resources. Since 2010, those efforts have involved voluntary-based cooperation with landowners to restore natural watershed processes, protection of freshwater systems and associated watersheds, restoration of spring, stream and riparian habitats, and large-scale control of invasive riparian plants. In recognition of those efforts, Tim and cooperators were recognized through numerous state and national awards including the 2012 Fisheries Worker of the Year Award from the Texas Chapter of the American Fisheries Society, 2014 Award for Extraordinary Action in Fish Habitat Conservation jointly presented by the American Fisheries Society and National Fish Habitat Partnership, 2015 Texas Parks and Wildlife Conservation Award, 2016 Dr. James A. Henshall Warmwater Fisheries Award presented by Fly Fishers International, and the 2016 Sport Fish Restoration Outstanding Project Award presented by the American Fisheries Society. Tim serves on numerous regional and national advisory councils and committees, including the Native Fish Conservation Network, National Fish Habitat Science and Data Committee, Association of Fish and Wildlife Agencies Climate Change Committee, and as past chair of the Southeast Aquatic Resources Partnership and Great Plains Landscape Conservation Cooperative. He has a MS in Fisheries and Coastal Sciences from Louisiana State University, a BS in Biology and Education from Southeastern Oklahoma State University, and a Certificate in Nonprofit Management from the University of Texas at Austin.

Tuesday, 8:15 a.m. – 9:15 a.m., Regency East – *Dr. Fred Allendorf*



Dr. Fred Allendorf is a Regents Professor of Biology Emeritus at the University of Montana. Dr. Allendorf received his PhD from the University of Washington in 1975, and he was a post-doctoral scholar in Denmark and England. He has also held academic positions in New Zealand and Australia. He is an evolutionary geneticist who has spent much of his career applying the theory and molecular techniques of population genetics to problems in conservation. Dr. Allendorf's book Conservation and the Genetics of Populations (2013), co-authored with Gordon Luikart and Sally Aitken, provides an understanding of how genetics can be used to conserve species threatened with extinction. He has written several papers that strive to unite the fields of ecology and evolution with the spiritual practice of Zen.

Tuesday, 6:30 p.m. – 7:30 p.m., Regency East – *Wyman Meinzer*



Wyman Meinzer is the only official State Photographer of Texas, named so in 1997 by the Texas State Legislature and then Governor George W. Bush, an honor he still holds today. He was raised on the League Ranch, a 27,000-acre ranch in the rolling plains of Texas. Since then, he has traveled to every corner of this great state and all points in between in search of the first and last rays of sunlight in its magnificent sweep across the Texas landscape. Meinzer graduated from Texas Tech University in 1974 with a Bachelor of Science degree in Wildlife Management and was voted Outstanding Alumnus in 1987 by the Department of Range and Wildlife Management at Texas Tech. He also received the Distinguished Alumnus award in 1995 from the School of Agricultural Sciences and Natural Resources. In August of 1999, Meinzer was honored to give the graduation commencement address at his alma matter. During his 12 years as adjunct instructor in communications at Texas Tech, Wyman was selected as Agriculture Communications Teacher of the Year in 2005. In 2009,he received the Distinguished Alumnus award from Texas Tech in recognition of outstanding achievement and dedicated service. Post-graduation, Wyman spent five years as a professional predator hunter on the big ranches of the rolling plains. During this period, he worked to perfect his photographic skills and now, after 33 years as a professional photographer, Wyman has photographed and /or written 24 large format books, and his images have appeared on more than 250 magazine covers throughout America. His images have appeared in Smithsonian, National Geographic Books, Natural History, Ebony, Time, Newsweek, U.S. News and World Report, Audubon, Sports Afield, Field and Stream, Outdoor life, Texas Parks and Wildlife, Texas Highways, Korea GEO, German GEO, Das Tier, Airone, Horzu, BBC Wildlife, and a host others. He was recently named one of America's ten outdoor legends by Field & Stream Magazine. Wyman also received the Living Legacy Award by the Harvey Weil Foundation for his artwork and encouraging others to engage in land and wildlife conservation.

Wednesday, 8:15 a.m. – 9:15 a.m., Regency East – *Dr. Jeanette Howard*

Dr. Jeanette Howard is Director of Science - Water Program, The Nature Conservancy (TNC) California Chapter. Jeanette leads TNC's freshwater science engagements focused on developing and fostering a science enterprise to sustain healthy aquatic ecosystems in California. This work includes conservation planning for freshwater biodiversity statewide, defining environmental flows to maintain and restore freshwater species, habitats and ecological processes, building partnerships for water policy and management, and on-the-ground research projects to evaluate conservation actions. Prior to working at TNC, Jeanette completed her PhD in physical geography at the University of California, Berkeley, was a research scientist for the Confederated Tribes of the Umatilla Indian Reservation restoring freshwater mussels and Pacific lamprey to Tribal rivers and worked as a researcher at the National Geographic.

Wednesday, 2:00 p.m. – 2:30 p.m., Regency East – *Erika Proser-Nirenberg*

Erika Proser-Nirenberg is the Director of Customer Insights for H-E-B. She leads a team charged with helping guide the development of H-E-B's strategic vision and operational efforts by providing customer insights to change the business, gain share and establish preference for the company. Growing up as a migrant in the Rio Grande Valley, Erika now holds a Masters in Communication from the University of Pennsylvania Annenberg School, and a B.A. in Plan II Liberal Arts and a second Bachelor's of Science in Advertising from the University of Texas at Austin. She was the 2018 Chairwoman of the San Antonio Hispanic Chamber of Commerce, having served on its Executive Board for 6 years, and is also a member of the H-E-B Corporate Diversity Leadership Council and various workplace Task forces. A former board member of Say Si Youth Arts, Erika now sits on the Girls Scouts of Southwest Texas Board, the San Antonio Economic Development Foundation board, the Latina Power Network board and is part of the advisory Board for iEmpower. In 2018 she was honored as a Leadership Texas Luminary Woman, having been an LT 2015 graduate and in 2017 was give the Rising Star Award by the San Antonio Women's Chamber of Commerce. In 2016, she received the prestigious H-E-B's David Ashworth Community Service Award and has received the Corporate Diversity Excellence Award for 2015 and 2016. Her proudest honor, however, was receiving the 2010 Association of Migrant Educators of Texas' Migrant Alumni Award. As a co-founder and 2015/2016 Chair of the Latina Leadership Institute, much of Erika's passion revolves around efforts to help improve quality of life among underserved populations through girls & women empowerment, arts education and literacy. She has led the creation of multiple education and economic development white papers, as well as an internationally available, bilingual workbook aimed at helping elementary school-aged children develop entrepreneurial mindsets.

PLATFORM SESSIONS – QUICK REFERENCE MONDAY 15 April 2019		PLATFORM SESSIONS – QUICK REFERENCE TUESDAY 16 April 2019	
	Welcome, Monday, 8:00 a.m. – Regency East		Welcome, Tuesday, 8:00 a.m. – Regency East
Page 1	PLENARY SESSION 1: WELCOME TO TEXAS AND INTRODUCTORY REMARKS *Craig Bonds* 8:15 a.m. – Regency East	Page 2	PLENARY SESSION 3: ZEN & DEEP EVOLUTION: WHEN DID YOUR LIFE BEGIN? *Fred Allendorf* 8:15 – 9:15 a.m. – Regency East
Page 1	PLENARY SESSION 2: MULTISPECIES AND WATERSHED APPROACHES TO CONSERVATION OF FRESHWATER FISHES AND MOLLUSKS *Timothy Birdsong* 8:50 a.m. – Regency East	Page 2	PLENARY SESSION 4: BEHIND THE LENS WITH WYMAN MEINZER *Wyman Meinzer* 6:30 – 7:30 p.m. – Regency East
Pages 3 – 5	SESSION 1: ANTHROPOGENIC IMPACTS I 10:20 a.m. – Rio Grande East	Pages 26 – 29	SESSION 10: SURVEYS & MONITORING I 9:40 a.m. – Rio Grande East
Pages 6 – 9	SESSION 2: GENETICS & PHYLOGENY I 10:20 a.m. – Rio Grande Center	Pages 29 – 33	SESSION 11: SOUTHWESTERN MOLLUSKS II 9:40 a.m. – Rio Grande Center
Pages 9 – 12	SESSION 3 CONTAMINANTS & TOXICOLOGY I 10:20 a.m. – Rio Grande West	Pages 33 – 37	SESSION 12: GENETICS & PHYLOGENY IV 9:40 a.m. – Rio Grande West
Pages 12 – 15	SESSION 4: ANTHROPOGENIC IMPACTS II 2:00 p.m. – Rio Grande East	Pages 38 – 40	SESSION 13: CONTAMINANTS & TOXICOLOGY IV 2:00 p.m. – Rio Grande East
Pages 15-17	SESSION 5: GENETICS & PHYLOGENY II 2:00 p.m. – Rio Grande Center	Pages 40 – 42	SESSION 14: PROPAGATION I 2:00 p.m. – Rio Grande Center
Pages 17 – 20	SESSION 6: CONTAMINANTS & TOXICOLOGY II 2:00 p.m. – Rio Grande West	Pages 42 – 44	SESSION 15: SURVEYS & MONITORING II 2:00 p.m. – Rio Grande West
Pages 20 – 22	SESSION 7: SOUTHWESTERN MOLLUSKS I 3:40 p.m. – Rio Grande East	Pages 44 – 48	SESSION 16: MANAGEMENT I 3:40 p.m. – Rio Grande East
Pages 22 – 24	SESSION 8: GENETICS & PHYLOGENY III 3:40 p.m. – Rio Grande Center	Pages 48 – 51	SESSION 17: PROPAGATION II 3:40 p.m. – Rio Grande Center
Pages 24 – 26	SESSION 9: CONTAMINANTS & TOXICOLOGY III 3:40 p.m. – Rio Grande West	Pages 52 – 55	SESSION 18: SOUTHWESTERN MOLLUSKS III 3:40 p.m. – Rio Grande West

PLATFORM SESSIONS – QUICK REFERENCE WEDNESDAY 17 April 2019	
Page 2	PLENARY SESSION 4: THE ELUSIVE SPRING SNAILS: A NEW CONSERVATION FOCUS IN WESTERN NORTH AMERICA *Jeanette Howard* 8:15 – 9:15 a.m. – Regency East
Pages 55 – 59	SESSION 19: MUSSEL KILLS 9:40 p.m. – Rio Grande East
Pages 59 – 63	SESSION 20: RESTORATION TOOLS I 9:40 p.m. – Rio Grande Center
Pages 63 – 66	SESSION 21: GASTROPODA 9:40 p.m. – Rio Grande West
Pages 67 – 68	SESSION 22: INVASIVE SPECIES 9:40 p.m. – Rio Grande East
Pages 69 – 70	SESSION 23 RESTORATION TOOLS II 2:40 p.m. – Rio Grande Center
Pages 71 – 72	SESSION 24: MANAGEMENT II 2:40 p.m. – Rio Grande West
Pages 73 – 74	SESSION 25: MANAGEMENT III 4:00 p.m. – Rio Grande East
Pages 74 – 76	SESSION 26: RESTORATION TOOLS III 4:00 p.m. – Rio Grande Center
Pages 76 – 77	SESSION 27: ECOLOGY 4:00 p.m. – Rio Grande West
POSTER NUMBER	**POSTER SESSION – QUICK REFERENCE MONDAY 15 April 2019**
Pages 78 – 79	CONTAMINENTS & TOXICOLOGY (Posters 1 – 3)
Pages 80 – 85	GENETICS & PHYLOGENY (Posters 4 – 14)
Pages 86 – 93	LIFE HISTORY & ECOLOGY (Posters 15 – 29)
Pages 94 – 99	MANAGEMENT & NATURAL RESOURCE ISSUES (Posters 30 – 40)
Pages 99 – 107	RELOCATION, REINTRODUCTION AND PROPAGATION (Posters 41 – 53)
Pages 107 – 118	STATUS/TRENDS (Posters 54 – 74)

WELCOME & PLENARY 1 & 2 **Monday, 8:00 a.m. – 10:00 a.m.** **Regency East** Student Papers are denoted in RED					
Plenary 1 8:15 a.m.	**MULTISPECIES AND WATERSHED APPROACHES TO CONSERVATION OF FRESHWATER FISHES AND MOLLUSKS** *Timothy Birdsong*				
Plenary 2 8:45 a.m.	**WELCOME TO TEXAS AND INTRODUCTORY REMARKS** *Craig Bonds*				
SESSION 1: ANTHROPOGENIC IMPACTS I **Monday, 10:20 a.m. – 12:00 p.m.** **Rio Grande East** *Moderator: James Stoeckel*		**SESSION 2: GENETICS & PHYLOGENY I** **Monday, 10:20 a.m. – 12:00 p.m.** **Rio Grande Center** *Moderator: David Berg*		**SESSION 3: CONTAMINANTS & ECOTOXICOLOGY I** **Monday, 10:20 a.m. – 12:00 p.m.** **Rio Grande West** *Moderator: Greg Cope*	
Platform 1 10:20 a.m.	**IMPACTS OF ACUTE AND CHRONIC HEAT STRESS ON POTENTIAL METABOLIC ACTIVITY (PMA) OF FRESHWATER MUSSELS** *Hisham A Abdelrahman, Austin R Haney & James A Stoeckel*	**Platform 6 10:20 a.m.**	**GENOME-WIDE DDRAD-SEQ DATA DISENTANGLES SPECIES RELATIONSHIPS AND REVEALS FINE SCALE POPULATION GENETIC STRUCTURE OF FRESHWATER MUSSELS (*CYPROGENIA* SPP.) IN NORTH AMERICA** *Kevin J Roe & Kyung-Seok Kim*	**Platform 11 10:20 a.m.**	**LIFE STAGE SENSITIVITY OF A FRESHWATER SNAIL TO HERBICIDES USED IN INVASIVE AQUATIC WEED CONTROL** *Jennifer M Archambault & W Gregory Cope*
Platform 2 10:40 a.m.	**MOVE ON OR TAKE THE HEAT: CAN LIFE HISTORY STRATEGIES OF FRESHWATER MUSSELS PREDICT THEIR PHYSIOLOGICAL AND BEHAVIORAL RESPONSES TO DROUGHT AND DEWATERING?** *Zachary A Mitchell, Jaclyn McGuire, Joshua Abel, Astrid N Schwalb & Bianca Hernandez*	**Platform 7 10:40 a.m.**	**HISTORIC AND CONTEMPORARY GENE FLOW IN THE SHEEPNOSE MUSSEL (*PLETHOBASUS CYPHYUS*) AND THEIR IMPLICATIONS FOR CONSERVATION** *Kevin J Roe & Sara Schwarz*	**Platform 12 10:40 a.m.**	**ASSESSING MULTI-GENERATIONAL AND DEVELOPMENTAL ECOTOXICOLOGICAL ENDPOINTS IN FRESHWATER GASTROPODS** *Rebecca K Osborne, Patricia L Gillis & Ryan S Prosser*
Platform 3 11:00 a.m.	**EFFECT OF DECLINING VIABILITY AND RISING TEMPERATURE ON OXYGEN DEMAND OF MUSSEL BROODS** *Jim Stoeckel, Ryan Fluharty & Hisham Abdelrahman*	**Platform 8 11:00 a.m.**	**POPULATION GENOMICS OF THE CRITICALLY IMPERILED GENUS *PLETHOBASUS*** *McKenna Pa Burns, Steven R Hein & David J Berg*	**Platform 13 11:00 a.m.**	**TRANSFORMATION SUCCESS OF *LAMPSILIS CARDIUM* GLOCHIDIA EXPOSED TO A MIXTURE OF URBAN CONTAMINANTS AT ENVIRONMENTALLY RELEVANT CONCENTRATION** *Justin C Rappold, Mandy Annis & Daelyn A Woolnough*

	Jim Stoeckel, Ryan Fluharty & Hisham Abdelrahman		*McKenna Pa Burns, Steven R Hein & David J Berg*		**ENVIRONMENTALLY RELEVANT CONCENTRATION** *Justin C Rappold, Mandy Annis & Daelyn A Woolnough*
Platform 4 11:20 a.m.	**EFFECTS OF THERMAL AND HYPOXIA STRESS VARY AMONG MUSSEL SPECIES AND SUBPOPULATIONS IN CENTRAL TEXAS** *Austin Haney, James Stoeckel, Hisham Abdelrahman & Brian Helms*	**Platform 9 11:20 a.m.**	**PHYLOGEOGRAPHY OF GULF SLOPE *ELLIPTIO* TAX** *Michael M Gangloff, Victoria C Fowler, Daniel Mason, Jonathan D Wells & Lynn M Siefferman*	**Platform 14 11:20 a.m.**	**ASSESSING THE EFFECT OF SALT-LADEN WINTER RUNOFF ON FRESHWATER MUSSELS** *Patricia L Gillis, Joseph Salerno, Quintin Rochfort, Vicki McKay, Austin Pratt, James Bennett & Ryan Prosser*
Platform 5 11:40 a.m.	**FRESHWATER MUSSEL LIFE HISTORY AND ADAPTIVE MANAGEMENT AT THE CLAYTOR HYDROELECTRIC PROJECT, NEW RIVER, VIRGINIA** *William C Fleece, Dillon McNulty, Elizabeth Dilbone, Jon Magalski & Liz Parcell*	**Platform 10 11:40 a.m.**	**PHYLOGEOGRAPHIC PATTERNS AMONG THE LANCEOLATE *ELLIPTIO* SPECIES COMPLEX** *Hans R Lohmeyer, Michael M Gangloff, Tori V Fowler, Jon D Wells & Gretchen D Bailey*	**Platform 15 11:40 a.m.**	**BIOACCUMULATIVE AND ECOLOGICAL RESPONSES OF UNIONIDS TO AGRICULTURAL AND URBAN CONTAMINANTS AT ENVIRONMENTALLY RELEVANT CONCENTRATIONS** *Daelyn A Woolnough, Mandy Annis, Stephanie P Gill, et al.*

LUNCH (ON YOUR OWN) AND COMMITTEE MEETINGS (HILL COUNTRY FOYER FOR BOXED LUNCHES)
Gastropod Status & Distribution – Nueces Room
Environmental Quality and Affairs – Frio Room
Information Exchange – Blanco Room
Propagation and Restoration – Llano Room
Ad hoc – Ecosystem Services – Pecan Room
Ad hoc – Chapters / International – Chula Vista
Awards – Rio Grande East Room
Ad hoc – Professional Certification – Rio Grande Center Room
12:00 p.m. – 2:00 p.m.

SESSION 4: ANTHROPOGENIC IMPACTS II Monday, 2:00 p.m. – 3:20 p.m. Rio Grande East *Moderator: Jeremy Tiemann*		SESSION 5: GENETICS & PHYLOGENY II Monday, 2:00 p.m. – 3:20 p.m. Rio Grande Center *Moderator: Nathan Johnson*		SESSION 6: CONTAMINANTS & ECOTOXICOLOGY II Monday, 2:00 p.m. – 3:20 p.m. Rio Grande West *Moderator: Daelyn Woolnough*	
Platform 16 2:00 p.m.	**USE OF MUSSELS AS SENTINELS IN THE CONFLICT FOR WATER USES: EXPLOITING MUSSELS' SENSITIVITY TO OPTIMIZE WATER RESOURCE MANAGEMENT WITHOUT THREATENING BIODIVERSITY** *Nicoletta R Riccardi, Camilla Della Torre, Jouni Taskinen & Maria Urbanska*	**Platform 20 2:00 p.m.**	**UNIOVERSE: PHYLOGENOMIC RESOURCE FOR RECONSTRUCTING FRESHWATER MUSSEL EVOLUTION** *John M Pfeiffer, Larry Page & Jesse Breinholt*	**Platform 24 2:00 p.m.**	**BIOACCUMULATION POTENTIAL AND FATTY ACIDS OF UNIONIDS EXPOSED TO CONTAMINANTS FOUND IN AGRICULTURAL WATERSHEDS** *Stephanie P Gill, Mandy Annis & Daelyn A Woolnough*
Platform 17 2:20 p.m.	**FRESHWATER MOLLUSK DIE-OFF RESPONSE DEVELOPMENT AND ONE HEALTH ASSESSMENT** *Nancy Boedeker & Brant Fisher*	**Platform 21 2:20 p.m.**	**UTILIZING ANCHORED HYBRID ENRICHMENT TO TEST THE MONOPHYLY OF THE FRESHWATER MUSSEL GENUS *POTAMILUS* (BIVALVIA: UNIONIDAE)** *Chase H Smith, John M Pfeiffer & Nathan A Johnson*	**Platform 25 2:20 p.m.**	**METHOD DEVELOPMENT FOR SHORT-TERM EFFLUENT TESTS WITH A FRESHWATER MUSSEL (FATMUCKET, *LAMPSILIS SILIQUOIDEA*)** *Ning Wang, James Kunz, Doug Hardesty, Jeffery Steevens, et al.*
Platform 18 2:40 p.m.	**DROUGHT-INDUCED MASS MORTALITY OF FRESHWATER MUSSELS ALTERS ECOSYSTEM FUNCTION: A MESOCOSM EXPERIMENT** *Traci P Dubose, Carla L Atkinson, Caryn C Vaughn & Stephen W Golladay*	**Platform 22 2:40 p.m.**	**FRESHWATER MUSSELS (BIVALVIA: UNIONIDAE) FROM THE RISING SUN (FAR EAST ASIA): PHYLOGENY, SYSTEMATICS AND DISTRIBUTION** *Manuel Lopes-Lima, Akimasa Hattori, Takaki Kondo, et al.*	**Platform 26 2:40 p.m.**	**EFFECTS OF AMMONIA ON RESPIRATION AND VALVE CLOSURE OF TWO MUSSEL SPECIES FROM CENTRAL TEXAS** *Rebecca Gibson & Jim Stoeckel*
Platform 19 3:00 p.m.	**ASSESSING THE TRANSFERABILITY OF A FRESHWATER FUNDAMENTAL NICHE MODEL WITHIN THE OZARK ECOREGION, MISSOURI** *Jordan N Holtswarth, Amanda E Rosenberger, Garth Lindner & Kayla Key*	**Platform 23 3:00 p.m.**	**PATTERNS OF GENETIC VARIATION, STRUCTURE AND THE COMPLEX HISTORIES OF UNIONID POPULATIONS IN GLACIATED REGIONS OF NORTH AMERICA** *David T Zanatta*	**Platform 27 3:00 p.m.**	**COMPARATIVE TOXICITY OF SELECTED ALGAECIDES TO FRESHWATER MUSSELS** *Sean B Buczek, W Gregory Cope, Meredith Shehdan, West M Bishop, Robert J Richardson, Joann M Burkholder, Thomas J Kwak, Justin Nawrocki, Tom Warmuth & Monte A McGregor*
AFTERNOON BREAK (RIO GRANDE FOYER) 3:20 p.m. – 3:40 p.m.					

SESSION 7: SOUTHWESTERN MOLLUSKS I **Monday, 3:40 p.m. – 4:40 p.m.** **Rio Grande East** *Moderator: Kevin Cummings*		**SESSION 8: GENETICS & PHYLOGENY III** **Monday, 3:40 p.m. – 4:40 p.m.** **Rio Grande Center** *Moderator: David Campbell*		**SESSION 9: CONTAMINANTS & ECOTOXICOLOGY III** **Monday, 3:40 p.m. – 4:40 p.m.** **Rio Grande West** *Moderator: Janet Clayton*	
Platform 28 3:40 p.m.	**THE FRESHWATER MUSSELS OF MÉXICO (UNIONIDAE & MYCETOPODIDAE)** *Kevin S Cummings, Charles R Randklev, Kentaro Inoue, Jeremy S Tiemann, Nathan A Johnson, John M Pfeiffer, Daniel L Graf, Tom Miller, Amy L Burden & Edna Naranjo-García*	**Platform 31 3:40 p.m.**	**POPULATION GENETICS OF THE CAROLINA HEELSPLITTER (*LASMIGONA DECORATA*) A CRITICALLY-ENDANGERED FRESHWATER MUSSEL** *Victoria C Fowler & Michael Gangloff*	**Platform 34 3:40 p.m.**	**APPARENT MICROCYSTIN-INDUCED MUSSEL KILL WITHIN A SMALL IMPOUNDMENT IN WEST VIRGINIA** *Janet L Clayton, Kevin J Oxenrider, Brandon J Keplinger & Clayton D Raines*
Platform 29 4:00 p.m.	**ASSESSING THE GENUS *POPENAIAS* FRIERSON, 1927, IN THE MEXICAN GULF COASTAL DRAINAGES** *Kentaro Inoue, Kevin S Cummings, Jeremy S Tiemann, Thomas D Miller, Chase H Smith, Nathan A Johnson, Edna Naranjo-García & Charles R Randklev*	**Platform 32 4:00 p.m.**	**SPLITTING HEELS: INVESTIGATIONS INTO THE LASMIGONA GENUS** *Alissa M Ganser, Eric M Hallerman & Jess W Jones*	**Platform 35 4:00 p.m.**	**TRACE ELEMENT ASSESSMENT AND EXPOSURE OFJUVENILE RAINBOW MUSSELS (*VILLOSA IRIS*) IN THE POWELL RIVER IN VIRGINIA AND TENESSEE** *Andrew Phipps, Serena Ciparis, Carl E Zipper & Jess W Jones*
Platform 30 4:20 p.m.	**LOCAL GENETIC ADAPTATION AND POPULATION STRUCTURE OF A FEDERALLY ENDANGERED UNIONID, *POPENAIAS POPEII*** *Steven R Hein, Daniel A Trujillo & David J Berg*	**Platform 33 4:20 p.m.**	**GENETIC STRUCTURE OF *OBOVARIA OLIVARIA* (HICKORYNUT) REVEALED USING MTDNA AND SNPS** *Jamie Bucholz, David Zanatta & Nicholas M Sard*	**Platform 36 4:20 p.m.**	**COMBINED EFFECTS OF TRACE-METAL MIXTURES ON JUVENILE RAINBOW MUSSELS (*VILLOSA IRIS*)** *Tony Timpano, Jess W Jones, Braven Beaty, Matthew Hull, David J Soucek & Carl E Zipper*

POSTER SESSION (REGENCY EAST)
6:00 p.m. – 7:00 p.m.

SOCIAL – ROADMAP BREWING COMPANY
(7:00 p.m. – 10:00 p.m.)

WELCOME & PLENARY 3
Tuesday, 8:00 a.m. – 9:15 a.m.
Regency East

Student Papers are denoted in RED

Plenary 3 8:00 a.m.	**ZEN & DEEP EVOLUTION: WHEN DID YOUR LIFE BEGIN?** *Fred Allendorf*				
SESSION 10: SURVEYS & MONITORING I **Tuesday, 9:40 a.m. – 12:00 p.m.** **Rio Grande East** *Moderator: Alison Stodola*		**SESSION 11: SOUTHWESTERN MOLLUSKS II** **Tuesday, 9:40 a.m. – 12:00 p.m.** **Rio Grande Center** *Moderator: Shaun Donovan*		**SESSION 12: GENETICS & PHYLOGENY IV** **Tuesday, 9:40 a.m. – 12:00 p.m.** **Rio Grande West** *Moderator: John Pfeiffer*	
Platform 37 9:40 a.m.	**MONITORING UNIONID ASSEMBLAGES OF FLORIDA: BASELINES, THREATS, AND CONSERVATION CHALLENGES** *Sahale Casebolt & Susan R Geda*	**Platform 44 9:40 a.m.**	**EXPLORATION OF A REINTRODUCTION IN THE HIGHLY URBANIZED MISSION REACH OF THE SAN ANTONIO RIVER** *Shaun M Donovan, Chris Vaughn, Doug Knabe & Larry Larralde*	**Platform 51 9:40 a.m.**	**INTEGRATING MOLECULAR AND MORPHOLOGICAL DATA TO CONFIRM NEW RECORDS OF *PLEUROBEMA RIDDELLII* (LEA, 1862), A FRESHWATER MUSSEL BEING CONSIDERED FOR PROTECTION UNDER THE ENDANGERED SPECIES** *Nathan A Johnson, Chase H Smith, Caitlin E Beaver, Paul D Hartfield & Charles R Randklev*
Platform 38 10:00 a.m.	**SPATIAL VARIATION IN COMPOSITION OF MUSSEL COMMUNITIES IN RELATION TO MODELED HABITAT SUITABILITY IN THE MERAMEC DRAINAGE OF MISSOURI** *Kayla N Key & Amanda E Rosenberger*	**Platform 45 10:00 a.m.**	**PRIORITIZING DAM REMOVAL FOR FRESHWATER MUSSEL CONSERVATION IN THE GUADALUPE – SAN ANTONIO RIVER SYSTEM** *Erin D Dascher*	**Platform 52 10:00 a.m.**	**ESTABLISHING THE SPECIES BOUNDARIES, RELATIONSHIPS, AND DISTRIBUTIONS WITHIN QUADRULA (RAFINESQUE, 1820)** *Sean M Keogh, Bernard Sietman, Kentaro Inoue, Andrew Simons & Charles R Randklev*
Platform 39 10:20 a.m.	**BASIN-WIDE SURVEY OF THE KALAMAZOO RIVER (MICHIGAN, USA) USING A SEQUENTIAL TIMED SEARCH AND QUADRAT APPROACH** *Scott M LaValley & Daelyn A Woolnough*	**Platform 46 10:20 a.m.**	**DETERMINING THE SURVIVABILITY AND GROWTH OF FRESHWATER MUSSELS IN A RECENTLY RESTORED STRETCH OF THE UPPER SAN ANTONIO RIVER TO STEER A DECISION ON REINTRODUCTION** *Christopher R Vaughn & Shaun M Donovan*	**Platform 53 10:20 a.m.**	**ASSESSING GENETIC DIVERSITY IN WILDSTOCK, BROODSTOCK AND HATCHERY-REARED PROGENY OF ENDANGERED EPIOBLASMA SPECIES** *Jess W Jones, Katlyn Ortiz & Eric M Hallerman*

Platform 40 10:40 a.m.	**A PRELIMINARY ANALYSIS OF MUSSEL POPULATION DYNAMICS IN THE KISHWAUKEE RIVER, ROCKFORD, IL** *Sarah Douglass, Jeremy Tiemann, Ethan Kessler & Michael Dreslik*	**Platform 47 10:40 a.m.**	**FRESHWATER MUSSEL HABITAT MODELING AND ENVIRONMENTAL FLOW ANALYSIS IN THE LOWER COLORADO RIVER, TEXAS** *Bradley M Littrell, Kyle T Sullivan & Edmund L Oborny, Jr.*	**Platform 54 10:40 a.m.**	**CONSERVATION GENOMIC ASSESSMENT OF WILD AND CAPTIVE POPULATIONS OF THE LOUISIANA PEARLSHELL, *MARGARITIFERA HEMBELI* (CONRAD), USING RADSEQ** *Nicole L Garrison, Nathan Whelan & Paul Johnson*
Platform 41 11:00 a.m.	**MESOHABITAT RELATIONSHIPS TO ABUNDANCE FOR THREE MUSSELS FOUND IN NORTHEASTERN U.S. STREAMS** *Ayla J Skorupa, Allison H Roy, Peter D Hazelton, David Perkins, Sean C Sterrett & Timothy Warren*	**Platform 48 11:00 a.m.**	**DISTRIBUTIONAL PATTERNS AND HABITAT UTILIZATION OF FRESHWATER MUSSEL COMMUNITIES IN THE MAINSTEM COLORADO RIVER, TEXAS** *Kyle T Sullivan & Bradley M Littrell*	**Platform 55 11:00 a.m.**	**EVOLUTION OF HOST INFECTION STRATEGIES IN THE LAMPSILINE MUSSELS (BIVALVIA: UNIONIDAE): A PHYLOGENOMIC PERSPECTIVE** *Trevor L Hewitt, Diarmaid Ó Foighil & Amanda Haponski*
Platform 42 11:20 a.m.	**INVESTIGATING THE EFFICACY OF FLOATING VS HAND-HELD PIT TAG READERS AT FRESHWATER MUSSEL TRANSLOCATION SITES** *Alison P Stodola, Rachel M Vinsel, Jeremy S Tiemann & Kirk W Stodola*	**Platform 49 11:20 a.m.**	**MUSSELS OF TEXAS: VISUALIZING STATEWIDE MUSSEL BIODIVERSITY DATA ONLINE** *Yang Cao, Charles R Randklev, Jennifer Morton, Ross Anderson, Mark Fisher & Roel Lopez*	**Platform 56 11:20 a.m.**	**MORPHOLOGY AND PATTERNS IN ARBORESCENT PAPILLAE OF THE INCURRENT APERTURE AMONG PEARLSHELL MUSSELS, FAMILY MARGARITIFERIDAE** *André L Martel, Arthur Bogan, Ivan Bolotov, Juergen Geist, Paul Johnson, et al.*
Platform 43 11:40 a.m.	**MUSSEL AND HABITAT ASSESSMENT OF THE DUCK RIVER SYSTEM, TENNESSEE** *Kristin L Irwin, John B Alford, Gerald R Dinkins, Steven A Ahlstedt & Amanda E Rosenberger*	**Platform 50 11:40 a.m.**	**HYDRAULIC REQUIREMENTS OF FRESHWATER MUSSELS (UNIONIDAE) AND A CONCEPTUAL FRAMEWORK FOR PREDICTING HOW MUSSELS RESPOND TO BED MOBILITY: TWO CASE STUDIES FROM THE BRAZOS AND TRINITY RIVERS OF THE WESTERN GULF COASTAL PLAIN REGION OF SOUTH-CENTRAL USA** *Charles R Randklev, Michael A Hart, Jennifer Khan, Eric Tsakiris & Clinton R Robertson*	**Platform 57 11:40 a.m.**	**FRESHWATER MUSSELS TRANSLOCATED INTO CAPTIVITY EXHIBIT UP-REGULATION OF GENES INVOLVED IN STRESS AND ENERGY METABOLISM** *Ieva Roznere, Brandon T Sinn & G Thomas Watters*

LUNCH (ON YOUR OWN) AND COMMITTEE MEETINGS (HILL COUNTRY FOYER FOR BOXED LUNCHES)
Mussel Status & Distribution – Nueces Room
Guidelines and techniques – Frio Room
Genetics – Rio Grande East Room
Outreach – Rio Grande Center Room
Symposia – Rio Grande West Room
12:00 p.m. – 2:00 p.m.

SESSION 13: CONTAMINANTS & ECOTOXICOLOGY IV Tuesday, 2:00 p.m. – 3:20 p.m. Rio Grande East *Moderator: Jennifer Archambault*		SESSION 14: PROPAGATION I Tuesday, 2:00 p.m. – 3:20 p.m. Rio Grande Center *Moderator: Monte McGregor*		SESSION 15: SURVEYS II Tuesday, 2:00 p.m. – 3:20 p.m. Rio Grande West *Moderator: Allison Roy*	
Platform 58 2:00 p.m.	**QUANTIFYING POLLUTANT-REMOVAL ECOSYSTEM SERVICES BY UNIONID MUSSELS** *Jennifer M Archambault, W Gregory Cope, Meredith L Shehdan, Clayton L Lynch, Sean B Buczek, Teresa J Newton, Heidi L Dunn & Chris B Eads*	**Platform 62 2:00 p.m.**	**METAMORPHOSIS OF MUSSEL LARVAE WITHOUT A HOST FISH: ADVANCES IN IN VITRO CULTURE USING A COMBINATION OF SERUM MIXTURES IN A PHYSIOLOGICAL NUTRIENT SOLUTION** *Monte A McGregor & Julieann Jacobs*	**Platform 66 2:00 p.m.**	**EVALUATING THE FEEDING ECOLOGY OF ENDEMIC FRESHWATER MUSSELS (UNIONIDAE) IN CENTRAL TEXAS USING STABLE ISOTOPE AND FATTY ACID ANALYSIS** *Kaelyn J Fogelman, Jim Stoeckel, Hisham Abdelrahman, Brendan Higgins, Haixin Peng & Brian Helms*
Platform 59 2:20 p.m.	**CHARACTERIZING IMPACT OF CONTAMINANTS OF EMERGING CONCERN ON JUVENILE TRANSFORMATION: AN APPLICATION OF ZERO INFLATED POISSON LINEAR MIXED MODELS AND DOSE RESPONSE CURVE** *Lacey D Rzodkiewicz, Mandy Annis & Daelyn A Woolnough*	**Platform 63 2:20 p.m.**	**FRESHWATER MUSSEL IN VITRO CULTURE METHOD USING SERUM REPLACEMENTS** *Jacqualyn Halmbacher*	**Platform 67 2:20 p.m.**	**USING STANDARDIZED PROTOCOLS TOWARD IMPROVING RANGEWIDE CONSERVATION OF RARE MUSSEL SPECIES** *Allison H Roy, Peter D Hazelton & Sean C Sterrett*
Platform 60 2:40 p.m.	**INFLUENCE OF *CORBICULA FLUMINEA* AND WATER TEMPERATURE ON JUVENILE MUSSEL GROWTH IN THE WILD** *Drew White, Wendell R Haag, Steven J Price, Jacob J Culp & Monte A McGregor*	**Platform 64 2:40 p.m.**	**PROPAGATION AND CULTURE EFFORTS AT THE VIRGINIA FISHERIES AND AQUATIC WILDLIFE CENTER** *Rachel A Mair, Amy Maynard, Brian T Watson, Michael Odom, Benjamin Davis, Bryce Maynard & John Moore*	**Platform 68 2:40 p.m.**	**ARE STANDARDIZED PROTOCOLS IN OHIO MEASURING UP? A 5 YEAR REVIEW OF SURVEY DATA** *Rebecca Winterringer, Megan Michael, Lindsey Moss & Sarah Bender*
Platform 61 3:00 p.m.	**BIOMARKER RESPONSES OF JUVENILE FRESHWATER MUSSELS TO STARVATION AND EXPOSURE TO STREAM CONDITIONS** *Wendell Haag, Steven Price, Andrea Darracq, Jacob Culp & Monte McGregor*	**Platform 65 3:00 p.m.**	**DEVELOPMENT OF EMPIRICALLY-DRIVEN GENETIC GUIDELINES FOR CAPTIVE PROPAGATION OF IMPERILED FRESHWATER MUSSELS** *Nichelle M VanTassel & David T Zanatta*	**Platform 69 3:00 p.m.**	**WHAT IN THE MUCK IS GOING ON? AN OVERVIEW OF SURVEY METHODOLOGY, EFFORT, IMPLEMENTATION, AND REPORTING REQUIREMENTS THROUGH A CONSULTANT'S VIEW BUCKET** *David A Foltz, II, John P Spaeth & Casey D Swecker*
AFTERNOON BREAK (RIO GRANDE FOYER) 3:20 p.m. – 3:40 p.m.					

SESSION 16: MANAGEMENT I **Tuesday, 3:40 p.m. – 5:40 p.m.** **Rio Grande East** *Moderator: Heidi Dunn*		**SESSION 17: PROPAGATION II** **Tuesday, 3:40 p.m. – 5:40 p.m.** **Rio Grande Center** *Moderator: Jess Jones*		**SESSION 18: SOUTHWESTERN MOLLUSKS III** **Tuesday, 3:40 p.m. – 5:40 p.m.** **Rio Grande West** *Moderator: Neil Ford*	
Platform 70 3:40 p.m.	**SCIENTIFIC RIVER DIVING SAFETY: A NEW PADI SPECIALTY CERTIFICATION TO COMPLEMENT THE FRESHWATER MUSSEL CURRICULUM AT THE NATIONAL CONSERVATION TRAINING CENTER (NCTC).** *Matthew A Patterson, Heidi Dunn, Mitch Osborne, Tyler Hern, Nathan Eckert & Ryan Hagerty*	**Platform 76 3:40 p.m.**	**EFFECTS OF DIET SUPPLEMENTS ON JUVENILE FRESHWATER MUSSEL SURVIVAL AND GROWTH** *Andrew T McDonald, Meghan W Owings, Monte McGregor & Wendell Haag*	**Platform 82 3:40 p.m.**	**GROWTH RATES IN THREE POPULATIONS OF LOUISIANA PIGTOE, *PLEUROBEMA RIDDELLII*, IN THE NECHES RIVER OF NORTHEASTERN TEXAS** *David F Ford & Neil B Ford*
Platform 71 4:00 p.m.	**RESTORATION AND MONITORING OF MUSSELS IN THE CLINCH AND POWELL RIVERS, VIRGINIA AND TENNESSEE: RECONCILING EXPECTED VERSUS MEASURED ABUNDANCES AT RELEASE SITES** *John M Hyde & Jess W Jones*	**Platform 77 4:00 p.m.**	**STANDARDIZING A NON-LETHAL METHOD FOR CHARACTERIZING THE REPRODUCTIVE STATUS AND LARVAL DEVELOPMENT OF FRESHWATER MUSSELS** *Caitlin E Beaver & Nathan A Johnson*	**Platform 83 4:00 p.m.**	**IDENTIFICATION OF POTENTIAL FISH HOSTS FOR FRESHWATER MUSSELS OF EAST TEXAS USING COMMUNITY MODELING TECHNIQUES** *Robert A Francis, Ashley D Walters, Neil B Ford & David J Berg*
Platform 72 4:20 p.m.	**ESTIMATING APPALACHIAN ELKTOE (*ALASMIDONTA RAVENELIANA*) ABUNDANCE AND OCCUPANCY IN THE SOUTH TOE RIVER, NC** *Chantelle L Rondel, Michael M Gangloff & Jason Mays*	**Platform 78 4:20 p.m.**	**ESTIMATING DEMOGRAPHIC VITAL RATES OF *EPIOBLASMA BREVIDENS* AND *EPIOBLASMA CAPSAEFORMIS* FROM ANNUAL POPULATION CENSUSES IN THE CLINCH RIVER, TENNESSEE, FROM 2004–2014** *Tim Lane, Brett Ostby, Don Hubbs, Robert Butler & Jess Jones*	**Platform 84 4:20 p.m.**	**EVALUATION OF THE LETHAL AND SUBLETHAL EFFECTS OF MUSSEL TRANSLOCATION: TWO CASE STUDIES FROM THE SOUTHWESTERN UNITED STATES** *Michael Hart, Charles R Randklev, Eric Tsakiris & Mark Fisher*
Platform 73 4:40 p.m.	**DENSITY-DEPENDENT EFFECTS OF FRESHWATER MUSSELS ON GROWTH OF EMERGENT AQUATIC PLANTS** *Jonathan W Lopez, Thomas B Parr & Caryn C Vaughn*	**Platform 79 4:40 p.m.**	**THE PHENOLOGICAL RELATIONSHIP BETWEEN MUSSEL GLOCHIDIA AND SPAWNING RIVER HERRING** *Julia S Cox & Allison Roy*	**Platform 85 4:40 p.m.**	**USING LIFE-HISTORY STRATEGY AND HISTORICAL BASELINE INFORMATION TO EVALUATE THE CONSERVATION STATUS OF FRESHWATER MUSSELS (FAMILY: UNIONIDAE) IN THE NAVASOTA RIVER, TEXAS** *Jennifer M Khan, Jack Dudding, Michael Hart, Eric Tsakiris & Charles R Randklev*

Platform 74 5:00 p.m.	**EVALUATING HOST FISH MOVEMENT FOR THE WINGED MAPLELEAF MUSSEL (*QUADRULA FRAGOSA*): WHY PROXIMITY MATTERS** *Michelle Bartsch, Diane Waller, Wi Brent Knights, Jon Vallazza, Eric Lord, Mark Hove & Byron Karns*	**Platform 80 5:00 p.m.**	**PHYLOGENETIC AND FUNCTIONAL TRAIT DIVERSITY DRIVES STREAM ECOSYSTEM FUNCTION** *Carla L Atkinson, Brian C Van EE & John M Pfeiffer*	**Platform 86 5:00 p.m.**	**HOW REGULATORY COMPLIANCE HAS GUIDED CONSULTANT CONTRIBUTION TO TEXAS FRESHWATER MUSSEL CONSERVATION** *Jacob D Owen, Jeremy D Maikeotter, David McBee & Krista McDermid*
Platform 75 5:20 p.m.	**ANTIBIOTIC TREATMENT AND BACTERIAL CHALLENGE CAUSES CHANGES IN OVERALL BACTERIAL DIVERSITY AND COMPOSITION IN THE FRESHWATER MUSSEL *VILLOSA NEBULOSA* (CONRAD, 1834)** *Alison Aceves, Paul D Johnson, Francisca A Burgos, Stephen A Bullard & Cova R Arias*	**Platform 81 5:20 p.m.**	**SPECIES BOUNDARIES AND LEVELS OF INTERMIXING BETWEEN *LAMPSILIS SILIQUOIDEA* AND *L. RADIATA*** *Isabel P Hannes, Lyubov L Burlakova, Howard R Lasker & David T Zanatta*	**Platform 87 5:20 p.m.**	**UPDATE ON FRESHWATER MUSSEL SPECIES CURRENTLY UNDER REVIEW FOR POSSIBLE ENDANGERED SPECIES ACT PROTECTIONS IN TEXAS** *Gary Pandolfi*
PLENARY, DINNER, AND AUCTION (REGENCY EAST) **6:30 p.m. – 11:00 p.m.**					

WELCOME & PLENARY 4
Wednesday, 8:15 a.m. – 9:15 a.m.
Regency East

Student Papers are denoted in RED

Plenary 4 8:15 a.m.	**THE ELUSIVE SPRING SNAILS: A NEW CONSERVATION FOCUS IN WESTERN NORTH AMERICA** *Jeanette Howard*				
SESSION 19: MUSSEL KILLS **Wednesday, 9:40 a.m. – 12:00 a.m.** **Rio Grande East** *Moderator: Diane Waller*		**SESSION 20: RESTORATION TOOLS I** **Wednesday, 9:40 a.m. – 12:00 a.m.** **Rio Grande Center** *Moderator: Caryn Vaughn*		**SESSION 21: GASTRPODA** **Wednesday, 9:40 a.m. – 12:00 a.m.** **Rio Grande West** *Moderator: Kathryn Perez*	
Platform 88 9:40 a.m.	**METABOLIC FINGERPRINTING AS A HEALTH ASSESSMENT TOOL: CHARACTERIZING TISSUE RESPONSE** *Diane L Waller, Joel Putnam & Jeff Bernardy*	**Platform 95 9:40 a.m.**	**EXPLORING THE EFFECT OF SHELL DEFORMITY ON AGE AND GROWTH OF MUSSELS FROM THE NASHUA RIVER, MA** *Andrew M Gascho Landis, Kyle Olivencia, Peter D Hazelton & Andrew McElwain*	**Platform 102 9:40 a.m.**	**A STUDY ON THE DIVERSITY OF SNAIL SPECIES WITHIN NNAMDI AZIKIWE UNIVERSITY AWKA NIGERIA** *Charles Obinwanne Okoye & John Joseph Okeke*
Platform 89 10:00 a.m.	**EXPLORING MUSSEL POPULATION IMPAIRMENT IN THE ELK RIVER, WEST VIRGINIA** *Janet L Clayton*	**Platform 96 10:00 a.m.**	**TEMPERATURE DEPENDENCE OF FUNCTIONAL TRAITS AND THERMAL THRESHOLDS OF FRESHWATER MUSSELS** *Brian C Van EE & Carla L Atkinson*	**Platform 103 10:00 a.m.**	**WHAT IS *PRISTINICOLA*?** *David C Campbell & Edward Johannes*
Platform 90 10:20 a.m.	**IDENTIFICATION OF BACTERIA CULTURED FROM MUSSEL MORTALITY EVENTS** *Sara M Erickson, Eric Leis, Diane Waller, Susan Knowles, Tony Goldberg, Joel Putnam, Richard Jordan, Emilie Blevins & Jesse Weinzinger*	**Platform 97 10:20 a.m.**	**SHIFTING HOTSPOTS: OVERLAPPING AGGREGATIONS OF MUSSELS AND FISH INTERACT TO INFLUENCE RESOURCE HETEROGENEITY AND FLUXES IN STREAMS** *Caryn C Vaughn, Keith B Gido, Thomas B Parr, Traci P Dubose & Garrett W Hopper*	**Platform 104 10:20 a.m.**	**DETERMINING THE SPECIFIC STATUS OF AN UNUSUAL, PHREATIC, TEXAS CAVESNAIL (MOLLUSCA; GASTROPODA; HYDROBIIDAE)** *Dominique A Alvear, Pete Diaz, Randy Gibson, Benjamin Hutchins, Benjamin Schwartz & Kathryn E Perez*
Platform 91 10:40 a.m.	**CASES AND REASONS OF FRESHWATER MUSSEL DIE-OFFS IN POLAND** *Maria Urbańska, Agnieszka Pękala-Safińska, Wojciech Andrzejewski, Małgorzata Ożgo, Ewa Paździor & Joanna Szablewska*	**Platform 98 10:40 a.m.**	**USING BAYESIAN DECISION NETWORKS TO GUIDE RESTORATION OF FRESHWATER MUSSELS IN ILLINOIS** *Sara Andree, Alison Stodola & Sarah Douglass*	**Platform 105 10:40 a.m.**	**UPDATING THE KNOWN RANGES OF TEXAS'S ENDEMIC, FRESHWATER CAVESNAILS (MOLLUSCA; GASTROPODA; "HYDROBIIDAE")** *Kathryn E Perez, Dominique Alvear, Pete Diaz, Randy Gibson, Benjamin Hutchins & Benjamin Schwartz*

Platform 92 11:00 a.m.	**DOCUMENTING ENIGMATIC MUSSEL DIE-OFFS IN WESTERN U.S. RIVERS** *Emilie Blevins, Cynthia Tait & F Teal Waterstrat*	**Platform 99 11:00 a.m.**	**ORDINATION ANALYSIS REVEALS THREE DISTINCT FRESHWATER MUSSEL ASSEMBLAGES CORRELATED WITH RIVER MILE AND AGRICULTURE IN THE BLACK RIVER, MISSOURI AND ARKANSAS** *Alan D Christian, Sean T McCanty, Thomas Dimino, Helenmary Hotz, Stephan E McMurray & John L Harris*	**Platform 106 11:00 a.m.**	**DOCUMENTING RARE AQUATIC SNAILS (COCHLIOPIDAE, LITHOGLYPHIDAE & HYDROBIIDAE) FROM THE HYPORHEIC ZONE OF TEXAS STREAMS: A NEW HABITAT FOR POORLY KNOWN SPECIES** *Benjamin T Hutchins, Aaron P Swink, Benjamin F Schwartz, Dominique Alvear & Kathryn E Perez*
Platform 93 11:20 a.m.	**ASSESSING A SUSPECTED MASS MORTALITY EVENT OF PHEASANTSHELL (*ACTINONAIAS PECTOROSA*) IN THE CLINCH RIVER USING LONG-TERM MONITORING DATA** *Caitlin Carey, Andrew Phipps, Jordan Richard, Brett Ostby, Tim Lane & Jess Jones*	**Platform 100 11:20 a.m.**	**A REVIEW OF COLLABORATIVE DECISION-MAKING PROCESSES: HELPING TO FIND A PATH TO COEXISTENCE** *David R Smith & Michelle A Haynes*	**Platform 107 11:20 a.m.**	**MESOHABITAT ASSOCIATIONS AND TROPHIC ECOLOGY OF ENDEMIC AND ENDANGERED SNAILS IN DESERT SPRING** *Weston H Nowlin, Nina E Noreika, Pete H Diaz & Chad Norris*
Platform 94 11:40 a.m.	**DO YOU NEED A FAT POCKETBOOK? CATALOGING MUSSEL PRODUCTION CAPABILITIES AND COSTS FOR USE IN NATURAL RESOURCE DAMAGE ASSESSMENT** *Serena Ciparis, Susan Lingenfelser & Anthony Velasco*	**Platform 101 11:40 a.m.**	**WIDELY AVAILABLE DATA CURRENTLY UNDER UTILIZED FOR SPECIES ASSESSMENTS, LISTING DECISIONS, AND DETERMINING THE TRAJECTORY OF RIVER CONDITIONS INTO THE FUTURE** *Thomas G Jones, Nathan Hoxie & Erica Pauley*	**Platform 108 11:40 a.m.**	**MORE IS BETTER: HUNDREDS OF NUCLEAR GENES IMPROVE UNDERSTANDING OF PLEUROCERIDAE (GASTROPODA: CERITHIOIDEA) RELATIONSHIPS** *Nathan V Whelan, Nicole Garrison, Paul D Johnson, Jeffrey T Garner & Ellen E Strong*
BUSINESS LUNCH & STUDENT AWARDS (REGENCY EAST) **12:00 p.m. – 2:30 p.m**					

SESSION 22: INVASIVE SPECIES **Wednesday, 2:40 p.m. – 3:40 p.m.** **Rio Grande East** *Moderator: Sarah Douglass*		**SESSION 23: RESTORATION TOOLS II** **Wednesday, 2:40 p.m. – 3:40 p.m.** **Rio Grande Center** *Moderator: Steve McMurray*		**SESSION 24: MANAGEMENT II** **Wednesday, 2:40 p.m. – 3:40 p.m.** **Rio Grande West** *Moderator: Casey Swecker*	
Platform 109 2:40 p.m.	**DISCOVERY OF A SILICATE ROCK-BORING ORGANISM AND MACROBIOEROSION IN FRESH WATER** *Ilya V Vikhrev, Ivan N Bolotov, Olga V Aksenova, Torkild Bakken, et al.*	**Platform 112 2:40 p.m.**	**STOCKING THE EASTERN PEARLSHELL (*MARGARITIFERA MARGARITIFERA*) IN NORWAY: EXPERIENCES FROM THE FIRST FEW YEARS** *Jon H Magerøy, Steinar Kålås, Ingrid Wathne, Anton Rikstad & Kristian Julien*	**Platform 115 2:40 p.m.**	**A DECADE OF EFFORTS TO GAIN ENDANGERED SPECIES ACT PROTECTION FOR IMPERILED FRESHWATER MOLLUSK** *Tierra R Curry*
Platform 110 3:00 p.m.	**CHARACTERIZING NONINDIGENOUS MOLLUSKS OF THE UNITED STATES** *Wesley M Daniel & Cayla R Morningstar*	**Platform 113 3:00 p.m.**	**HABITAT SUITABILITY AND POPULATION ASSESSMENT OF THE COLLAPSED LITTLE BLACK RIVER MUSSEL FAUNA, MISSOURI** *Matthew C Schrum, Amanda E Rosenberger & Stephen E McMurray*	**Platform 116 3:00 p.m.**	**MUSSEL SALVAGE AND RELOCATION EFFORTS ASSOCIATED WITH A LARGE-SCALE REMEDIATION PROJECT IN THE KALAMAZOO RIVER, MICHIGAN, U.S.** *Adam K Benshoff, John Spaeth & Casey Swecker*
Platform 111 3:20 p.m.	**SHOULD I STAY OR SHOULD I FLOW? THE CLASH BETWEEN *CORBICULA* E-DNA AND STREAM FLOW** *Jeremy S Tiemann, Amanda N Curtis, Sarah A Douglass, Mark A Davis & Eric R Larson*	**Platform 114 3:20 p.m.**	**INVESTING IN FRESHWATER MUSSEL BEDS FOR WATER QUALITY ENHANCEMENT: THE MUSSELS FOR CLEAN WATER INITIATIVE** *Danielle A Kreeger, Angela Padeletti, Kurt Cheng, Roger Thomas & Lance Butler*	**Platform 117 3:20 p.m.**	**RECOVERY ADVANCEMENT OF THE PALE LILLIPUT, *TOXOLASMA CYLINDRELLUS*: A FEDERALLY ENDANGERED FRESHWATER MUSSEL** *Paul Johnson, Todd Fobian, Michael Buntin, Don Hubbs, Dan Hua, Jesse Holifield, Thomas Tarpley & Jeff Garner*
AFTERNOON BREAK (REGENCY GRANDE FOYER) **3:40 p.m. – 4:00 p.m.**					

SESSION 25: MANAGEMENT III **Wednesday, 4:00 p.m.– 5:00 p.m.** **Rio Grande East** *Moderator: John Spaeth*		**SESSION 23: RESTORATION TOOLS III** **Wednesday, 4:00 p.m.– 5:00 p.m.** **Rio Grande Center** *Moderator: Daniel Symonds*		**SESSION 24: ECOLOGY** **Wednesday, 4:00 p.m.– 5:00 p.m.** **Rio Grande West** *Moderator: Bernard Sietman*	
Platform 118 4:00 p.m.	**LARGEST EVER ENDANGERED RAYED BEAN RELOCATION UNCOVERS FIRST RECORD OF NORTHERN RIFFLESHELL MUSSEL FROM NEW YORK.** *Casey Swecker, John Spaeth, Doug Locy, Adam Benshoff, David Foltz, Mitchell Kriege, Aaron Prewitt & Tom Jones*	**Platform 121 4:00 p.m.**	**USING REMOTE SENSING TECHNOLOGIES TO ASSIST IN DETERMINING AND MITIGATING EFFECTS OF ANTHROPOGENIC ACTIVITIES ON MUSSEL HABITAT AND ASSEMBLAGES** *Charlie Morgan*	**Platform 124 4:00 p.m.**	**INFECTION OF FRESHWATER PEARL MUSSEL (*MARGARITIFERA MARGARITIFERA*) GLOCHIDIA AFFECTS BROWN TROUT (*SALMO TRUTTA*) PREY HANDLING TIME AND GROWTH** *Niklas Wengstrom, Johan Hojesjo, Karl Filipsson, Hampus Kvarnliden, Lisa Loeb & Martin Osterling*
Platform 119 4:20 p.m.	**SEMI-NATURAL INFESTATION OF HOST FISH AND REINTRODUCTION OF A THREATENED MUSSEL** *Martin Osterling, Lena Andersson, Maria Stjernlöf, Anders Nilsson, Johan Hojesjo & Niklas Wengstrom*	**Platform 122 4:20 p.m.**	**EFFICACY OF SIDE SCAN SONAR PREDICTING SUITABLE MUSSEL HABITAT IN DEEP AND TURBID CONDITIONS IN THE OHIO RIVER** *Daniel E Symonds, Elizabeth K Dilbone, James D Kiser & W Cody Fleece*	**Platform 125 4:20 p.m.**	**ARE MASS DIE-OFF EVENTS ACTUALLY A GOOD THING FOR MUSSEL HEALTH?** *Jordan Richard, Eric Leis, Diane Waller, Susan Knowles, Tony Goldberg, Joel Putnam, Sara Erickson, & Emilie Blevins*
Platform 120 4:40 p.m.	**MUSSEL ASSEMBLAGE DYNAMICS OF A HIGGINS EYE PEARLYMUSSEL (*LAMPSILIS HIGGINSII*) ESSENTIAL HABITAT AREA IN THE UPPER MISSISSIPPI RIVER, USA** *John P Spaeth, Mitchell Kriege & Joseph Jordan*	**Platform 123 4:40 p.m.**	**BRIDGING THE DATA GAP IN THE PENNSYLVANIA DEPARTMENT OF TRANSPORTATION PROGRAMMATIC AGREEMENT** *Ryan Schwegman, Dale Dunford, Toni Zawisa & Gregory Zimmerman*		OPEN
DINNER ON YOUR OWN **MIXER AND MUSIC 7:00 p.m. – 10:00 p.m. (REGENCY EAST)**					

Plenary Sessions

Monday

WELCOME TO TEXAS AND INTRODUCTORY REMARKS

Craig Bonds
Texas Parks & Wildlife Department

Over the past 25 years, Texas Parks and Wildlife Department (TPWD) and partners have implemented a litany of survey, monitoring, research, and conservation actions for freshwater mollusks. In 1993, TPWD established freshwater mussel sanctuaries in reaches of river known to harbor diverse and abundant mussel beds. Considerable investments of public and private funds have been made in the voluntary-based restoration and preservation of springs, instream habitats, and riparian habitats in watersheds considered priorities for conservation of native freshwater fishes and mollusks. Efforts to manage invasive freshwater mollusks have involved risk assessments, research, public outreach, and regulatory actions to slow or prevent their spread. Listing of 15 species of freshwater mussels as State Threatened afforded additional regulatory protections that have helped avoid or minimize impacts to freshwater mussels from water infrastructure construction and maintenance projects. Although still building towards a comprehensive program, historic and ongoing investments to conserve freshwater mollusks in Texas have been substantial. However, human population growth and concomitant changes in land uses and increased water demands are expected to present even greater conservation challenges for freshwater mollusks. The theme of this symposium,*Life on the Edge: Reconciling Human Needs and Freshwater Mollusk Conservation*, is incredibly timely and relevant in Texas, and we look forward to the information exchange and collaboration that will result from this symposium

MULTISPECIES AND WATERSHED APPROACHES TO CONSERVATION OF FRESHWATER FISHES AND MOLLUSKS

Timothy Birdsong
Texas Parks & Wildlife Department

Innovative conservation approaches are needed to restore and preserve freshwater habitats, species and ecosystems, while simultaneously supporting human needs. Conceptual frameworks such as Conservation Opportunity Areas, Landscape Conservation Designs, and Native Fish Conservation Areas facilitate collaborative stewardship at watershed scales while incorporating species life history needs and acknowledging compatible human uses. Associated analytical approaches integrate conservation biology, connectivity, and spatial prioritization principles to provide rigorous, science-based, and spatially explicit tools to inform conservation planning. Innovative conservation planning approaches have yielded broad-based partnerships and leveraged funding and other resources to deliver large-scale, meaningful and transformative conservation actions for freshwater fishes and mollusks. This presentation will profile case studies from throughout Texas in successful application of these approaches.

Tuesday

ZEN & DEEP EVOLUTION: WHEN DID YOUR LIFE BEGIN?

Fred W. Allendorf
University of Montana

The Buddha taught that everything is connected and constantly changing. These fundamental observations of the world are shared by ecology and evolution. We are living in a time of unprecedented rates of extinction. Science provides us with the information that we need to address this extinction crisis. However, the problems underlying extinction generally do not result from a lack of scientific understanding, but they rather result from an unwillingness to take the needed action. I present mindfulness and meditative aspects of Zen practice that provide the deeper "knowing," or awareness that we need to inspire action on these problems.

BEHIND THE LENS WITH WYMAN MEINZER

Wyman Meinzer

"Behind the Lens" is a discussion about the work that goes into the creation of great imagery, from wildlife, sky, people and landscape. About 75 images will be presented with an explanation of how and why the images were created. The power point will end with a 4 minute showing of the video, "West Texas," a salute to all that defines our great state of Texas.

Wednesday

THE ELUSIVE SPRING SNAILS: A NEW CONSERVATION FOCUS IN WESTERN NORTH AMERICA

Jeanette Howard
The Nature Conservancy

Springsnails are one of the most abundant and diverse members of the endemic western North American aquatic biota. These tiny gastropods are imperiled by threats ranging from groundwater pumping to livestock grazing. During the past decade, this long-neglected group has emerged as a new focus of conservation-related activities, including protection of several species under the Endangered Species Act and monitoring and habitat restoration efforts. This talk will focus on springsnails in the context of this year's annual meeting theme – life on the edge: reconciling human needs and freshwater mollusk conservation. The talk will provide an overview of springsnail natural history, taxonomy and genetics, and discuss prospects for improving protection and restoration of springsnail habitats in the face of current and future threats.

Session 1: Anthropogenic Impacts I
Monday (10:20 – 12:00) – Rio Grande East

1. IMPACTS OF ACUTE AND CHRONIC HEAT STRESS ON POTENTIAL METABOLIC ACTIVITY (PMA) OF FRESHWATER MUSSELS

Hisham A Abdelrahman, Austin R Haney & James A Stoeckel
Auburn University, Auburn, AL

Anthropogenic factors may cause shifts in stream temperatures. Development of conservation and management plans for freshwater mussels requires an understanding of physiological responses to temperature shifts ranging from quick to gradual, and whether responses differ among species and subpopulations. In this study, we used the Potential Metabolic Activity (PMA) assay to evaluate cellular-level responses to acute and chronic thermal stress by three mussel species from central Texas (*Cyclonaias necki*, Guadalupe River; *C. petrina*, Colorado River; *C. pustulosa*, Colorado and Navasota rivers). The PMA assay measures activity of respiratory enzymes in the electron transport system and estimates how the maximum potential metabolic rate of an organism changes with temperature. To assess enzyme response to abrupt temperature changes, we acclimated mussels to a single temperature (21 ^{o}C) for >1 week, extracted enzymes, then abruptly exposed enzymes to each of nine temperatures (range: 15 – 36 ^{o}C). The effect of temperature on PMA differed among taxa and subpopulations with enzymes of *C. pustulosa* (Colorado) having a significantly higher optimal temperature (Topt) than *C. necki* and *C. pustulosa* (Navasota). Optimal temperature breadth of *C. petrina* was significantly smaller than that of other species. To assess enzyme response to gradual temperature changes, we modified temperature by 1^{o} C/day, acclimated mussels for >1 week to each of nine temperatures (range: 15 - 36 ^{o}C), extracted enzymes, and conducted the PMA assay at each acclimation temperature. Following acclimation, Topt and maximum PMA activity increased for *C. pustulosa* (Colorado) and *C. petrina*. Conversely, Topt did not change and maximum PMA activity declined for *C. pustulosa* (Navasota) and *C. necki*. In summary, enzymes of *C. pustulosa* (Colorado) and *C. petrina* showed a greater ability to adjust to slowly rising temperatures, whereas gradual acclimation to rising temperatures did not seem to provide any adaptive advantage to *C. pustulosa* (Navasota) or *C. necki*.

2. MOVE ON OR TAKE THE HEAT: CAN LIFE HISTORY STRATEGIES OF FRESHWATER MUSSELS PREDICT THEIR PHYSIOLOGICAL AND BEHAVIORAL RESPONSES TO DROUGHT AND DEWATERING?

Zachary A Mitchell[1], Jaclyn McGuire[1], Joshua Abel[2], Astrid N Schwalb[1] & Bianca Hernandez[1]
[1]Texas State University, San Marcos, TX; [2]USFWS, San Marcos, TX

Freshwater organisms have developed different physiological, behavioral, and life history strategies to cope with drying events. Although freshwater mussels (Unionidae) are endangered and drought and dewatering events pose a major threat, especially in the southern US, little is known about their responses to such events and how physiology, behavior and life history strategies may be linked. Our goal was to examine whether and how behavioral responses to dewatering and physiological tolerances to desiccation are linked in five species of freshwater mussels (Unionidae) within Texas, including two state threatened species (*Cyclonaias petrina* and *Lampsilis bracteata*) and one federally endangered species (*Popenaias popeii*) to explore how differences in responses relate to life history strategies. We measured horizontal and

vertical movements under three dewatering rates and assessed desiccation tolerance by examining survival after emersion at 30 and 40°C with laboratory experiments. *Amblema plicata* and *C. petrina* had the lowest horizontal movement rates and the highest desiccation tolerances, whereas *L. bracteata* and *L. teres* were less tolerant to desiccation, but more mobile. *P. popeii* were intermediate in its responses. Our results show that differences between species in their behavioral response to dewatering and physiological tolerance to desiccation tend to be associated with differences in life history strategies or may be explained by differences in adaptation to certain habitat conditions. We propose a life-history strategy-based framework for responses of mussels to drying events, which may be applicable to other taxa.

3. EFFECT OF DECLINING VIABILITY AND RISING TEMPERATURE ON OXYGEN DEMAND OF MUSSEL BROODS.

Jim Stoeckel, Ryan Fluharty & Hisham Abdelrahman
Auburn University, Auburn, AL

Female mussels may be particularly susceptible to thermal and hypoxia stress while brooding glochidia in their gills. Previous research suggests that broods reduce the respiratory capacity of gravid females and that brood respiration comprises ~10% of composite (female + brood) oxygen consumption. In this study we adapted and refined current microrespirometry techniques to measure respiratory patterns of *Ligumia subrostrata* glochidia at multiple temperatures as DO declined from normoxic to hypoxic conditions. Endpoints included respiration rate, regulation index (RI: ability to maintain a constant respiration rate as DO declines), and critical dissolved oxygen concentration (DOcrit: threshold below which an organism shifts to predominately anaerobic respiration). Glochidia were placed in a 24-well, microrespirometry plate (2,000 glochidia/well; 3 replicate wells/brood) equipped with optical DO sensors. Respiration rates were monitored as DO declined from >6 mg O2/L to < 0.5 mg O2/L). We first tested whether respiratory patterns of glochidia at a moderate temperature (18oC) were affected by initial brood viability. We found no significant relationship between brood viability (range 46-94%) and respiration rate, RI, or DOcrit of glochidia. We then tested effects of temperature (13, 18, 23, and 28°C; one week acclimation prior to trials) on respiration rate, RI, and DOcrit of glochidia. Time in respirometry wells ranged from 8 hrs at 28°C to 3 days at 13°C. While in wells, decline in glochidia viability was minimal: from 91 to 88% at 28°C and from 93 to 87% at 13°C. At 18°C, we estimated glochidial oxygen demand to comprise ~6.4% of gravid female respiration rates. Effects of temperature on respiration rate, RI, and DOcrit are currently being analyzed. Results will indicate whether glochidial respiration responds in a similar fashion as adult mussels to thermal and hypoxic stress, and the extent to which broods place increasing respiratory stress on gravid females as temperatures rise.

4. EFFECTS OF THERMAL AND HYPOXIA STRESS VARY AMONG MUSSEL SPECIES AND SUBPOPULATIONS IN CENTRAL TEXAS

Austin Haney[1], James Stoeckel[1], Hisham Abdelrahman[1] & Brian Helms[2]
[1]Auburn University, Auburn, AL; [2]Troy University, Troy, AL

Mussels are at particular risk from thermal stress and hypoxia due to limited range and mobility. Of particular interest to managers is whether responses to temperature are uniform or vary among species and subpopulations. We used relationships between metabolic rate and temperature to investigate effects of temperature on energy demand and hypoxia tolerance of two narrowly distributed species (*Cyclonaias petrina*, Colorado River; *C. necki*, Guadalupe River), and two subpopulations of a widely distributed species (*C. pustulosa*: Colorado and

Navasota rivers) in central Texas. Study temperatures ranged from 15-36°C. We observed zero mortality during acclimation periods and respirometry runs even when mussels were exposed to hypoxic conditions for several hours. Resting metabolic rate (RMR) increased with increasing temperature for all taxa but the shape and slope of the relationship varied among species and subpopulations. RMR increased linearly with temperature up to 36°C for *C. pustulosa* (Colorado), *C. petrina*, and *C. necki* whereas *C. pustulosa* (Navasota) exhibited metabolic depression at >28°C. Amongst species and subpopulations, *C. pustulosa* (Colorado) had the highest RMR and greatest rate of increase with temperature. Ability to maintain a consistent respiration rate with declining DO was negatively affected by warming temperatures for *C. petrina*. Results suggest exposure to short-term thermal and hypoxia events in rivers would not be lethal to any taxa tested. However, mussels would suffer sublethal effects and these effects would vary across species and subpopulations. *C. pustulosa* (Colorado) is likely to be at highest risk of food limitation during thermal events due to higher metabolic demands than other species and subpopulations. *C. petrina* would exhibit the greatest decrease in hypoxia tolerance during thermal events whereas tolerance of *C. pustulosa* (Navasota) and *C. necki* would remain unaffected. Management strategies tailored to individuals and subpopulations are likely to be more effective than a simple "one-size-fits-all" approach.

5. FRESHWATER MUSSEL LIFE HISTORY AND ADAPTIVE MANAGEMENT AT THE CLAYTOR HYDROELECTRIC PROJECT, NEW RIVER, VIRGINIA

William C Fleece[1], Dillon McNulty[1], Elizabeth Dilbone[1], Jon Magalski[2] & Liz Parcell[3]
[1]Stantec Consulting, Cincinnati, OH; [2]American Electric Power Service Corporation, Columbus, OH; [3]American Electric Power Service Corporation, Roanoke, VA

Stantec Consulting was contracted to conduct water quality and mussel surveys on the New River as part of Claytor Dam's FERC licensing renewal. This study is part of a Freshwater Mussel Adaptive Management Plan (the Plan) that is designed to determine if flow, temperature, and/or occasionally depressed dissolved oxygen (DO) concentrations are affecting freshwater mussels downstream of Claytor Dam over the term of the new license (FERC No. 739). This presentation summarizes work from the first two field seasons in a fifteen-year program designed to gain insight into mussel resources in the project area. This study employed a control/impact experimental design where water quality and mussel assemblages were sampled both upstream and downstream of the dam. Water quality was measured in 2015 and 2017 using deployed DO and temperature loggers at two sites upstream of Claytor Lake and two sites downstream of Claytor Dam. Seasonal temperature patterns were similar at three of the four sites. Temperature immediately below Claytor Dam, remained cooler deeper into the summer and warmer longer into the fall. Summer DO was consistently lowest downstream of Claytor Dam but was also occasionally lower than 4.0 mg/L at the furthest upstream location. Mussel abundance was low at both upstream and downstream sites, but especially so downstream. In 2017, mussels were present at 46 percent of the upstream transect segments versus only 11 percent of the downstream transect segments. The 2015 and 2017 survey data suggest that there was reproduction for some species at the upstream sites as indicated by the presence of smaller, younger mussels. Some recruitment has been documented at the downstream sites for some species, but small sample sizes continue to obscure our ability to understand population dynamics for other species.

Session 2: Genetics and Phylogeny I
Monday (10:20 – 12:00)

6. GENOME-WIDE DDRAD-SEQ DATA DISENTANGLES SPECIES RELATIONSHIPS AND REVEALS FINE SCALE POPULATION GENETIC STRUCTURE OF FRESHWATER MUSSELS (*CYPROGENIA* SPP.) IN NORTH AMERICA

Kevin J Roe & Kyung-Seok Kim
Iowa State University, Ames, IA

Detailed information on species delineation and population genetic structure is a prerequisite for developing tailored restoration and conservation strategies for imperiled organisms. Published phylogenetic and population genetic analyses based on mitochondrial DNA sequences and microsatellite loci have produced conflicting results concerning the taxonomy and species delimitation within the freshwater mussel genus *Cyprogenia*. These studies also indicated a link between the mitochondrial sequences and the color of the conglutinate lures used by mussels to attract and infect a fish host. We used genome-wide ddRAD-Seq data generated from non-destructively collected samples to resolve these issues and to document genetic structure in *Cyprogenia* throughout its range. Phylogenomic and population genomic analyses based on unlinked SNPs generated using STACKS pipeline identified three genetically distinct clusters in *Cyprogenia* corresponding to the Eastern, Ozark and Ouachita highland regions. *Cyprogenia stegaria* is restricted to the Eastern Highlands region and displays little structuring within this region. However, the two allopatric *C. aberti* clusters in the Ozark and Ouachita highlands exhibited substantial levels of genetic differentiation between subpopulations. *Cyprogenia* specimens in the Ouachita and Ozark highlands were further subdivided into discrete lineages conforming to river systems, indicating fine-scale genetic structure in this region. These findings suggest that conservation measures for *Cyprogenia* should consider at least 5, and possibly up to 7 distinct evolutionarily significant units (ESUs). Conglutinate color did not exhibit a geographic pattern based on analysis of the SNP loci, but FST outlier analysis of specimens with red or brown conglutinates revealed several loci under selection with high sequence similarity to annotated sequences coding for lysozyme. Our study confirms that the use of genome-wide ddRAD-Seq data produced from non-destructively collected samples can provide greatly improved resolution of this species' taxonomy and detection of shallow population structure at a regional scale, and highlights the value of this approach to address uncertainties associated with the management and conservation of imperiled species.

7. HISTORIC AND CONTEMPORARY GENE FLOW IN THE SHEEPNOSE MUSSEL (*PLETHOBASUS CYPHYUS*) AND THEIR IMPLICATIONS FOR CONSERVATION

Kevin J Roe & Sara Schwarz
Iowa State University, Ames, IA

North American freshwater mussel species have experienced substantial range fragmentation and population reductions due to anthropogenic impacts. These impacts have potential to reduce genetic connectivity between populations and increase risk of losing genetic diversity. This has become a concern for one imperiled mussel species, the Sheepnose (*Plethobasus cyphyus*). This study aims to understand

potential human induced impacts on genetic connectivity historically occurring among Sheepnose populations. Sixteen microsatellite loci and an 883 bp fragment of the mitochondrial ND1 gene were used to assess genetic diversity, population structure, contemporary and historical migration rates, and population size changes across the range of the Sheepnose. Population structure analyses reveal two distinct Sheepnose populations, one occupying the Upper Mississippi River Basin and the other in the Ohio River Basin, each consisting of several isolated demes. Sheepnose demes exhibit a high degree of genetic diversity and contemporary migration estimates indicate that migration between demes is occurring within (although at very low rates) but not between populations. Historical migration estimates indicate that significantly more migration was occurring within and between populations, also at very low rates. Bottlenecks were not detected in any of the demes and all demes except for the Wisconsin River exhibited the signature of population expansion. Our results indicate that anthropogenic influences have altered genetic connectivity among Sheepnose populations, though, recent fragmentation and isolation have yet to be reflected in losses of genetic diversity. Managers should work to regain and maintain historic genetic connectivity to conserve remaining genetic diversity for future viable Sheepnose populations.

8. POPULATION GENOMICS OF THE CRITICALLY IMPERILED GENUS *PLETHOBASUS*

McKenna Pa Burns[1], Steven R Hein[1] & David J Berg[2]
[1]Miami University, Oxford , OH; [2]Miami University Hamilton, Hamilton, OH

The unionid genus *Plethobasus* consists of three species endemic to the eastern half of the United States: *P. cooperianus* (Orangefoot pimpleback), *P. cyphyus* (Sheepnose), and *P. cicatricosus* (White wartyback). All three species have undergone massive population losses attributed largely to river impoundments and all are currently listed as federally endangered. *Plethobasus cooperianus* has been reduced to less than 100 known individuals from three geographic populations, all living in propagation facilities or in cages within the Tennessee river. While *P. cyphyus* is extant in numerous states, *P. cicatricosus* is only known to exist in one remaining population consisting of less than 10 individuals seen in the past 20 years in Alabama. In 2017, one mussel appearing to be *P. cicatricosus* was collected from the Tennessee River. We used standard Sanger sequencing methods to sequence two mitochondrial genes and one nuclear gene for all three species of *Plethobasus* and employed next-generation type IIb restriction site associated DNA sequencing (2bRAD) to conduct population genomic analyses. Phylogenetic analyses based on Sanger sequencing placed the putative *P. cicatricosus* within *P. cyphyus*. However, Bayesian phylogenomic analysis of 1,797 SNPs distinguished *P. cicatricosus* as sister to *P. cyphyus* with 100% posterior probability, evidence of a relatively recent speciation event. Our *P. cooperianus* population genomics consisted of 1,196 SNPs from 24 *Plethobasus cooperianus*. The three populations appear nearly panmictic, all with a moderate level of genetic diversity. The low degree of overall population differentiation suggests that all remaining individuals of *P. cooperianus* should be managed as a single population in order to maximize retention of genetic variation. Population genomic analyses provide improved understanding of recent species boundaries and population genetic structure. Increased sampling across the genome leads to increased power for understanding distribution of genetic variation within and among populations, especially for species at elevated risk of extinction.

9. PHYLOGEOGRAPHY OF GULF SLOPE *ELLIPTIO* TAX

Michael M Gangloff, Victoria C Fowler, Daniel Mason, Jonathan D Wells & Lynn M Siefferman
Appalachian State University, Boone, NC

Elliptio is considered to be the most species-rich and taxonomically-problematic freshwater mussel genus in North America. The latest taxonomic assessment suggested that at least 30 taxa occur in the United States. Of these, 10 are currently believed to occur in Gulf of Mexico drainages east of the Mobile River. We examined mtDNA sequences of >500 individuals from among 11 of 12 *Elliptio* taxa; *E. arca*, *E. arctata*, *E. chipolaensis*, *E. crassidens*, *E. jayensis*, *E. fraterna*, *E. fumata*, *E. mcmichaeli*, *E. occulta*, *E. pullata*, and *E. purpurella*. *Elliptio nigella* sequences were not included in this analysis) from Gulf drainages extending from the Mobile to the Hillsborough basins. We also included *E. jayensis* and *E. ahenea* specimens from the St. John's Basin as outgroups in the dataset. We used parsimony networks to examine the distribution of haplotypes among putative taxa and drainages. Analysis of mtDNA sequence overlaps suggests a high degree of genetic interchange among taxa in lowland drainages and a much higher degree of genetic differentiation observed for taxa/populations occurring in upland, Gulf-Drainage streams compared to populations and putative taxa collected from lowland Gulf-Drainage streams. For example, populations currently identified as *E. arca*, *E. arctata*, *E. pullata*, and *E. jayensis* exhibit evidence of historical geographical isolation and genetic differentiation. Phylogeographic patterns observed within this genus may mirror those observed in many other freshwater taxa. Additionally, despite very large sample sizes, we were unable to readily differentiate *E. crassidens* (the type species for *Elliptio*) from a number of putatively endemic (e.g., *E. arctata*, *E. mcmichaeli*) and widespread (e.g., *E. pullata*) taxa using these markers. Evidence of extensive genetic introgression among morphological taxa suggests that his suggests that systematists and managers may need to reconsider both species and management boundaries within this morphologically-plastic an ecologically-tolerant freshwater bivalve genus.

10. PHYLOGEOGRAPHIC PATTERNS AMONG THE LANCEOLATE *ELLIPTIO* SPECIES COMPLEX

Hans R Lohmeyer, Michael M Gangloff, Tori V Fowler, Jon D Wells & Gretchen D Bailey
Appalachian State University, Boone, NC

DNA sequencing has provided many new opportunities to improve our understanding of how species are related and integrating molecular, morphological and biogeographic data can help better elucidate species boundaries and phylogenetic relationships. However, this approach may add complexity to field research it may improve the ability of biologists to recognize species using comparisons of phenotypic attributes. The extreme amount of morphological variation observed among *Elliptio* species has led to the proliferation of a plethora of species names and generated a long-running debate about the phylogenetic structure within this genus. Although earlier workers including Johnson considered *Elliptio* to be comprised of three species complexes; *E. complanata*, *E. icterina* and *E. lanceolata*, current species lists recognize 30 *Elliptio* taxa including 7 taxa in the lanceolate group. We examined portions of the mitochondrial NADH dehydrogenase (ND1) and cytochrome oxidase ci (CO1) genes from >400 specimens and 6 species within the lanceolate *Elliptio* complex from 13 Atlantic Slope river basins. We constructed haplotype networks to examine species boundaries and the degree of genetic exchange among putative species. Our data reveal that *E. lanceolata* is genetically distinct from other lances. However, many other taxa in the lanceolate *Elliptio* complex exhibit evidence of substantial historical genetic exchange and likely do not comprise biologically distinct species. We found support for a northern *E. fisheriana*

and a southern *E. angustata* lance clade with a boundary somewhere in the Pamlico Sound drainages. However, due to small sample sizes it is unclear whether lance taxa from drainages south of the Savannah River (e.g., *E. aheanea* and *E. sherpardiana*) are genetically distinct. Future work will involve sampling lances from drainages in Georgia and Florida and the use of microsatellite or next generation approaches to examine fine-scale resolution of lanceolate *Elliptio* taxa.

Session 3: Contaminants and Toxicology I
Monday (10:20 – 12:00)

11. LIFE STAGE SENSITIVITY OF A FRESHWATER SNAIL TO HERBICIDES USED IN INVASIVE AQUATIC WEED CONTROL

Jennifer M Archambault & W. Gregory Cope
Department of Applied Ecology, North Carolina State University, Raleigh, NC

Aquatic herbicides are often selected as a control strategy for invasive aquatic plants, but few studies address their effects on non-target organisms, especially native freshwater mussels and snails. The aim of this study was to assess the life stage sensitivity of a rare snail, *Somatogyrus virginicus* (Lithoglyphidae), to two aquatic herbicides (fluridone and dipotassium salt of endothall). We collected adult snails, cultured their eggs on a substrate, exposed adults and eggs in 96-h static-renewal experiments, and monitored eggs through hatching. Because fluridone is typically applied for 60 d, we included an additional treatment exposure through hatching time (30 d total) to improve environmental relevance. Eggs present on the shells of adult snails were also monitored. Endpoints were adult survival and egg hatching success. Fluridone did not affect adult snail survival at concentrations up to 1500 µg/L, and in the test with eggs on substrate, fluridone did not significantly delay ($p = 0.12$) or influence overall hatching success ($p = 0.22$), including in the 30-d exposure (Dunnett's $p = 0.09$). However, fluridone significantly delayed hatching of eggs on adult shells ($p < 0.01$) and reduced their overall hatching success ($p < 0.01$). The 96-h median effect concentration (EC50) for fluridone on egg hatching success was 1334 µg/L (95% CI, 1215-1466 µg/L). For endothall, the adult 96-h median lethal concentration (LC50) was 223 mg/L (157-318 mg/L). Endothall delayed hatching ($p < 0.01$ in both tests) and reduced overall hatching success ($p = 0.04$ for eggs on cards, and $p < 0.01$ for eggs on adults). The endothall 96-h EC50s for egg hatching success were 54.1 mg/L (95% CI, 35.6-82.2 mg/L; eggs on adults) and 83.4 mg/L (95% CI, 60.4 -115.2 mg/L; eggs on cards). Neither herbicide had toxic effects to either life stage at concentrations typically prescribed for control of hydrilla (5-15 µg/L fluridone and 1-5 mg/L endothall). However, applying the minimum amount of herbicide needed for effective weed control is recommended for ensuring safety of non-target organisms.

12. ASSESSING MULTI-GENERATIONAL AND DEVELOPMENTAL ECOTOXICOLOGICAL ENDPOINTS IN FRESHWATER GASTROPODS

Rebecca K Osborne[1], Patricia L Gillis[2] & Ryan S Prosser[1]

[1]School of Environmental Sciences, University of Guelph, Guelph, ON; [2]Aquatic Contaminants Research Division, Environment and Climate Change Canada, Burlington, ON

Gastropods play a critical role in aquatic ecosystems and often make-up a significant proportion of the benthic biomass. Despite their considerable diversity and importance, freshwater gastropods are severely underrepresented in ecotoxicological studies and account for fewer than 1% of the publications in the US Environmental Protection Agency's ECOTOX database. To evaluate the potential utility of multi-generational contaminant studies and develop feasible generational test designs, as well as to characterize the normal growth and development of the freshwater file ramshorn snail (*Planorbella pilsbryi*), we conducted both a multi-generational toxicity test and several snail embryo development studies. During the multi-generational study, adult exposure to five sub-lethal concentrations of copper resulted in decreased reproduction with increasing copper exposure and complete reproductive inhibition at the highest concentration (75 µg/L). Mortality and inhibition of reproduction were not observed in the control and three lowest concentrations (4.69, 9.38, 18.75 µg/L Cu) over the course of the exposure and during recovery in clean water indicating no lasting adverse effects. However, subsequent exposure of the un-exposed juveniles that were produced during the recovery period (i.e. those not directly exposed to copper) showed that juveniles born to copper-exposed parents (LC50: 11.57 µg/L Cu; 95% CI: 3.71-19.43 µg/L Cu) were significantly less tolerant to copper exposure than juveniles born to un-exposed parents (LC50: 29.25 µg/L Cu; 95% CI: 22.17-36.32 µg/L Cu). Despite no obvious changes in parental reproductive success, the fitness of un-exposed juveniles was compromised due to parental exposure. Further studies to characterize development in *P. pilsbryi* embryos and to evaluate the potential use of developmental endpoints as a sensitive and non-invasive bioindicator in environmental risk assessment and freshwater mollusk conservation are ongoing.

13. TRANSFORMATION SUCCESS OF *LAMPSILIS CARDIUM* GLOCHIDIA EXPOSED TO A MIXTURE OF URBAN CONTAMINANTS AT ENVIRONMENTALLY RELEVANT CONCENTRATION

Justin C Rappold[1], Mandy Annis[2] & Daelyn A Woolnough[1]

[1]Central Michigan University, Biology Department and Institute for Great Lakes Research, Mt. Pleasant, MI; [2]US Fish & Wildlife Service, Michigan Ecological Services Field Office, East Lansing, MI

A goal of the National Strategy for the Conservation of Native Freshwater Mollusks is to determine how various perturbations impact mollusks. Contaminants, including contaminants of emerging concern (CECs), have been identified as a possible cause for the declines of mollusks. In our study we addressed this goal by studying the effects of a subset of CECs frequently detected in urban watersheds across the Great Lakes basin on the unionid, *Lampsilis cardium*. Our mixture contained estrone, DEET, BPA, 4-nonylphenol, desvenlafaxine, fexofenadine, sulfamethoxazole, metformin, 4-methyl-1H-benzotriazole, tris (2-butoxyethyl) phosphate, and Galaxolide. To understand potential effects of CECs on early life stages, we exposed gravid adult female *L. cardium* to environmentally relevant concentrations of this subset of CECs at two different lengths of exposure (short-term vs. long-term). *Micropterus salmoides* were then infested with glochidia to measure transformation success. Treatments included a positive and negative control and a low, medium and high dosage of the CEC mixture. Nonparametric Kruskal-

Wallis tests followed with post-hoc Dunn's tests indicate differences in transformation success across the different treatments for both exposure times. Specifically, glochidia exposed to the contaminants long-term in the medium treatment had the highest transformation success. Glochidia exposed short-term were observed to have the highest transformation success in the control water treatment, followed by the medium treatment. In addition, glochidia from the short-term exposure transformed into juveniles earlier than glochidia from the long-term exposure. Results from this study will provide insights to unionid conservation and the possible causes of declines.

14. ASSESSING THE EFFECT OF SALT-LADEN WINTER RUNOFF ON FRESHWATER MUSSELS

Patricia L Gillis[1], Joseph Salerno[1], Quintin Rochfort[1], Vicki McKay[2], Austin Pratt[2], James Bennett[1] & Ryan Prosser[3]
[1]Environment and Climate Change Canada, Burlington, ON; [2]Lower Thames Valley Conservation Authority, Chatham, ON; [3]University of Guelph, Guelph, ON

The increase in chloride concentrations in surface waters in temporal regions correlates with increased application of de-icing salts. During winter, road salt builds up in snowbanks on roads and bridges and when the temperature rises, salt-laden meltwater is conveyed to aquatic habitats through bridge runoff or overland flow. Freshwater salinization has implications for ecosystem health as chloride concentrations in urban streams frequently exceed levels harmful to aquatic life. Early life stage freshwater mussels are particularly sensitive to salt. This study focused on the Thames River watershed (ON), the second most species-rich watershed for freshwater mussels in Canada. Two bridges near an expressway spanning mussel species at risk habitat were targeted. The chloride in the surrounding creek was assessed throughout the year, and following winter melt events, samples collected from bridges and drains were used in glochidia exposures using standard methods. Mussel distribution surrounding the bridges was also examined to determine whether the response of early life stage mussels in the lab translates into altered mussel distribution in natural habitats. Throughout the year, surface water in Baptiste and McGregor Creeks ranged from 9-89 and 39-323 mg Cl/L, respectively. In both cases, maximum chloride concentrations corresponded to the colder season. Lab exposures with serial-diluted meltwater revealed 48-h EC50s for *Lampsilis fasciola* glochidia of 26.4% meltwater (2,764 mg Cl/L) at Baptiste Creek bridge (deck-drain, 8,250 mg Cl/L) and 43.8% meltwater (1,517 mg Cl/L) at McGregor Creek bridge (tile-drain, 3,110 mg Cl/L). No live mussels were found surrounding the bridge in Baptiste Creek. In McGregor Creek, mussels were more abundant far upstream (77/hr) and 200 m downstream (56/hr) of the bridge than in areas immediately upstream (0-100 m, 13/hr) and downstream (33/hr) of the bridge. However, given surrounding agricultural lands, differences in mussel abundance cannot necessarily be attributed to negative effects from bridge runoff.

15. BIOACCUMULATIVE AND ECOLOGICAL RESPONSES OF UNIONIDS TO AGRICULTURAL AND URBAN CONTAMINANTS AT ENVIRONMENTALLY RELEVANT CONCENTRATIONS

Daelyn A Woolnough[1], Mandy Annis[2], Stephanie P Gill[1], Scott M La Valley[1], Justin C Rappold[1] & Lacey D Rzodkiewicz[1]

[1]Central Michigan University, Biology Department and Institute for Great Lakes Research, Mt. Pleasant, MI; [2]US Fish & Wildlife Service, Michigan Ecological Services Field Office, East Lansing, MI

Unionids inhabit waterways that are increasingly being affected by contaminants introduced by humans throughout the world. Unfortunately, influences of these contaminants on unionids are largely unknown and many are unregulated. We have considered a variety of potentially toxic substances at environmentally relevant concentrations in both a vivarium setting, on unionids and host fish, and in a controlled streamside lab, on unionids. In the vivarium we considered a mixture of contaminants found to be common in agricultural watersheds (0.1x, 1x, 10x mean level treatments) and urban watersheds (0.1x, 1x, 10x mean level treatments) as well as 2 controls (H20 and EtOH) over 40 day and 100 day exposures. In the streamside setting we collected water from 8 sites in an agricultural watershed (Maumee R., OH) and 6 sites in an urban watershed (Milwaukee R., WI) over a 21 day exposure. We will present how DEET bioaccumulates differentially among treatments and species as well as highlight land use specific contaminants with distinct trends. Examples of contaminants we considered include atrazine, metformin, and sulfamethoxazole. We will also present non-lethal responses that may influence reproduction (e.g., glochidia viability) and discuss potential population effects that we observe between agricultural and urban sites and treatments. These data will aid in the understanding and conservation of unionids as well as contribute to the breadth of knowledge on contaminants of emerging concern.

Session 4: Life History, Ecology & Anthropogenic Impacts II
Monday (2:00 – 3:20)

16. USE OF MUSSELS AS SENTINELS IN THE CONFLICT FOR WATER USES: EXPLOITING MUSSELS' SENSITIVITY TO OPTIMIZE WATER RESOURCE MANAGEMENT WITHOUT THREATENING BIODIVERSITY

Nicoletta R Riccardi[1], Camilla Della Torre[2], Jouni Taskinen[3] & Maria Urbanska[4]

[1]CNR Institute of Water Research National Research Council, Verbania, Italy; [2]Dept. of Biosceinces, University of Milan, Milan, Italy; [3]University of Jyvaskyla, Jyvaskyla, Finland; [4]Poznan University of Life Sciences, Poznan, Poland

The growing impact of climate change on water resources has generated conflicts between the users in the catchment area of Lake Maggiore, Northern Italy. As Lake Maggiore is one of the largest reserves of freshwater and biodiversity shared between Italy and Switzerland, a urgent need to start a concerted and ecologically sustainable mangement strategy has emerged. A just starting EU Interreg project aims to assess the threshold limits beyond which anthropic use conflicts with the preservation of biodiversity. As native mussels are undegoing a dramatic decline in the last decade, the project includes both the evaluation of the main threats and the use of mussels as potential warning sentinels to indicate the reaching of the conflict thresholds. As a first step of the project we are comparing the current status of populations with historical data to address the next efforts towards effectively documented threats than a wide range of putative threats. A wide array of stressors,

ranging from local (riparian clearing, pollution disease, invasive species), to regional influences (altered flow regimes, river fragmentation) to global climate change were documented to threat freshwater mussels. However, there are still many knowledge gaps that mainly stem from the difficulty of disentangling the respective roles of the factors interacting in field. Relatively easy to highlight is the effect of lethal factors, such as pollution or drought, but the evidence is weaker for many biotic interactions. Even the role of invasions as a driver for mussel loss is still far from being unraveled, despite being largely supported by correlative evidence. Obviously, this applies even more to parsites, less studied and generally overlooked as a driver in the decline of wild populations. Lake Maggiore is a suitable case study to contribute filling these these gaps. Comparison of the data available between 2003 and taday suggest that invasive species and disease played a predominant role, likely boosted by the alterations of the hydrological regime. Therefore, the project will be mainly focused on defining tolerable water management limits, i.e. which can be reached without depleting the mussels' ability to resist biotic stressors.

17. FRESHWATER MOLLUSK DIE-OFF RESPONSE DEVELOPMENT AND ONE HEALTH ASSESSMENT

Nancy Boedeker[1] & Brant Fisher[2]
[1]Indiana Department of Natural Resources, Division of Fish and Wildlife, West Lafayette, IN; [2]Indiana Department of Natural Resources, Division of Fish and Wildlife, Edinburgh, IN

Freshwater mussels are among North America's most imperiled species. Die-offs are increasingly recognized as population threats, with etiologies frequently undetermined. Minimal health and disease data exists for freshwater mussels. Detailed plans and descriptions of techniques for thorough and rapid diagnostics to guide a targeted die-off response are lacking. This project's objectives are to develop die-off response protocols in coordination with partners nationwide and establish and compare baseline health parameters for freshwater mollusks in Indiana waterways. Study species include native Fatmucket (*Lampsilis siliquoidea*) and Plain Pocketbook (*Lampsilis cardium*) and non-native Asian clam (*Corbicula fluminea*), all common in Indiana. Methods involve: 1) collection of mollusks (20 per species per site) from three Wildcat Creek drainage sites under assessment for mussel translocation suitability, 2) determination of microbial populations (viral, bacterial, parasitic, and fungal) and antibiotic resistance of bacteria cultured, and 3) assay of hemolymph and tissue samples to determine analyte levels (including glycogen, stable isotopes, contaminants) and histologic tissue evaluation. Analysis of results, compared between species and sites and to water quality parameters, identifies potential pathogens associated with Asian clam that might threaten native species, evaluates potential interspecies competition based on dietary composition comparison, adds to assessment of the suitability of the three sites for translocations, and increases understanding of antimicrobial resistance in aquatic environments. Using common species, this study allows for optimization of techniques and protocols for use in diagnostic response to die-offs of potentially endangered species. It establishes baseline health parameters of multiple species at varied sites which is critical for interpretation of results in the event of a die-off. We seek partnerships for future expansion of this pilot study, incorporating additional locations and species over time, to generate data to develop risk mitigation strategies for microbes and contaminants that contribute to freshwater mussel morbidity and mortality.

18. DROUGHT-INDUCED MASS MORTALITY OF FRESHWATER MUSSELS ALTERS ECOSYSTEM FUNCTION: A MESOCOSM EXPERIMENT

Traci P Dubose[1], Carla L Atkinson[2], Caryn C Vaughn[1] & Stephen W Golladay[3]
[1]University of Oklahoma, Norman, OK; [2]University of Alabama, Tuscaloosa, AL; [3]Jones Center at Ichauway, Newton, GA

Droughts are becoming more frequent and intense globally. As sedentary organisms, native freshwater mussels are vulnerable to the high water temperatures and shrinking aquatic habitat caused by these extreme events. While drought-driven die offs have been documented in the southern Great Plains, the ecosystem impacts of these droughts have not been completely quantified. To better quantify impacts of mussel mass mortality events on ecological function, we conducted a mesocosm experiment that simulated a mussel die-off. We created three scenarios in eighteen 946L mesocosms: nine control mesocosms without freshwater mussels, four mesocosms with a live mussel community, and five mesocosms with a mussel community that experienced a die-off. We measured water column nutrients, primary production and the macroinvertebrate community before (3 samples over 20 days) and after (4 samples over 39 days) the mussel mortality event. We also measured mussel decomposition following the die-off. In the week after the die-off, ammonium increased by 94% in the mortality mesocosms and was significantly higher than the control mesocosms, but not the live mesocosms. Soluble reactive phosphorus increased in mortality mesocosms but was not significantly different than the control or live mesocosms. The rapid nutrient release following mussel mortality likely stimulates both the autotrophic and heterotrophic components of river food webs. Benthic gross primary production was greater in mortality and live mesocosms than in control mesocosms. Decomposition of organic matter increased immediately following mussel death in mortality mesocosms and was statistically different than live mesocosms. We combined our mesocosm experiment results with field observations and the literature to build a conceptual model of how unionid mass mortality events likely impact ecosystem function across short and long time scales. This conceptual model should aid development of conservation and management strategies that sustain stream structure and function in the face of drought-driven mussel losses.

19. ASSESSING THE TRANSFERABILITY OF A FRESHWATER FUNDAMENTAL NICHE MODEL WITHIN THE OZARK ECOREGION, MISSOURI

Jordan N Holtswarth[1], Amanda E Rosenberger[2], Garth Lindner[3] & Kayla Key[1]
[1]Tennessee Technological Institute, Tennessee Cooperative Fisheries Research Unit, Department of Biology, Cookeville, TN; [2]U.S. Geological Survey, Tennessee Cooperative Fisheries Research Unit, Tennessee Tech University, Cookeville , TN; [3]University of Missouri School of Natural Resources, Columbia, MO

The freshwater mussel fauna of the United States, while extraordinarily rich, has the highest imperilment rate of any group of organisms. It is important to understand what factors allow riverine freshwater mussels to persist to inform successful conservation efforts, yet challenging because of their unique life cycle, benthic habitat preferences, and sensitivity to disturbance across spatial and temporal scales. However, habitat suitability modeling including hydrogeomorphic variables has been successful in predicting mussel establishment and persistence in the Meramec River of Missouri. While the creation of habitat suitability models is helpful in well-sampled areas like the Meramec River, model transferability is desirable to make predictions in areas with little survey information. We apply existing knowledge of habitat requirements of rich mussel beds in the Meramec River Basin to other Ozark rivers. Five GIS layers representing lateral channel stability, stream power, proximity to persistent gravel bars, the presence of channel controls, and areas of low water will be applied to the Gasconade and Little Black

rivers. Using existing information supplied by the Missouri Department of Conservation and studies conducted in the rivers, we will determine correspondence between species-rich beds and these hydrogeomorphic variables to evaluate their utility for predicting mussel presence in Ozark rivers outside of the Meramec River Basin.

Session 5: Genetics and Phylogeny II
Monday (2:00 – 3:20)

20. UNIOVERSE: PHYLOGENOMIC RESOURCE FOR RECONSTRUCTING FRESHWATER MUSSEL EVOLUTION

John M Pfeiffer, Larry Page & Jesse Breinholt
Florida Museum of Natural History, Gainesville, FL

The application of molecular phylogenetics has revolutionized freshwater mussel systematics but limited consensus has emerged in regard to the early evolution of the Unionoida, especially the relationships of the families and the suprageneric relationships of its most diverse radiation, the Unionidae. Inadequate character sampling appears to be the primary analytical impediment obfuscating a coherent phylogeny of the Unionoida, specifically the lack of conservative nuclear markers appropriate for reconstructing higher-level relationships and testing macroevolutionary hypotheses. The objective of this study is to develop an anchored hybrid enrichment probe set capable of capturing hundreds of molecular markers from across the freshwater mussel tree of life and demonstrate the phylogenetic utility of these loci at multiple evolutionary scales. Our novel freshwater mussel specific phylogenomic probe set (called Unioverse) successfully captures an average of 587 nuclear protein coding loci from all major lineages of the Unionidae, and 320-550 loci from the other families of the Unionoida. We explore the phylogenetic signal of these loci by employing various reconstruction methods and dataset permutations. We discuss these results in the context of some simple but pressing issues in freshwater mussel systematics: What are some of the more inclusive clades of the Unionoida and how do you tell them apart? Why are hypotheses of the higher-level relationships of the Unionidae so unstable? What, if anything, is a lampsiline? We conclude by describing how the malacological community might could leverage this resource moving forward.

21. UTILIZING ANCHORED HYBRID ENRICHMENT TO TEST THE MONOPHYLY OF THE FRESHWATER MUSSEL GENUS *POTAMILUS* (BIVALVIA: UNIONIDAE)

Chase H Smith[1], John M Pfeiffer[2] & Nathan A Johnson[3]
[1]Baylor University, Waco, TX; [2]Florida Museum of Natural History, Gainesville, FL; [3]U.S. Geological Survey Wetlands and Aquatic Research Center, Gainesville, FL

Larval (glochidial) morphology has been relied upon as a character for taxonomic classification in freshwater mussels and is often considered to be highly conserved across multiple taxonomic levels. The genus *Potamilus* consists of seven species endemic to the Gulf of Mexico drainages and depicts some of the most unique glochidial morphologies in the Unionidae: ligulate shaped glochidia that resemble axe-heads. Despite this significant morphological divergence in glochidial morphology, previous phylogenetic studies utilizing sanger sequenced markers

have questioned the monophyly of *Potamilus*. We utilize Anchored Hybrid Enrichment (AHE) loci to resolve systematic relationships between *Leptodea* and *Potamilus*. AHE is a phylogenomic approach that can be used to sequence hundreds of molecular markers suitable for reconstructing phylogenies at multiple evolutionary scales and captures both protein-coding probe regions and more rapidly evolving non-coding flanking regions. AHE provides a valuable resource for studies on imperiled freshwater mussels considering ethanol preserved tissues, previously extracted DNA, and ancient DNA from museum specimens can be utilized. We used a recently developed AHE probe set (Unioverse) to: 1) evaluate the performance of the AHE probe set in resolving phylogenetic relationships across Ambleminae by implementing multiple datasets comprised of both exonic and hypervariable flanking regions; 2) incorporate AHE loci to test the monophyly of axe-head shaped glochidia (i.e., *Potamilus*); 3) implement scanning electron microscopy (SEM) to examine the unique larval morphology in *Leptodea* and *Potamilus* spp.; and 4) identify genome-wide signatures of selection in regards to diversification of adaptations linked to host fish infection.

22. FRESHWATER MUSSELS (BIVALVIA: UNIONIDAE) FROM THE RISING SUN (FAR EAST ASIA): PHYLOGENY, SYSTEMATICS AND DISTRIBUTION

Manuel Lopes-Lima[1], Akimasa Hattori[2], Takaki Kondo[3], Jin Hee Lee[4], Sang Ki Kim[4], Kanta Sakuma[2], Taishi Toriya[2], Youhei Sunamura[2], Haruki Ishikawa[2], Naoki Hoshino[2], Hinata Kumaki[2], Akiko Tanaka[2], Kentaro Sao[2], Akihisa Shirai[2], Hironori Hayashi[2], Taira Usui[2], Duarte V. Gonçalves[5], Olga Klishko[6], Ekaterina Konopleva[7], Ilya Vikhrev[7], Alexander V Kondakov[7], Mikhail Y Gofarov[7], Ivan Bolotov[7], Alexandra Zieritz[8], Arthur E Bogan[9] & Elsa Froufe[5]

[1]CIBIO, University of Porto, Porto, Portugal; [2]Matsuyama High School, Saitama, Japan; [3]University Kashiwara, Osaka, Japan; [4]Kyungpook National University, Daegu, South Korea; [5]CIIMAR, Porto, Portugal; [6]Institute of Natural Resources, Ecology and Cryology Siberian Branch, Russian Academy of Sciences, Chita, Russia; [7]Federal Center for Integrated Arctic Research, Arkhangelsk, Russian Federation; [8]University of Nottingham, School of Geography, Nottingham, UK; [9]North Carolina Museum of Natural Sciences, Raleigh, NC

In Far East Asia (here restricted to Japan, Korea, and Russia east of the Baikal Lake and Lena River basin), freshwater mussel diversity has been described mainly at the national and regional levels, but a more comprehensive framework is needed in order to better understand their global biogeographic patterns. Until the present study, around 31 species in 15 genera were described for two Unionidae subfamilies (Unioninae and Gonideinae) in Far East Asia. Over the last decades important research has been dedicated to the systematics of Unionida mussels in this region, but some of these studies used only morphological and/or biogeographic arguments that have been shown to consistently fail to delineate taxonomic units. Others, used molecular tools that have shown to be crucial to reveal the evolutionary relationships and delineate species. However, they included a limited number of taxa from a single region or country and very few taxa from outside the study area, making it difficult to understand the phylogenetic relationships of these taxa within the Unionidae. Therefore, the aims of the current study were to: i) elaborate a phylogeny of the freshwater mussels from Eastern Asia; 2) establish and test species boundaries and revise the taxonomy and systematics of East Asian mussels; 3) describe the distribution of each taxonomic unit; and 4) discuss the conservation implications of the results. In order to achieve these aim, 303 specimens from 156 sites were sampled across the region. The phylogenies and species delineation methods, together with morphological inspection of the collected specimens revealed a higher species richness than expected with 40 species in 16 genera. The genera *Amuranodonta*, *Beringiana*, and *Buldowskia* have been elevated from

synonymy. Seven new species were identified and several others were elevated from previously recognized varieties. Further conservation status assessments and measures should consider our results.

23. PATTERNS OF GENETIC VARIATION, STRUCTURE AND THE COMPLEX HISTORIES OF UNIONID POPULATIONS IN GLACIATED REGIONS OF NORTH AMERICA

David T Zanatta
Central Michigan University, Mount Pleasant, MI

For many unionid species, understanding the pattern of genetic diversity across large spatial scales is necessary for developing appropriate conservation strategies. The geologic and glacial history of North America makes this region interesting and ideal for understanding patterns of dispersal and recent evolution in unionid mussels. Published genetic datasets based on mitochondrial sequences and/or microsatellite genotypes have been used to analyze the phylogeography and population genetics of both common and rare/imperiled unionid species from regions spanning the Pleistocene glacial maximum. Patterns that have emerged from these studies indicated that: 1) all species show considerable genetic diversity within populations, even in recently glaciated regions; 2) some species show evidence of recent reductions in genetic diversity as a result of genetic bottlenecks or founder effects; 3) most species show distinctly structured populations by river drainage, possibly reflecting colonization from multiple glacial refugia; and 4) a minority of species show limited or no genetic structure even on broad scales. These patterns may be linked to a species' life history, host fish use, or colonization from a single or multiple glacial refugia. The results of these studies are providing a greater understanding of genetic diversity and structure linked to the often-complex pattern of redistribution of mussels into new habitats following the dramatic climactic shift at the end of the Pleistocene and have important implications for recovering imperiled species.

Session 6: Contaminants and Toxicology II
Monday (2:00 - 3:20)

24. BIOACCUMULATION POTENTIAL AND FATTY ACIDS OF UNIONIDS EXPOSED TO CONTAMINANTS FOUND IN AGRICULTURAL WATERSHEDS

Stephanie P Gill[1], Mandy Annis[2] & Daelyn A Woolnough[1]
[1]Central Michigan University, Biology Department and Institute for Great Lakes Research, Mt. Pleasant, MI; [2]US Fish & Wildlife Service, Michigan Ecological Services Field Offic, East Lansing, MI

Contaminants of emerging concern (CECs) are ubiquitous throughout our waterways, and previous research on individual contaminants has shown that individual CECs can negatively affect aquatic biota. However, in the natural environment CECs are mixed within the water column and have the potential to have combined effects on the local biota. We wanted to know what these effects were by examining how a mixture of common CECs found in agriculturally dominated landscapes affects one of the more sensitive aquatic organisms- the freshwater mussel

(*Lampsilis cardium*). Contaminants were used at a low (1/10x medium), medium (natural levels), and high (10x medium) concentration during a long and short trial for 100 and 40 days respectively. Tissues for analyzing 40 fatty acids and bioaccumulation of atrazine and DEET, both known endocrine disrupting chemicals, were collected during the experiment. There were no differences among treatments on the levels of mono-, poly-, and saturated fatty acids for either trial. However, chemical analyses showed predictable, but currently unreported, trends of bioaccumulation of atrazine and DEET, with significantly higher concentrations in tissues than within the surrounding water column. Greater bioaccumulation of atrazine and DEET in tissue was observed in the high treatment when compared to the medium, low, and two control treatments. This research provides both novel bioaccumulation data on chemicals which are commonly found in our waterways, and reason for concern regarding the biological impacts of these little understood chemicals. Additional research is warranted to understand if, like other aquatic biota, these chemicals will bioaccumulate to levels which can impact the health and reproductive abilities of the freshwater mussel.

25. METHOD DEVELOPMENT FOR SHORT-TERM EFFLUENT TESTS WITH A FRESHWATER MUSSEL (FATMUCKET, *LAMPSILIS SILIQUOIDEA*)

Ning Wang[1], James Kunz[1], Doug Hardesty[1], Jeffery Steevens[1], Teresa Norberg-King[2], Edward Hammer[3], Candice Bauer[3], Tom Augspurger[4], Suzanne Dunn[5], David Martinez[5], Chris Barnhart[6], Jordan Murray[6], Marcus Bowersox[7], John Roberts[7], Robert Bringolf[8], Robert Ratajczak[8], Serena Ciparis[9], Greg Cope[10], Sean Buczek[10], Daniel Farrar[11], Lauren Rabalais[11], Mailee Garton[12], Patricia Gillis[13], Jim Bennett[13], Joseph Salerno[13], Brian Hester[14], Richard Lockwood[15], Chris Tarr[16], Dennis McIntyre[16] & Jonathan Wardell[17]

[1]U.S. Geological Survey, Columbia, MO; [2]US Environmental Protection Agency, Duluth, MN; [3]US Environmental Protection Agency, Chicago, IL; [4]US Fish & Wildlife Service, Raleigh, NC; [5]US Fish & Wildlife Service, Tulsa, OK; [6]Missouri State University, Springfield, MO; [7]Tetra Tech, Owings Mills, MD; [8]University of Georgia, Athens, GA; [9]US Fish & Wildlife Service, Blacksburg, VA; [10]North Carolina State University, Raleigh, NC; [11]US Army Engineer Research and Development Center, Vicksburg, MS; [12]Great Lakes Environmental Center, Traverse City, MI; [13]Environment and Climate Change Canada, Burlington; [14]EcoAnalysts, Port Gamble, WA; [15]Ramboll, Brentwood, TN; [16]Great Lakes Environmental Center, Columbus, OH; [17]US Fish & Wildlife Service, Orangeburg National Fish Hatchery, Orangeburg, SC

Short-term freshwater toxicity testing methods have been promulgated by the USEPA for estimating chronic toxicity of effluent only using three standard species: a fish (*Pimephales promelas*; 7-d exposure), a cladoceran (*Ceriodaphnia dubia*; 6 to 8-d exposure), and a green alga (*Raphidocelis subcapitata*; 4-d exposure). Unionid mussels are among the most sensitive species to a variety of contaminants, including ammonia, some metals and major ion salts. Their sensitivity, ecological relevance, and conservation significance make mussels an attractive additional taxon for effluent toxicity assessments. Between 2012 and 2016, we evaluated the sensitivity of two mussel species (*Villosa constricta* and *Lampsilis siliquoidea*) and two standard species (*C. dubia* and *P. promelas*) to field-collected effluents and laboratory-prepared mock effluents in 7-d exposures. These studies showed that both mussels were more sensitive to the effluents compared to the two standard species. In 2017, we refined the mussel testing method using *L. siliquoidea* by determining optimum feeding rates and ages of juvenile mussels (1-, 2-, and 3-wk old) in a 7-d feeding study and by assessing the sensitivity of the three ages of mussels in 7-d reference toxicant (NaCl) tests. The 1- to 3-wk-old mussels increased in length by up to 50% over the 7-d feeding study, and the sensitivity to NaCl was similar among the three ages of mussels. Finally, an interlaboratory study was performed in 2018 by 13 volunteer laboratories from the USA and Canada to evaluate the performance of 1-wk-old *L. siliquoidea* in a 7-d NaCl toxicity test using the refined methods. All 13 laboratories met the test

acceptability criterion of 80% control survival, and the differences in 20% effect concentrations among laboratories were within a factor of 3, indicating that the proposed methods with *L. siliquoidea* have acceptable precision and can be performed routinely. Disclaimer: This presentation does not necessarily reflect the views or the policies of the US Environmental Protection Agency.

26. EFFECTS OF AMMONIA ON RESPIRATION AND VALVE CLOSURE OF TWO MUSSEL SPECIES FROM CENTRAL TEXAS

Rebecca Gibson & Jim Stoeckel
Auburn University, Auburn, AL

Effects of ammonia on unionids are of concern to managers charged with protecting mussels from ammonia toxicity and to researchers conducting studies in closed systems where excreted ammonia can affect study results. We used a combination of intermittent and closed respirometry to examine effects of ammonia on metabolic patterns of *Cyclonaias pustulosa* and *C. petrina* from the Colorado River, Texas. Concentrations tested were 0.5 mg TAN/L – representing the mean concentration typically accumulated in closed respirometry chambers, and 2 mg TAN/L – representing the 2013 U.S. EPA acute TAN benchmark for unionids under standard conditions of 20°C, pH = 7. Our trials were run at 28°C, pH = 8.5 to more closely match conditions at collection sites. Under these conditions, recommended acute and chronic benchmarks are adjusted downward to 0.77 and 0.21 mg TAN/L respectively. Amongst *C. pustulosa* that remained open during trials, we found no effect of increasing TAN on resting metabolic rate or ability to obtain oxygen as ambient DO concentrations declined. *C. petrina* closed more frequently and did not yield enough continually respiring individuals for analysis. We subsequently used a MosselMonitor to examine effects of 2 mg TAN/L on 48 hr valve-gape patterns. For both species, ammonia exposure resulted in significant reductions in percent gape and percent of time mussels were scored as open. The percent of time "closed" was consistently low (i.e. 0-20%) for control mussels but varied widely (i.e. 0-60%) for exposed mussels. Results suggest ammonia accumulation up to 0.5 mg TAN/L does not significantly affect closed respirometry experiments when mussels remain open. Sublethal effects of ammonia levels approaching 2 mg TAN/L include reduced gape and likely reductions in feeding and respiration. Exposure to high (2 mg TAN/L) concentrations in the natural environment could have detrimental effects on a sensitive subset of the population via impacts on gaping behavior.

27. COMPARATIVE TOXICITY OF SELECTED ALGAECIDES TO FRESHWATER MUSSELS

Sean B Buczek[1], W Gregory Cope[1], Meredith Shehdan[1], West M Bishop[2], Robert J Richardson[3], Joann M Burkholder[1], Thomas J Kwak[4], Justin Nawrocki[5], Tom Warmuth[6] & Monte A McGregor[7]
[1]Department of Applied Ecology, NC State University, Raleigh, NC; [2]SePRO Research and Technology Campus, Whitakers, NC; [3]Dept. of Crop and Soil Sciences, NC State University, Raleigh, NC; [4]U.S. Geological Survey, NC Cooperative Fish and Wildlife Research Unit, Dept. of Applied Ecology, NC State University, Raleigh, NC; [5]UPI, King of Prussia, PA; [6]BioSafe Systems LLC, Hartford, CT; [7]Center for Mollusk Conservation, Kentucky Department of Fish and Wildlife Resources, Frankfort, KY

Harmful algal blooms are becoming an ever increasing global threat to human health, ecological health, biodiversity, and the economy. Giant Lyngbya (*Lyngbya wollei*) is a filamentous cyanobacterium that is capable of producing blooms and toxins that can adversely affect water quality and aquatic life. The distribution of *Lyngbya* is rapidly expanding in the United States, including several water bodies in North Carolina.

Little is known about the potential effects of *Lyngbya* or candidate algaecides that may be used for its control on already imperiled native freshwater mussel fauna. We evaluated the sensitivity of subadult plain pocketbook (*Lampsilis cardium*) mussels to six candidate algaecides for control of *Lyngbya* in a series of standard acute (96 h) toxicity tests. The 96-h median lethal concentration [LC50] for each algaecide tested are as follows: Algimycin® PWF [0.12 mg/L AI], Captain® XTR [0.29 mg/L AI], Cutrine®-Ultra [0.24 mg/L AI], Reward® [135.6 mg/L AI] and Green-Clean® Liquid 5.0 [12.85 mg/L AI]. Three additional 96-h toxicity tests with combinations of the algaecides (Algimycin® PWF/AMP activator, Captain® XTR/ Reward®, Hydrothol® 191/ GreenClean® Liquid 5.0) currently recommended for *Lyngbya* control showed no evidence of additive or synergistic toxicity to mussels. Lastly, we conducted concurrent toxicity tests with two water types (standard laboratory softwater and water from Lake Gaston, NC) in the presence of *Lyngbya* to assess algaecide efficacy and potential differences in mussel sensitivity under more realistic treatment conditions. Results indicated that Lake Gaston water had little effect on algaecide toxicity to mussels. Overall, our results suggest that freshwater mussels are sensitive to all of the algaecides tested, except for Reward® and GreenClean® Liquid 5.0, at the concentrations recommended for control of *Lyngbya*. Assessment of other eradication options in systems where *Lyngbya* and mussels co-occur, and development of other strategies to minimize the spread of *Lyngbya* to new waterbodies, may be important management priorities.

Session 7: Southwestern Freshwater Mollusks I
Monday (3:40 – 4:40)

28. THE FRESHWATER MUSSELS OF MÉXICO (UNIONIDAE & MYCETOPODIDAE)

Kevin S Cummings[1], Charles R Randklev[2], Kentaro Inoue[3], Jeremy S Tiemann[1], Nathan A Johnson[4], John M Pfeiffer[5], Daniel L Graf[6], Tom Miller[7], Amy L Burden[8] & Edna Naranjo-García[9]

[1]Illinois Natural History Survey, University of Illinois, Urbana-Champaign, IL; [2]Texas A&M University Natural Resources Institute, Dallas, TX; [3]Shedd Aquarium, Chicago, IL; [4]U.S. Geological Survey, Wetland and Aquatic Research Center, Gainesville, FL; [5]University of Florida, Florida Museum of Natural History, Gainesville, FL; [6]University of Wisconsin-Stevens Point, Biology Department, Stevens Point, WI; [7]Laredo Community College, Laredo, TX; [8]Swavesey, England, UK; [9]Universidad Nacional Autónoma de México, Ciudad de México, MX

Mesoamerica is a global hotspot of freshwater mussel (Unionida) diversity. However, the mussel fauna of Central America in general, and México specifically, is poorly known and is badly in need of revision. The last comprehensive treatments of the fauna were made by Fischer & Crosse (1870-1902) and von Martens (1890-1901). Frierson (1927) provided a checklist of species from México and placed many of the "species" in the genera of Crosse & Fischer without comment. The Mussel Project (MUSSELp, 2018) currently lists 75 species from México as valid. We examined 1393 total lots (including types) from 16 museum collections collected from the Río Grande drainage south to the Usumacinta basin that separates México and Guatemala. We also conducted fieldwork in the Río Pánuco in San Luis Potosí in December of 2017 and 2018 and the Río Conchos (Río Grande del Norte basin in Chihuahua) in May 2018. After examination of type specimens and preliminary DNA analysis from newly collected samples, we now recognize 49 species of freshwater mussels (42 Unionidae and 7 Mycetopodidae) from México and boundary waters as valid. Cryptic diversity and new species will certainly increase that number. The basins

with the greatest species richness are the Río Grande del Norte (16), Papaloapan / Coatzacoalcos (16), Pánuco (15), and Usumacinta (14). Historically, members of the Unionidae in Central America have been classified with the Nearctic lineages, especially the Ambleminae. Mycetopodids are otherwise endemic to South America. With the exception of a few species, the Mesoamerican assemblage is distinct from that of North America (only 9 species are shared between them) and consists of a large number of endemic species, making it a transition zone between Nearctic and Neotropic faunas. We will present an overview on the history of research on freshwater mussels in México and discuss potential future research directions and opportunities.

29. ASSESSING THE GENUS *POPENAIAS* FRIERSON, 1927, IN THE MEXICAN GULF COASTAL DRAINAGES

Kentaro Inoue[1], Kevin S Cummings[2], Jeremy S Tiemann[2], Thomas D Miller[3], Chase H Smith[4], Nathan A Johnson[5], Edna Naranjo-García[6] & Charles R Randklev[7]

[1]Shedd Aquarium, Chicago, IL; [2]Illinois Natural History Survey, Champaign, IL; [3]Laredo Community College, Laredo, TX; [4]Baylor University, Waco, TX, [5]U.S. Geological Survey, Gainesville, FL; [6]Universidad Nacional Autónoma de México, Ciudad de México, MX; [7]Texas A&M Natural Resources Institute, Dallas, TX

The Gulf coastal drainages of Mesoamerica are a transition zone between the Nearctic and Neotropic biogeographic realms and harbor unique assemblages of aquatic biota. While community composition is distinct between North and South America, the Mesoamerican fauna is composed of species of both Unionidae and Mycetopodidae. However, little information is currently available regarding the distribution and evolutionary history of the Mesoamerican mussel fauna, including the genus *Popenaias*. *Popenaias popeii* (Texas Hornshell) was recently listed as endangered under the U.S. Endangered Species Act; however, the detailed distribution and conservation status of *P. popeii* in Mexico is uncertain. In December 2017 and 2018, we conducted mussel surveys for *P. popeii* in rivers of the Río Pánuco basin in the state of San Luis Potosí, Mexico, and obtained DNA samples for phylogenetic analyses. Additionally, we examined museum specimens from elsewhere in Mexico to understand a holistic picture of *Popenaias* distribution. We sequenced two mitochondrial and one nuclear DNA genes and reconstructed phylogenetic trees to delineate species boundaries. We found that the genus *Popenaias* is sister to species of Lampsilini, where *Popenaias* is attributed to the tribe Popenaiini. Within *Popenaias*, molecular and shell morphometric data indicated that there are three species in the genus: 1) *P. popeii* which is endemic to the Rio Grande drainage; 2) *P. semirasa* which appears to be endemic to the Río Gallinas (Río Pánuco basin in San Luis Potosí); and 3) an undescribed species of *Popenaias* that occurs from the Río Soto la Marina in Tamaulipas south to the Río Jamapa in Veracruz, Mexico. The undescribed species is sister to *P. semirasa* in the Río Gallinas. This study showed drastic reduction of presumed distributional ranges for *P. popeii* and the presence of hidden diversity in Mexican Gulf coastal drainages.

30. LOCAL GENETIC ADAPTATION AND POPULATION STRUCTURE OF A FEDERALLY ENDANGERED UNIONID, *POPENAIAS POPEII*

Steven R Hein[1], Daniel A Trujillo[2] & David J Berg[3]

[1]Miami University, Oxford, OH; [2]New Mexico Department of Game and Fish, Albuquerque, NM; [3]Miami University, Hamilton, OH

Widely distributed species are often subjected to heterogenous habitats and environmental pressures across their ranges. These differential pressures can lead to divergence and populations becoming locally adapted. The emerging field of landscape genomics aims to understand

how the local environment drives local adaptation within populations by identifying areas of the genome potentially under selection and correlating those areas with environmental differences across the species' distribution. When combined with more traditional population genetic techniques that focus on non-adaptive or neutral areas of the genome, strong inferences can be made regarding the evolutionary history of a species. We combined population and landscape genomic principles to investigate the evolutionary history of a federally endangered unionid mussel, *Popenaias Popeii*. Historically, *P. popeii* ranged throughout the Rio Grande drainage of New Mexico, Texas, and northern Mexico but is now restricted to five geographically separated populations. Standard genetic markers do not have the resolving power to associate population genetic variation with environmental variation, but newer techniques are changing our ability to understand local genetic adaption. We used a next-generation sequencing technique, IIb-restriction site-associated DNA sequencing (2bRAD), to scan the genome for single nucleotide polymorphisms (SNPs). We genotyped representatives from all five populations at over 2,000 SNPs and estimated gene flow between populations. Our initial STRUCTURE and DAPC analysis on four of the five known populations found little evidence of admixture between populations. Fst values (an estimate of genetic relatedness) showed evidence of strong genetic isolation between all populations. Currently, we are performing genetic outlier and environmental association analyses to look for areas of the genome under selection and their relationship to climatic variables. This research can shed light on how historical climatic conditions shape the evolutionary trajectories of isolated populations and how different populations will respond to climate change, allowing for informed and effective management decisions.

Session 8: Genetics and Phylogeny III
Monday (3:40 – 4:00)

31. POPULATION GENETICS OF THE CAROLINA HEELSPLITTER (*LASMIGONA DECORATA*) A CRITICALLY-ENDANGERED FRESHWATER MUSSEL

Victoria C Fowler & Michael Gangloff
Appalachian State University, Boone, NC

Freshwater mussel biodiversity has declined substantially in many southern Atlantic Slope streams during the last four decades and several species are now critically endangered. The Carolina heelsplitter (*Lasmigona decorata*) is a federally-endangered freshwater mussel that historically occurred in the Pee Dee, Santee and Savannah basins in Georgia, North Carolina and South Carolina. Currently, Carolina heelsplitters persist as small, isolated populations, primarily within the Charlotte and Carolina Slate Belt physiographic provinces. In order to assess range-wide genetic diversity among Carolina heelsplitter populations, we obtained non-lethal DNA samples from wild animals and individuals in hatchery facilities and sequenced a portion of the mitochondrial COI gene. To date, we have generated and examined COI sequences from 95 Carolina heelsplitters including 25 from the Catawba, 46 from the Pee Dee and 24 from the Savannah drainages. At the COI locus genetic variation in this species appears to be minimal (i.e., <0.23% pairwise divergence) both within populations and among river basins. Three haplotypes were identified from across the 6 populations examined. Two haplotypes were shared among populations in all three river basins, whereas the other haplotype was restricted to Goose and Duck creeks, tributaries to the Pee Dee River. These data provide evidence of

widespread historical connections among Carolina heelsplitter populations in the Pee Dee, Santee and Savannah drainages. This suggests that moving individuals among drainages seems unlikely to negatively impact populations and may prove to be an effective way of rescuing this species. Additionally, crossing individuals from the very small Goose and Duck creek populations with individuals from larger, more stable populations from other drainages (e.g., Lynches River) may provide a way to improve heterozygosity and perhaps introduce genes for increased tolerance to sedimentation or warmer water temperatures from these systems.

32. SPLITTING HEELS: INVESTIGATIONS INTO THE *LASMIGONA* GENUS

Alissa M Ganser[1], Eric M Hallerman[1] & Jess W Jones[2]
[1]Virginia Tech, Blacksburg, VA; [2]U.S. Fish & Wildlife Service, Blacksburg, VA

Within the freshwater mussel genus *Lasmigona*, taxonomic uncertainty exists among *Lasmigona holstonia* in the Tennessee River basin, *L. etowaensis* in the Mobile River basin, and the undescribed *Lasmigona* species in the Cumberland River basin. Previously, these three species were classified as *L. holstonia*; however, recent investigations into this genus now consider *L. etowaensis* a separate species and suggest that the undescribed *Lasmigona* also may be a separate species. *Lasmigona holstonia* inhabits headwater streams in the northern part of Alabama and Georgia, North Carolina, eastern Tennessee, and southwestern Virginia. *Lasmigona etowaensis* occurs in tributaries of the Coosa, Cahaba, and Black Warrior Rivers in Alabama and Georgia. The undescribed *Lasmigona* species occurs exclusively in a few Tennessee streams of the Upper Caney Fork system and Upper Duck River. Given each species' preferred habitat of isolated first- and second-order streams, all three are critically under-studied. For this project, individuals from several populations of *L. holstonia* were collected throughout the Clinch River (VA), New River (VA), and Ocoee River (TN) systems. Individuals of the undescribed *Lasmigona* species were collected from Pocahontas Creek (TN), and DNA sequences of *L. etowaensis* were obtained from individuals previously sampled from populations in Alabama and Georgia. The mitochondrial DNA gene ND1 was used to determine the degree of genetic diversity between populations and across species. Results of this genetic analysis were compared to additional morphological characters, including shell tooth structure, which varies across species. Currently, *L. holstonia* is a candidate for listing under the U.S. Endangered Species Act. Requirements for listing include documentation of the species' current and historically occupied range, which supports the need for assessing the taxonomic validity of these species. Data will be used to provide recommendations for recovery and management efforts and will provide critical information on the need for listing *L. holstonia*.

33. GENETIC STRUCTURE OF *OBOVARIA OLIVARIA* (HICKORYNUT) REVEALED USING MTDNA AND SNPS

Jamie Bucholz[1], David Zanatta[1] & Nicholas M Sard[2]
[1]Central Michigan University, Mount Pleasant, MI; [2]State University of New York-Oswego, Oswego, NY

Obovaria olivaria is a freshwater mussel from the Mississippi River and Great Lakes-St. Lawrence River drainages of central North America. This mussel has experienced substantial population declines across its distribution and is considered imperiled in many jurisdictions. *O. olivaria* uses the similarly imperiled Lake Sturgeon (*Acipenser fulvescens*) and possibly other sturgeons as hosts. Understanding the genetic structure and diversity of *O. olivaria* will enable management agencies to make informed decisions for future recovery programs. In this study, we examined the population structure and diversity of *O. olivaria* from 16 sampling locations including the St. Lawrence River drainage (7 sites),

the Great Lakes drainage (3 sites), the Mississippi River drainage (4 sites), and the White River in the Ozarks (1 site), using both cytochrome oxidase 1 (COI) and Restriction-site Associated DNA sequencing (RADseq) generated single-nucleotide polymorphic (SNP) markers. Inter-region pairwise ST values calculated using COI mtDNA sequence data from *O. olivaria* (n=110 specimens) were significant among most regions, but non-significant (P>0.05) between collection locations in the Great Lakes and Mississippi River drainages. Haplotype and nucleotide diversity at COI was greatest in the Mississippi River drainage with lower diversity in the Great Lakes and St. Lawrence drainages, consistent with hypotheses of post-glacial colonization. Preliminary results from a reduced dataset of 698 SNPs (n=81 specimens) using assignment tests and ordination analyses suggest two genetic populations across the distribution (K=2): the St. Lawrence vs. remainder of distribution. Pairwise FST values were generally low, but significant (P<0.05) among some, but not all collection locations with the largest differentiation evident in the St. Lawrence and Ozarks populations. These results are consistent with the population genetics literature on Lake Sturgeon, and suggest that *O. olivaria* from the St. Lawrence drainage should be treated as a separate population for future conservation actions.

Session 9: Contaminants and Toxicology III
Monday (3:40 – 4:40)

34. APPARENT MICROCYSTIN-INDUCED MUSSEL KILL WITHIN A SMALL IMPOUNDMENT IN WEST VIRGINIA

Janet L Clayton[1], Kevin J Oxenrider[2], Brandon J Keplinger[2] & Clayton D Raines[2]
[1]WV Division of Natural Resources, Elkins, WV; [2]WV Division of Natural Resources, Romney, WV

Increased anthropogenic input of nutrients into freshwater systems has altered the composition of algal communities resulting in a greater number of toxic cyanobacterial (blue-green algal) blooms. Microcystins are hepatotoxins produced by cyanobacteria that are known to have adverse effects on aquatic organisms. In January 2018 a cyanobacterial bloom consisting primarily of *Planktothrix rubescens* occurred in a small impoundment, South Mill Creek Lake (SMCL), West Virginia. Impacts to aquatic life were assessed, and it was apparent that fish, leeches, frogs, and unionid mussels (*Utterbackia imbecillis*) all were affected. All available tissue and connected shells from the dead *U. imbecillis* were collected from two assessment periods. Tissues were analyzed for microcystins/nodularins (MCs/NODs) concentrations. Samples collected on 30 January had a concentration of 16,100 ng/g (ppb) MCs/NODs. Additional dead *U. imbecillis* from the 8 February collection were sent for analysis. As expected based on observed reduction in cyanobacterial coverage at the impoundment, MCs/NODs concentrations from the *U. imbecillis* sample were reduced to 5,900 ng/g (ppb). Although we cannot conclude that microcystin toxicity was the sole cause for the die-off of *U. imbecillis* observed at SMCL, our findings provide strong evidence that microcystin-producing cyanobacterial blooms may pose a serious threat to freshwater mussel populations. Within the last decade cyanobacteria biomasses and compounds have been a source of emerging concern for fisheries biologists in the Potomac River Watershed of WV. Both lentic and lotic surface waters have incurred negative effects relating to cyanobacteria. Over the past decade we have also observed a decline of mussel densities within the watershed.

35. TRACE ELEMENT ASSESSMENT AND EXPOSURE OF JUVENILE RAINBOW MUSSELS (*VILLOSA IRIS*) IN THE POWELL RIVER IN VIRGINIA AND TENESSEE

Andrew Phipps[1], Serena Ciparis[2], Carl E Zipper[3] & Jess W Jones[4]

[1]Department of Fish and Wildlife Conservation, Virginia Tech, Blacksburg, VA; [2]United States Fish and Wildlife Service, Blacksburg, VA; [3]Department of Crop and Soil Environmental Sciences, Virginia Tech, Blacksburg, VA; [4]United States Fish and Wildlife Service, Blacksburg, VA

The freshwater mussel fauna of the Powell River in southwestern Virginia and northeastern Tennessee has declined over the last three decades. Upstream mussel populations have been severely reduced or extirpated. The upper Powell River watershed has been extensively mined for coal, causing widespread disturbance in water and sediment quality. The purpose of this study was to examine concentrations of major ions and trace elements and to assess their effects on survival and growth of juvenile *Villosa iris* at eight sites in the Powell River. Two cohorts of juvenile mussels were deployed in silos: Cohort 1 was 23 months old (20-25 mm) and Cohort 2 was 7 months old (10-15 mm). On day 106 and day 422, juveniles were monitored for growth and survival, and tissue samples were harvested. Water samples were collected on day 0, day 106, and day 422. Specific conductivity was elevated throughout the Powell River, site means ranged from 450 to 900 µS/cm. Mortality was not significantly different between sites ($p>0.28$). Growth of juvenile mussels was significantly higher ($p<0.001$) in the lower river in Tennessee. Regression analysis showed significant relationships ($p<0.001$) between river kilometer and temperature, conductivity, and aqueous major ion concentrations. Principal component analysis (PCA) was conducted on all trace element data. Growth of Cohort 1 on Day 106 was best explained by the PC dominated by aqueous major ion concentrations ($p<.0001$, $R2= 0.65$) and growth of Cohort 2 on Day 106 was best explained by specific conductivity ($p<.0001$, $R2= 0.68$). Growth of Cohort 2 at Day 422 was best explained by tissue trace element concentrations PC1 and PC2 ($p<.0001$, $R2= 0.73$). This study suggests trace element concentrations in the Powell River are negatively effecting the growth of freshwater mussels and that the source of these trace elements is likely mining in the headwaters.

36. COMBINED EFFECTS OF TRACE-METAL MIXTURES ON JUVENILE RAINBOW MUSSELS (*VILLOSA IRIS*)

Tony Timpano[1], Jess W Jones[2], Braven Beaty[3], Matthew Hull[1], David J Soucek[4] & Carl E Zipper[1]

[1]Virginia Tech Blacksburg, VA; [2]US Fish & Wildlife Service, Blacksburg, VA; [3]The Nature Conservancy, Abingdon, VA; [4]Illinois Natural History Survey, Champaign, IL

Mussel populations in certain segments of the Clinch and Powell rivers have been in decline over several decades, but efforts to identify the stressor(s) responsible for such decline have been inconclusive. Toxicity from trace metals is a candidate cause of decline, as several metals are elevated above natural background concentrations in both rivers, but those metals have not been observed at levels exceeding water quality criteria. Given that many trace metals co-occur in the Clinch and Powell rivers, it was hypothesized that multiple-metal mixtures may exert a combined effect that is more toxic than would be predicted based solely on the concentration of any single metal within the mixture. The objective of this study was to test the combined effects hypothesis by conducting chronic toxicity tests using juvenile Rainbow mussels (*Villosa iris*). Mussels were exposed for 42 days to copper, nickel, and zinc singly and as three-metal mixtures at levels near or below Environmental Protection Agency-recommended ambient water quality criteria (WQC) for the individual metals. Metal exposure did not reduce survival, but all metal treatments significantly inhibited growth. Metal concentrations as low as 30% of WQC inhibited growth by more than 25% relative to

controls. Combined effects were evident; the three-metal mixture inhibited growth significantly more ($p < 0.05$) than single-metal exposures of similar concentration (52% inhibition for the mixture versus 34-40% for the individual metals). These results suggest that toxic effects of trace metals on juvenile freshwater mussels may be underestimated based on single-metal concentrations and criteria. Further study of combined effects of contaminants could lead to better understanding of mussel responses in complex systems with multiple stressors.

Session 10: Surveys & Montoring I
Tuesday (9:40 – 12:00)

37. MONITORING UNIONID ASSEMBLAGES OF FLORIDA: BASELINES, THREATS, AND CONSERVATION CHALLENGES

Sahale Casebolt[1] & Susan R Geda[2]
[1]Florida Fish and Wildlife Conservation Commission, Gainesville, FL; [2]Florida Fish and Wildlife Conservation Commission, Milton, FL

Over sixty species of freshwater mussels are known to occur in Florida, of which approximately two-thirds are endemic to the Greater Floridan Region, and 25% are federally listed under the Endangered Species Act. Variation in the distribution of mussel communities reflects distinct physiographic regions within the state. Mussels in Florida face a range of emerging threats including sea level rise, habitat alteration, water quality degradation, and changes to hydrological flow regimes. The Freshwater Mussel Monitoring and Research Program of the Florida Fish and Wildlife Conservation Commission aims to establish baseline mussel population data for the major river basins in Florida by characterizing taxonomic composition and abundance distributions. The program focuses on federally listed species and those designated as species of greatest conservation concern, while also monitoring stable populations of common species. Here we summarize historic and recent monitoring data, discuss the numerous threats facing Florida's mussels, and provide insight into population and community level trends.

38. SPATIAL VARIATION IN COMPOSITION OF MUSSEL COMMUNITIES IN RELATION TO MODELED HABITAT SUITABILITY IN THE MERAMEC DRAINAGE OF MISSOURI.

Kayla N Key[1] & Amanda E Rosenberger[2]
[1]Tennessee Technological University, Tennessee Cooperative Fisheries Research Unit, Department of Biology, Cookeville, TN; [2]U.S. Geological Survey, Tennessee Cooperative Fisheries Research Unit, Department of Biology, Cookeville, TN

State-wide mussel surveys have documented declines in mussel diversity in the Ozark region, including the Meramec River basin, a hotspot of mussel diversity in the Midwestern United States. One primary challenge to conservation of mussels is identifying suitable habitat. Mussel communities are influenced by hydrologic and geomorphic characteristics of streams that vary with stream size. We generated a fundamental niche model for mussels in the Meramec Drainage based on the presence of species-rich mussel beds and then compared species composition of mussel beds in relation to model predictions. We ask the following questions: 1) Does not only richness, but species composition of mussel beds vary with projected habitat suitability, 2) do we find specific community groupings in areas across the spectrum of suitability, 3) Is species richness an effective conservation unit in mussel habitat modeling efforts? We compared mussel assemblages from three subwatersheds in

the Meramec Drainage in Missouri: mainstem Meramec, Bourbeuse River, and Big River. We found that species richness was a useful, representative metric for modeling mussel bed distributions. Community composition of mussel beds act in an additive manner making beds with the most species effective in identifying areas that also can only support lower species beds. We present comparisons made among rivers, species-richness classifications, and habitat suitability. The information provided by this study will help to further support management and monitoring of mussels on a community level to improve conservation and threat management efforts.

39. BASIN-WIDE SURVEY OF THE KALAMAZOO RIVER (MICHIGAN, USA) USING A SEQUENTIAL TIMED SEARCH AND QUADRAT APPROACH

Scott M LaValley & Daelyn A Woolnough
Central Michigan University, Biology Department and Institute for Great Lakes Research, Mt. Pleasant, MI

Michigan has 43 native species of unionids, of which 29 species are listed as threatened, endangered or special concern. Some rivers, like the Kalamazoo River have never been comprehensively surveyed for unionids and any past surveys have been haphazard. The Kalamazoo River basin has a variety of anthropogenic inputs including an oil spill in 2010. Surveys prior to 1950, early 2000's and one small survey in 2012 indicated that the Kalamazoo River has a variety of unionid species but could also be influenced by variable habitat as well as invasive bivalves. In 2018 we completed a survey of 165 sites that were randomly selected based on stream type and temperature. We used a sequential survey protocol that incorporated both multi-tiered timed survey and quadrat searches that was based on Strayer and Smith (2003) and the Michigan Freshwater Mussel Survey Protocol (2018). We also collected shells during these searches. We analyzed species diversity and density parameters and compared them to past data. We then used species richness curves (with live and shells) to determine the optimal search time and considered whether this differs depending on the region of the watershed being surveyed. We will present these results and discuss what we have learned in the Kalamazoo River in the Great Lakes region and how this could be used for conservation efforts

40. A PRELIMINARY ANALYSIS OF MUSSEL POPULATION DYNAMICS IN THE KISHWAUKEE RIVER, ROCKFORD, IL

Sarah Douglass, Jeremy Tiemann, Ethan Kessler & Michael Dreslik
Illinois Natural History Survey, Champaign, IL

In 2013, the Illinois State Toll Highway Authority concluded a lane expansion project on the I-90 Toll Road from Chicago to Rockford, Illinois. INHS researchers initiated two studies during the last several years to evaluate the mussel community and possible long-term effects from construction practices in the Kishwaukee River at I-90. A short distance translocation study using two common mussel species marked with passive integrated transponder (PIT) tags and released upstream of the construction site began in 2013 and completed in 2015. In August 2015, we initiated a capture-mark-recapture mussel population study with special emphasis on rare and state-listed mussels. We've recorded life history data annually and monitored PIT tagged animals when water levels allow. These data will allow us a better understanding of biotic and abiotic factors influencing the mussel community within the Kishwaukee River and recolonization efforts within the post-construction stream area. Here, we present a preliminary analysis of apparent survival and detection rates for the mussel population existing at I-90. As the Kishwaukee River is a highly valuable biological and public aquatic resource, long-term monitoring and research will assist land managers with

needed information for retaining healthy ecosystems and intact biological communities. Additionally, results from our research will help inform mussel species' conservation at a broader scale.

41. MESOHABITAT RELATIONSHIPS TO ABUNDANCE FOR THREE MUSSELS FOUND IN NORTHEASTERN U.S. STREAMS

Ayla J Skorupa[1], Allison H Roy[2], Peter D. Hazelton[3], David Perkins[4], Sean C. Sterrett[5] & Timothy Warren[4]
[1]University of Massachusetts, Amherst, Amherst, MA; [2]Massachusetts Cooperative Fish and Wildlife Research Unit, Dept of Environmental Conservation, University of Massachusetts, Amherst, MA; U.S. Geological Survey, Amherst, MA; [3]Massachusetts Division of Fisheries and Wildlife, Natural Heritage and Endangered Species Program, Westborough; MA, [4]US Fish & Wildlife Service, Cronin Aquatic Resource Center, Sunderland, MA; [5]Monmouth University, Department of Biology, West Long Branch, NJ

The brook floater (*Alasmidonta varicosa*), triangle floater (*Alasmidonta undulata*) and creeper (*Strophitus undulauts*) are found in moderate grade rivers in the northeastern U.S. Both the brook floater and creeper are state endangered due to human alteration of habitat and urbanization causing runoff of pollutants. The tringle floater is not protected; however, many populations are low in density and recruitment is unknown. The triangle floater can tolerate impoundments and have been found in ponds, enabling it to survive in a wider variety of habitats than the creeper and brook floater but fine scale habitat features for this species have not been identified. We used a mesohabitat approach to assess which physical habitat characteristics explain abundances of the three mussel species. Mussel surveys were conducted in 29 different 100-m reaches, selected in rivers where there were records of present or historic occurrence. Each reach was separated into mesohabitat types (riffle, run, pool) that were 20 m long and then divided into longitudinal lanes in which surveyors collected mussels and habitat data. Canopy cover, bed texture and proportions of vegetation, algae, and wood were measured for each mesohabitat. A total of 110 brook floater occupied 44% of reaches surveyed, 112 creeper were found in in 48% of reaches, and 161 triangle floater were found in 55% of reaches. Runs and pools contained the highest number of all three species and mussels were absent from most riffles. Depth was the most significant predictor of brook floater; highest abundances occurred between 20-40 cm. Information on habitat requirements, habitat availability, and mussel population sizes will be used when considering locations for land protection or population augmentation and reintroduction.

42. INVESTIGATING THE EFFICACY OF FLOATING VS HAND-HELD PIT TAG READERS AT FRESHWATER MUSSEL TRANSLOCATION SITES

Alison P Stodola, Rachel M Vinsel, Jeremy S Tiemann & Kirk W Stodola
[1]Illinois Natural History Survey, Champaign, IL

Mussels are often relocated prior to construction projects to conserve populations or boost populations in a depauperate area. Tagging relocated individuals with passive integrated transponder (PIT) tags allows researchers to monitor survival and movement of these animals across time. However, detecting these animals requires increasingly more time and geographical coverage, as animals move to new areas within or outside of relocation sites. In Illinois, we have tagged over 5000 mussels at over a dozen sites as part of federal recovery plans, Illinois Department of Transportation, or Illinois State Toll Highway Authority projects. We compared detection rates of PIT tagged mussels at a subset of these sites using a large-scale floating antenna (measures 4 feet by 10 feet) to small-scale handheld wands (measures 12 inches wide) and also tested efficacy of the floating antenna to traverse stream sections several miles long. During this study, we discovered locations of tagged animals over 2 miles from the original relocation area. In the most extreme cases,

mussels were found that had not been located in five years despite eight sampling events. We also tested performance of both reader types at various tag densities (range of one tag per square meter to 90 tags per square meter) to understand limitations of the technology in translocated mussel beds. We found that the large-scale antenna performed significantly worse than the small-scale handheld wand at nearly all densities greater than 1 tag per square meter, likely due to interference from multiple tags in the 'read zone'.

43. MUSSEL AND HABITAT ASSESSMENT OF THE DUCK RIVER SYSTEM, TENNESSEE

Kristin L Irwin[1], John B Alford[2], Gerald R Dinkins[2], Steven A Ahlstedt[3] & Amanda E Rosenberger[4]
[1]USGS Coop Unit at Tennessee Technological University, Cookeville, TN; [2]University of Tennessee, Knoxville, TN; [3]U.S. Geological Survey, Retired, Knoxville, TN; [4]U.S. Geological Survey, Cookeville, TN

The Duck River in Tennessee is one of the most biologically diverse rivers in North America, and is a crucial locality for ongoing persistence of critically endangered freshwater mussel species. Although the main channel is regularly monitored, the tributaries have been neglected as a research focus. Due to these knowledge gaps and the potential for unknown populations of cryptic and listed species, a survey of the tributaries of the Duck River was conducted. Historical review revealed that 29 species occurred historically in the tributaries to the Duck River. One hundred thirteen sites on 46 tributaries from Blue Creek upstream to Crumpton Creek were sampled qualitatively for freshwater mussels. Nineteen species were observed, but only twelve were collected in live or fresh dead condition. This study suggests that 59% of the species known to have occurred historically in the study area are extirpated. Broad habitat degradation was observed throughout tributaries, and mussel populations were isolated and restricted to only a few streams. The potential causes of mussel declines in the Duck River tributaries are not apparent from the field aspect of this study. We propose to collect key information on the geomorphological and hydrological properties of the Duck River that have been important for an existing fundamental niche model developed for freshwater mussels in an Ozark system for the Duck River, where changes to hydrogeomorphology has been implicated in the loss of key mussel beds. This habitat suitability model will allow us to determine whether steam power, lateral channel stability, proximity to stable gravel bars and channel controls, and the presence of drought refugia are predictors of mussel presence in the Duck River and its tributaries. Information from this model will inform managers on the continued conservation and future restoration of the freshwater mussel fauna of the Duck River system.

Session 11: Southwestern Freshwater Mollusks II
Tuesday (9:40 – 12:00)

44. EXPLORATION OF A REINTRODUCTION IN THE HIGHLY URBANIZED MISSION REACH OF THE SAN ANTONIO RIVER

Shaun M Donovan, Chris Vaughn, Doug Knabe & Larry Larralde
San Antonio River Authority, San Antonio, TX

Various channel modifications to the San Antonio River (SAR) in and around downtown San Antonio, TX, have led to significant disturbances of native Unionid populations. However, populations are known to exist in remnants that were cut off from the main stem as a result of these

channel modifications. Completed in 2013, the Mission Reach Ecosystem Restoration project has largely restored ecological function and dramatically increased habitat availability in an eight-mile stretch of the SAR immediately downstream of San Antonio. Various projects in the Mission Reach have demonstrated this ecological lift, such as a three year avian study and the successful reintroduction of *Micropterus treculii*. Over the past two years, the San Antonio River Authority (River Authority) has begun exploring the possibility of reintroducing four native Unionid species into the Mission Reach; *Amblema plicata*, *Cyclonaias aurea*, *Lampsilis teres* and *Tritogonia verrucosa*. Numerous steps have been taken to assess the viability of a reintroduction including the Mission Reach Mussel Survivability (MRMS) study, which examines growth and survivability of adult mussels in various gear types. Additional effort includes fish stocking, routine nekton, benthic macroinvertebrate and habitat assessments, and intensive nekton sampling to analyze fish assemblage dynamics. A two year partnership with the United States Fish & Wildlife Service (2019-20) will examine propagation methodology for the aforementioned species, provide for the inclusion of juveniles into the MRMS study, explore induced captive spawning methodology and expose gravid adults, juveniles and glochidia to basic toxicology testing. Genetic analysis of the four species throughout the basin will be conducted in year two of the partnership and provide the basis for the development of a genetic management plan. Upon completion of the two year partnership, River Authority staff will determine the appropriate steps to re-establish a healthy Unionid population in the Mission Reach.

45. PRIORITIZING DAM REMOVAL FOR FRESHWATER MUSSEL CONSERVATION IN THE GUADALUPE – SAN ANTONIO RIVER SYSTEM

Erin D Dascher
Eastern Washington University Cheney, WA

Freshwater mussels are a globally threatened fauna that are particularly vulnerable to habitat fragmentation and other dam impacts. In Texas, more than half of the native freshwater mussels are potentially imperiled. While the majority of environmentally motivated dam removals occur in regions with anadromous fish populations, as the science of dam removal develops, other species impacted by fragmentation, such as native freshwater mussels, will become additional drivers of dam removal. This study assessed the potential of dam removal as a conservation strategy for freshwater mussels in a central Texas river system. Two dam removal prioritization models were created for the Guadalupe – San Antonio River System. The models incorporated expert opinion and compromise programming to assign priority ranks for removal to over 200 registered dams. Expert opinion was obtained from members of state and federal agencies, non-profits, and academic institutions at a one-day workshop. The first model included metrics agreed upon at the workshop and prioritized dam removals based solely on the potential for freshwater mussel conservation. The second model incorporated additional surrogate feasibility or likelihood of removal metrics in the form of dam attributes. The addition of these metrics resulted in higher differentiation between removal priority rankings for individual dams and prioritization rankings that more accurately reflected the possibility of removal. Results from both models indicated that dam removal in highly urbanized watersheds, as a solitary measure, may be a poor restoration strategy for freshwater mussels. The results also highlighted the need for better record keeping both of dams and dam removals as well as the need for increased mussel and host fish surveys. The methods and results presented in this study should be considered broad scale decision support tools for the complex decision making surrounding dam removal as a freshwater mussel conservation strategy.

46. DETERMINING THE SURVIVABILITY AND GROWTH OF FRESHWATER MUSSELS IN A RECENTLY RESTORED STRETCH OF THE UPPER SAN ANTONIO RIVER TO STEER A DECISION ON REINTRODUCTION

Christopher R Vaughn & Shaun M Donovan
San Antonio River Authority, San Antonio, TX

The Upper San Antonio River (USAR) was once home to a diverse freshwater mussel population before urbanization caused a drastic degradation of the ecosystem and an almost complete extirpation. Small relic populations of native mussels can be found in remnant channels of the USAR which avoided most of the impact of these anthropogenic forces. The five-year-old San Antonio River Improvements Project has rehabilitated a previously channelized eight mile portion of the USAR by providing more instream cover, increased sinuosity and improved habitat resiliency. Some post-restoration studies have taken place to showcase this lift; namely, the Mission Reach Avian Study as well as the successful reintroduction of the Guadalupe Bass. The Mission Reach Mussel Survivability Study is another post-restoration validation study that has been established to determine if the ecological lift has made this stretch more accommodating to four native freshwater mussel species that are found in the Lower San Antonio River (LSAR): Golden Orb, Threeridge, Pistolgrip, and Yellow Sandshell. The primary goal of this study is to determine the feasibility of a future reintroduction effort in this improved reach. Organisms are being held captive at two sites in the Mission Reach and at a control site in the LSAR to compare survivability and growth. If it is determined that the Mission Reach mussels grow at a similar rate as the LSAR mussels then a reintroduction of these organisms could be possible in the future. Results are currently limited due to high flows causing inaccessibility at the control site; therefore, comparisons and deeper inferences are difficult to make at this time. Initial survivability and growth are high in the Mission Reach.

47. FRESHWATER MUSSEL HABITAT MODELING AND ENVIRONMENTAL FLOW ANALYSIS IN THE LOWER COLORADO RIVER, TEXAS

Bradley M Littrell[1], Kyle T Sullivan[1] & Edmund L Oborny, Jr[2]
[1]BIO-WEST, Inc., San Marcos, TX; [2]BIO-WEST, Inc., Round Rock, TX

A previous instream flow study on the lower Colorado River, Texas generated instream flow recommendations based on fish habitat modeling and other flow-dependent ecological variables. However, previous studies in the basin have not addressed the environmental flow requirements of freshwater mussels. This study modeled habitat for freshwater mussels using two-dimensional hydraulic models at two sites on the lower Colorado River in conjunction with mussel habitat suitability data collected from the same system. Analysis was conducted for all mussels in aggregate, as well as for two species of interest, Texas pimpleback *Cyclonaias petrina* and Pimpleback *C. pustulosa*. We used an integrated modeling approach of first evaluating shear stress across a range of flow conditions to identify persistent habitat patches, followed by modeling of habitat suitability criteria based on depth, velocity, Froude number, Reynolds number, and dominate substrate type within those habitat patches at base flow levels. Independently collected mussel validation data were then overlaid on model output to evaluate usefulness of model predictions. Occurrence of *C. pustulosa* and catch-per-unit-effort (CPUE) of *C. pustulosa* and all mussels in aggregate were positively associated with model-predicted Composite Suitability Index (CSI) values. Habitat to discharge relationships were explored by calculating the weighted usable area of predicted mussel habitat within persistent patches, termed Persistent Weighted Usable Area (PWUA), at various modeled base flow rates. Results are discussed in context of existing environmental flow standards in the basin.

48. DISTRIBUTIONAL PATTERNS AND HABITAT UTILIZATION OF FRESHWATER MUSSEL COMMUNITIES IN THE MAINSTEM COLORADO RIVER, TEXAS.

Kyle T Sullivan & Bradley M Littrell
BIO-WEST, Inc., San Marcos, TX

Conservation of freshwater mussels requires data on distribution, abundance, and habitat utilization, among other factors. In Texas, the scarcity of historical and contemporary survey data has hindered ongoing conservation assessments. In central Texas, survey data on Colorado River basin mussel fauna was predominantly from tributaries, while information about the mainstem fauna was restricted to shell records and limited survey efforts. The Colorado River basin harbors 21 currently-recognized mussel species. This includes 4 regional endemics, Texas pimpleback *Cyclonaias petrina*, False spike *Fusconaia mitchelli*, Texas fatmucket *Lampsilis bracteata*, and Texas fawnsfoot *Truncilla macrodon*, which are currently pending review for federal protection under the Endangered Species Act (ESA). Our main objective was to conduct comprehensive longitudinal freshwater mussel surveys in two reaches of the mainstem Colorado River to provide baseline data and explore geographic patterns in mussel communities. A secondary objective was to evaluate habitat utilization, particularly for the species under ESA review. In total, we collected 2,798 live unionids represented by 15 species from the mainstem, including ESA candidates *C. petrina* and *T. macrodon*. Mussel assemblage structure varied among ecoregions, with a greater proportion of opportunistic life history strategist within Prairie sites, while more equilibrium strategist occurred in Edwards Plateau and Lowland sites. Taxa richness and abundance in the Lower Colorado increased with distance downstream, while the Middle Colorado exhibited a multimodal pattern. Among mesohabitats, richness was highest in pool-bank habitats, while abundance was highest in pool-bank, pool-channel, and run-bank habitats. Our results provide valuable insight on distributional patterns of the mainstem Colorado River mussel fauna that may help with developing future conservation plans for central Texas unionids.

49. MUSSELS OF TEXAS: VISUALIZING STATEWIDE MUSSEL BIODIVERSITY DATA ONLINE

Yang Cao[1], Charles R Randklev[2], Jennifer Morton[2], Ross Anderson[1], Mark Fisher[3] & Roel Lopez[4]
[1]Texas A&M Natural Resources Institute, College Station, TX; [2]Texas A&M University Natural Resources Institute, Dallas, TX; [3]Texas Department of Transportation, Austin, TX; [4]Texas A&M Natural Resources Institute, San Antonio, TX

One of the most important challenges facing conservation biologists is the lack of biogeographic information on the distributions of imperiled species and factors that are responsible for their decline. This challenge has been termed the Wallacean Shortfall and although a substantial effort has been made to address this shortfall, there remain significant knowledge gaps on the distribution of many species, including mussels. In Texas, effective biological surveys for mussels have only been implemented within the last 5 to 10 years, resulting in discoveries of extirpated and extinct species. As a result, hypothesis regarding species distribution patterns are beginning to change. These changes are also due to revisions in mussel taxonomy based on results from modern molecular studies but also a compilation of distribution datasets, many of which have not been validated or properly georeferenced. In this study, we address the latter by developing a web-based mussel database called the Mussels of Texas (MoT), using over 25,000 validated historical and contemporary records. This tool will eventually be made available to stakeholders and the general public to help with conservation planning and outreach.

50. HYDRAULIC REQUIREMENTS OF FRESHWATER MUSSELS (UNIONIDAE) AND A CONCEPTUAL FRAMEWORK FOR PREDICTING HOW MUSSELS RESPOND TO BED MOBILITY: TWO CASE STUDIES FROM THE BRAZOS AND TRINITY RIVERS OF THE WESTERN GULF COASTAL PLAIN REGION OF SOUTH-CENTRAL USA

Charles R Randklev[1], Michael A Hart[1], Jennifer Khan[1], Eric Tsakiris[2] & Clinton R Robertson[3]
[1]Texas A&M University Natural Resources Institute, Dallas, TX; [2]USFWS, Shepherdstown, WV; [3]TPWD, San Marcos, TX,

Spatiotemporal variability in flow determines the physical structures of habitat. During low flows, aquatic organisms can be exposed to reduced dissolved oxygen concentrations, increased water temperature, and desiccation, whereas at high flows, increased velocity and hydraulic forces on the stream bed can be equally detrimental. These constraints create a mosaic of habitat that influences the distribution and abundance of aquatic biota. This mosaic can change due to stochastic events or those mediated by humans. Understanding how high and low flow conditions affect aquatic organisms is critical not only for advancing ecological knowledge but also for protecting aquatic species such as unionid mussels and the conservation and restoration of freshwater ecosystems. The overall goal of this project was to examine how substrate and hydrologic conditions affect mussel habitat and to then use the resulting information combined with life history traits and shell morphology (i.e., sculpturing) to better understand how flow shapes mussel assemblage structure. Using quantile regression, we found that low values of relative shear stress (RSS), a measure of substrate stability, were associated with high mussel species richness and abundance. Change point analysis using threshold indicator taxa analysis (TITAN) indicated species-specific preferences for varying levels of bed stability. These preferences were be best explained by life-history strategy and shell morphology based on the results of a principal component analysis. Using these results, we then present a conceptual model from which to derive expectations concerning taxonomic composition, life history strategy, and shell sculpture type based on the degree of bed mobility using RSS.

Session 12: Genetics and Phylogeny IV
Tuesday (9:40 – 12:00)

51. INTEGRATING MOLECULAR AND MORPHOLOGICAL DATA TO CONFIRM NEW RECORDS OF *PLEUROBEMA RIDDELLII* (LEA, 1862), A FRESHWATER MUSSEL BEING CONSIDERED FOR PROTECTION UNDER THE ENDANGERED SPECIES

Nathan A Johnson[1], Chase H Smith[2], Caitlin E Beaver[1], Paul D Hartfield[3] & Charles R Randklev[4]
[1]U.S. Geological Survey Gainesville, FL; [2]Baylor University, Waco, TX; [3]US Fish & Wildlife Service, Jackson, MS; [4]Texas A&M University Natural Resources Institute, Dallas, TX

Misidentifications and inaccurate distributional information for rare or at-risk species can misguide conservation and recovery efforts. In fact, accurate delimitation of a species' current and historical range is arguably the most critical component of Species Status Assessments (SSA) and the Endangered Species Act (ESA) listing decision-making process. The Louisiana Pigtoe, *Pleurobema ridellii*, is currently being considered for protection under the ESA and we investigated the historical and current range of the species to better inform the listing process. The presumptive range of *P. riddellii* is north to the Little River basin in Arkansas, east to the Calcasieu River basin in Louisiana, and west to the

Trinity River basin in Texas. This range only includes rivers located west of the Mississippi River, including the Big Cypress, Calcasieu, Little, Neches-Angelina, Red, Sabine, San Jacinto, Sulphur, and Trinity river basins. We examined recent and historical collections and tentatively identified specimens collected east of the Mississippi River as *P. riddellii*. Using morphological and molecular characters, we were able to confirm their identity. This finding significantly increases the species' geographic range and raises questions about its imperiled status; however, additional surveys are needed to thoroughly document the eastern extent of the species' range.

52. ESTABLISHING THE SPECIES BOUNDARIES, RELATIONSHIPS, AND DISTRIBUTIONS WITHIN *QUADRULA* (RAFINESQUE, 1820)

Sean M Keogh[1], Bernard Sietman[2], Kentaro Inoue[3], Andrew Simons[1] & Charles R Randklev[4]
[1]University of Minnesota/Bell Museum, St. Paul, MN; [2]Minnesota Department of Natural Resources, Lake City, MN; [3]John G. Shedd Aquarium, Chicago, IL; [4]Texas A&M University Natural Resources Institute, Dallas, TX

The genus *Quadrula* has long been a source of frustration for North American malacologists. This frustration stems from a large degree of interspecific morphological and distributional overlap as well as confusion over the validity of taxa. Here, we use multilocus sequence (COI, ND1, ITSI) and three-dimensional shell morphometric data to evaluate the taxonomic identity of all extant *Quadrula* taxa: *Q. apiculata*, *Q. fragosa*, *Q. nobilis*, *Q. quadrula*, *Q. rumphiana* as well as closely related *Tritogonia verrucosa*. We used >100 specimens from >20 localities in addition to sequences obtained from GenBank to construct a robust phylogenetic hypothesis. Our results differ significantly from Serb et al. 2003, who published the most recent phylogeny of the clade. For example, we recovered a monophyletic *Q. nobilis* that was sister-related to *T. verrucosa*. We integrate our molecular dataset with three-dimensional reconstructions of species shells using micro-computed tomography scanning to visualize interspecific shell shape differences. Although this work is preliminary, we are digitizing CT-scans with three-dimensional landmark and semilandmark coordinates to quantify inter and intraspecific shell variation as well as validate our molecular results. We plan to leverage these results with museum shell material to infer the historic ranges of *Quadrula* species within the United States, which is necessary for developing effective conservation strategies, especially for wide-ranging species like those within the genus *Quadrula*.

53. ASSESSING GENETIC DIVERSITY IN WILDSTOCK, BROODSTOCK AND HATCHERY-REARED PROGENY OF ENDANGERED *EPIOBLASMA* SPECIES

Jess W Jones[1], Katlyn Ortiz[2] & Eric M Hallerman[2]
[1]US Fish & Wildlife Service, Blacksburg, VA; [2]Department of Fish and Wildlife Conservation, Virginia Tech, Blacksburg, VA

How much genetic variation is maintained during propagation and culture of mussels at hatcheries in the United States is a key management question in need of study. Current propagation practices can potentially reduce genetic variation in progeny via selection of gravid female mussels from the wild, limited number of broodstock used, fish host selection, and juvenile mussel rearing. We assessed genetic variation of wildstock, broodstock and progeny of five critically endangered *Epioblasma* species (*E. aureola*, *E. brevidens*, *E. capsaeformis*, *E. obliquata*, and *E. triquetra*) utilizing 10-14 nuclear DNA microsatellites and the mitochondrial DNA gene ND1. To obtain DNA, swab samples were collected from individuals in the Clinch River in Tennessee and Virginia, from Killbuck Creek in Ohio, and from progeny reared at the Virginia Department of Game and Inland Fisheries' Aquatic Wildlife Conservation Center, Virginia Tech's Freshwater Mollusk Conservation Center, and Kentucky

Department of Fish and Wildlife Resources' Center for Mollusk Conservation. At microsatellite loci, genetic variation of progeny remained high relative to wildstock and broodstock, as measured by standard genetic variation metrics such as heterozygosity (He and Ho), mean number of alleles, and private alleles (unique to sample, group or population). In some cases, microsatellite variation of *E. brevidens* and *E. capsaeformis* was slightly higher in progeny relative to wildstock and broodstock, and in other cases genetic variation was slightly lower in progeny. However, progeny generally contained less mitochondrial DNA genetic variation. Current propagation practices for collecting broodstock from the wild, especially from large and healthy populations, likely contributed to maintaining genetic variation in hatchery-reared progeny. Further, fertilization of females by multiple males in the wild may have acted to increase genetic variation among female broodstock. Application of species-level protocols for field-collection and utilization of broodstock at hatcheries is needed to ensure that high genetic variation is maintained in progeny.

54. CONSERVATION GENOMIC ASSESSMENT OF WILD AND CAPTIVE POPULATIONS OF THE LOUISIANA PEARLSHELL, *MARGARITIFERA HEMBELI* (CONRAD), USING RADSEQ

Nicole L Garrison[1], Nathan Whelan[2] & Paul Johnson[3]
[1]Auburn University, Auburn, AL; [2]U.S. Fish & Wildlife Service, Auburn, AL; [3]Alabama Aquatic Biodiversity Center, Marion, AL

Assessment of standing genetic variation in wild populations of threatened and endangered species is a crucial step in developing effective propagation, reintroduction, and long term management plans. To aid in conservation planning and evaluate genetic diversity of both wild and captive populations of the threatened freshwater mussel *Margaritifera hembeli*, we employed a genomic restriction enzyme associated approach (RADseq). Specifically, we sought to understand the partitioning of diversity within and among populations and the genetic consequences of rearing individuals for reintroduction from a single captive female. Twenty individuals were sampled (Isohelix swabs) from four streams in central Louisiana; Black Creek and Jordan Creek (Grant Parish) and Loving Creek and Brown Creek (Rapides Parish). In addition to wild populations, we sampled tissue clips of 20 individuals that were propagated at the Alabama Aquatic Biodiversity Center from a single Black Creek female. DNA was extracted and standardized prior to being sent to Floragenex for RAD-seq library prep and sequencing on the Illumina platform. Sequencing resulted in >1 million raw 100bp PE reads per individual. Reads were assembled and variants were called by the program Stacks, yielding 1776 SNPs for downstream analyses. Clustering algorithms implemented in the R packages LEA and adegenet (dapc) revealed genetic clustering of northern populations (Black Creek and Jordan Creek) and two distinct southern clusters corresponding to populations in Rapides Parish – Loving Creek and Brown Creek. Captive individuals were assigned to their wild population of origin successfully and showed levels of genetic diversity comparable to that of wild populations. While sampled populations are genetically distinguishable units, this species displays very low levels of sequence and allelic diversity within and among populations overall. Reduced fitness due to inbreeding may be a concern when planning propagation and amendment of populations, and cross-parish reintroductions should be avoided to maintain current patterns of diversity.

55. EVOLUTION OF HOST INFECTION STRATEGIES IN THE LAMPSILINE MUSSELS (BIVALVIA: UNIONIDAE): A PHYLOGENOMIC PERSPECTIVE

Trevor L Hewitt, Diarmaid Ó Foighil & Amanda Haponski
University of Michigan, Ann Arbor, MI

In North America, the Lampsilini tribe contains the greatest number of species and is one of the most imperiled taxonomic groups. This tribe also includes many remarkable examples of host infection strategies. Zanatta and Murphy (2006) found evidence for early evolution of mantle lures in this clade, with alternative active host infection strategies being derived. We used a double-digest RAD-seq (ddRAD) approach to assemble a comprehensive genomic dataset for the Lampsilini mussels and reassess the evolution of active host infection strategies using a new approach. Tissue samples from 65 of ~100 extant species were collected from various museums as well as from the field. We used a combination of EcoR1 and Mse to cut DNA into random fragments. We then isolated fragments between 300-400 base pairs long which were then amplified and sequenced on an Illumina HiSeq 2500 to generate paired end reads ~150bp long. This data was used to generate the first next-generation phylogeny of the Lampsilini to date. Our data will be used to corroborate the findings by Zanatta and Murphy (2006) and expand our knowledge of the phylogenetic relationships within the Lampsilini tribe. Host-specialization is a ubiquitous trait for all parasites and is presumed to have important implications for the evolutionary rates of parasite taxa. We estimate evolutionary rates and compare these estimates to host specificity in Lampsilini mussels to test predictions based on evolutionary theory.

56. MORPHOLOGY AND PATTERNS IN ARBORESCENT PAPILLAE OF THE INCURRENT APERTURE AMONG PEARLSHELL MUSSELS, FAMILY MARGARITIFERIDAE

André L Martel[1], Arthur Bogan[2], Ivan Bolotov[3], Juergen Geist[4], Paul Johnson[5], Olga Klishko[6], Manuel Lopes-Lima[7], Kazuki Miura[8], Vincent Prié[9], Bernard Sietman[10], Ilya Vikhrev[11], Greg Wilson[12] & David Zanatta[13]
[1]Research & Collections, Canadian Museum of Nature Gatineau, QC; [2]Research and Collections, North Carolina Museum of Natural Sciences, Raleigh, NC; [3]Lab of Molecular Ecology and Biogeography, Northern Arctic Federal University, Arkhangelsk, Russia; [4]Aquatic Systems Biology, Technical University of Munich, Munich, Germany; [5]Alabama Aquatic Biodiversity Center, Marion, AL; [6]Institute of Natural Resources Ecology and Cryology, Siberian Branch, Russian Academy of Sciences, Chita, Russia; [7]Interdisciplinary Centre of Marine and Environmental Research, University of Porto, Porto, Portugal; [8]Watershed Conservation and Management Lab, Hokkaido, Japan; [9]BIOTOPE et Muséum d'histoire naturelle, Paris, France; [10]River Ecology Unit, Center for Aquatic Mollusk Programs, Lake City, MN; [11]Lab of Molecular Ecology and Biogeography, Northern Arctic Federal University, Arkhangelsk, Russia; [12]Aquatic Species-at-Risk, BC Ministry of Environment, Victoria, BC; [13]Biology Department, Central Michigan University, Mount Pleasant, MI

The freshwater mussels of the family Margaritiferidae (pearl shells, freshwater pearl mussels) comprise an estimated 16 species occurring in Asia, North America, Europe and North Africa. The group is known for the presence of unique arborescent papillae (AP) bordering the rim of the incurrent aperture. The goals of this morphological investigation are to (i) describe and contrast AP along the aperture of each species, and (ii) document morphological differences in AP among the Margaritiferidae. We used (a) macro-photographs of the incurrent apertures of live, undisturbed filter-feeding mussels, and (b) prepared incurrent apertures of ethanol-preserved or freshly-euthanized specimens positioned for photography. Ten species have so far been examined: five from North America (*Margaritifera margaritifera*, *M. falcata*, *M. hembeli*, *M.*

marrianae, *Cumberlandia monodonta*), two from Europe (*M. margaritifera*, *Pseudunio auricularius*), one from Africa (*Pseudunio marocanus*) and three from Asia (*M. dahurica*, *M. laevis*, and *Gibbosula laoensis*). For all species examined, morphological complexity and size of AP rapidly increase towards the median region of the aperture, where small and intermediate papillae interspace larger and more complex papillae. Examination of successions of AP allowed us to discover and describe a predominant distributional pattern, or 'cycle', among the AP of Margaritiferidae, a pattern that we designate as the 'cycle of five'. This predominant pattern is based on size and branching complexity and can be described as: High-Low-Medium-Low-High. Each papillae type (H, L, M, L, H) plays a specific role in the formation of the 'ridge-and-trough' pattern, or succession of folds, along the incurrent aperture when expanded during filter-feeding. Although all Margaritiferids examined display AP, this study demonstrates variation in specific morphologies of AP between species. Functional morphology and appearance of a fractal geometry within AP will be discussed.

57. FRESHWATER MUSSELS TRANSLOCATED INTO CAPTIVITY EXHIBIT UP-REGULATION OF GENES INVOLVED IN STRESS AND ENERGY METABOLISM

Ieva Roznere[1], Brandon T Sinn[2] & G. Thomas Watters[1]
[1]The Ohio State University, Columbus, OH; [2]West Virginia University, Morgantown, WV

Freshwater mussels are often translocated between habitats or into captivity for purposes such as propagation, basic research, or as temporary refugia following environmental impacts. Although translocation is an important tool that is increasingly used in wildlife conservation and management, it often results in increased mortality and reduced growth rates. Despite the necessity, there is limited knowledge of mussel health and the effects of translocation on mussel physiology. The objective of this study was to determine how translocation into captivity changes the gene expression profile of the freshwater mussel *Amblema plicata* (Threeridge) using RNA-Seq. Four adult *A. plicata* were collected from the Muskingum River in Washington County, OH in September, 2014. Mussels were transported to the Columbus Zoo and Aquarium Freshwater Mussel Conservation and Research Center. Gill tissue samples were collected 11 months post-translocation from each of the mussels in captivity (treatment group) and from three mussels collected in the river (control group). RNA was extracted and sequenced on the Illumina HiSeq 2500 Sequencer. De novo assembly of sequenced reads was performed using Trinity and differential gene expression was determined using edgeR. Assembled transcripts were used as BLASTx queries against the NCBI nr database, and functional annotation was performed using Blast2GO. Transcriptome assembly produced 312,974 transcripts. A total of 1,760 transcripts were significantly differentially expressed: 1,251 were up-regulated in the translocated mussels, and 509 were down-regulated. Of the up-regulated transcripts, 527 received BLAST hits. Of the down-regulated transcripts, 161 received BLAST hits. Mussels translocated into captivity showed increased expression of genes that code for proteins involved in the stress response and energy metabolism. We will discuss how gene expression can be monitored in both natural and experimental settings to evaluate stress responses to a wide variety of environmental variables, and how such information can be used to improve conservation techniques.

Session 13: Contaminants and Toxicology IV
Tuesday (2:00 - 3:20)

58. QUANTIFYING POLLUTANT-REMOVAL ECOSYSTEM SERVICES BY UNIONID MUSSELS

Jennifer M Archambault[1], W. Gregory Cope[1], Meredith L Shehdan[1], Clayton L Lynch[1], Sean B Buczek[1], Teresa J Newton[2], Heidi L Dunn[3] & Chris B Eads[4]

[1]Department of Applied Ecology, North Carolina State University, Raleigh, NC; [2]USGS Upper Midwest Environmental Sciences Center, La Crosse, WI; [3]EcoAnalysts, Inc., O'Fallon, MO; [4]Dept of Marine, Earth, and Atmospheric Sciences, North Carolina State University, Raleigh, NC

The filter-feeding action of native freshwater mussels (Unionida) serves several recognized ecological functions, and it acts as an ecosystem service to humans by sequestering harmful pollutants from drinking water and recreation resources. Because mussels comprise a large proportion of benthic biomass, and each individual filters several liters of water per day, the potential for mussel populations to sequester large masses of contaminants is substantial. We quantified pollutant-removal ecosystem services by pairing pollutant concentrations in mussel tissue with population estimates to calculate the total mass of contaminants sequestered in mussel populations, and to understand the relative value of contaminant removal by native mussels (e.g., water treatment), and the cost of other important ecosystem services lost (e.g., nutrient cycling) from impacts on mussel populations (e.g., population decline). We estimated that two mussel populations in a large river system sequestered 4.3 and 11.3 tons of metals. We will also present estimates of organic pollutant removal by mussels. Building on our estimates of metal removal at the population level, we conducted three 28-day experiments with nickel (Ni) and cadmium (Cd) – two toxic heavy metals of environmental and human health concern – to determine how pollutant-removal services may fluctuate with differing environmental conditions. We exposed Eastern Elliptio (*Elliptio complanata*) to five concentrations of nickel, cadmium, or nickel + cadmium, that represented a range of conditions measured in North American surface waters (0 – 100 µg/L for Ni; 0 – 2 µg/L for Cd), and collected water, tissue, and excreta samples during the test. We will present on preliminary results from this work. Our research begins to illuminate the scale of pollutant sequestration by native mussel fauna, estimate environmental partitioning of pollutants by mussels, may help to estimate variation in pollutant removal ecosystem services (e.g., changes with varying environmental pollution), and will aid in contextualizing the role of native mussels in providing ecosystem service benefits to people.

59. CHARACTERIZING IMPACT OF CONTAMINANTS OF EMERGING CONCERN ON JUVENILE TRANSFORMATION: AN APPLICATION OF ZERO INFLATED POISSON LINEAR MIXED MODELS AND DOSE RESPONSE CURVE

Lacey D Rzodkiewicz[1], Mandy Annis[2] & Daelyn A Woolnough[1]

[1]Central Michigan University, Biology Department and Institute for Great Lakes Research, Mt. Pleasant, MI; [2]US Fish & Wildlife Service, Michigan Ecological Services Field Offic, East Lansing, MI

Contaminants of emerging concern (CECs) is a term used to define a large class of toxicants for which regulatory levels to avoid impacts on aquatic life have not yet been established. CECs may include pollutants such as pharmaceuticals, pesticides, or personal care products.

Unionids are known to have a unique life cycle that is vulnerable at multiple stages to the impact of CECs. In this study, *Lampsilis cardium* and host fish *Micropterus salmoides* were exposed to either an agricultural mixture (concentrations 0.1x, 1x, 10x ecologically relevant levels), an urban mixture (concentrations 0.1x, 1x, 10x ecologically relevant levels), an ethanol control, or a water control treatment for a long-term period of 60 days or a short-term period of 12 days prior to infestation during the summers of 2017 and 2018 in a controlled static renewal. At the end of 60 or 12 days, infestations were performed, and exposures resumed with counts of juveniles into filters completed every other day until day 100 or day 40 of the long- and short-term exposures respectively. Two techniques were used to characterize changes to juvenile drop off: a zero-inflated Poisson model and dose response curves fit to a third order polynomial. Both techniques noted a shift to a later date for the day peak juvenile excystment occurred in agricultural medium and urban medium treatments ($p = 0.16$). Additionally, the total number of juveniles differed significantly among treatments ($p << 0.05$) with juvenile production having highest similarity between control water and agricultural medium treatments. Overall, impact of CEC mixtures appeared dependent on contaminant concentrations. As CEC presence in some treatments resulted in a 90% reduction in peak juvenile transformation, management action must be taken to avoid population level impacts. Management efforts should focus on CECs associated with urban environments where greatest reduction was seen.

60. INFLUENCE OF *CORBICULA FLUMINEA* AND WATER TEMPERATURE ON JUVENILE MUSSEL GROWTH IN THE WILD

Drew White[1], Wendell R Haag[2], Steven J Price[1], Jacob J Culp[3] & Monte A McGregor[4]
[1]University of Kentucky, Department of Forestry and Natural Resources, Lexington, KY; [2]US Forest Service, Southern Research Station, Frankfort, KY; [3]Kentucky Division of Water, Frankfort, KY; [4]Kentucky Department of Fish and Wildlife Resources, Center for Mollusk Conservation, Frankfort, KY

We examined growth of juvenile *Lampsilis cardium*, *Venustaconcha troostensis*, and *Villosa taeniata* in 84-day silo exposures at 17 sites in the Rockcastle River system, Kentucky. We measured 155 water chemistry analytes in four samples taken about every 20 days at each site during the study. We also measured water temperature every 90 min and estimated *Corbicula* abundance at each site. Growth responses were similar among species, but the absolute increase in individual mass varied among sites by two orders of magnitude (mean across species = 0.001–0.241 g; instantaneous growth = 0.002–0.032 g d-1). *Corbicula* abundance varied among sites from <1 to 240 m-2. There was little evidence of severe water pollution (e.g., agriculture, coal mining, urban) in the watershed, and water chemistry explained little of the variation in growth among sites. Growth was best explained by a model including water temperature (positive effect) and *Corbicula* abundance (negative effect), and there was no significant interaction between these variables. The models explained 69–73% of the observed variation in growth and predicted strong, negative effects of *Corbicula* even at low *Corbicula* abundance. Predicted juvenile mussel growth was on average about 50% lower at 10 *Corbicula* m-2 than at 0.1 m-2. By reducing mussel growth, *Corbicula* may be an important factor in widespread native mussel declines.

61. BIOMARKER RESPONSES OF JUVENILE FRESHWATER MUSSELS TO STARVATION AND EXPOSURE TO STREAM CONDITIONS

Wendell Haag[1], Steven Price[2], Andrea Darracq[3], Jacob Culp[4] & Monte McGregor[5]
[1]US Forest Service, Frankfort, KY; [2]University of Kentucky, Lexington, KY; [3]Murray State University, Murray, KY; [4]Kentucky Division of Water, Frankfort, KY; [5]Kentucky Department of Fish and Wildlife Resources, Frankfort, KY

In previous research, we compared growth and biomarker responses of juvenile mussels placed in streams that previously have lost their mussel fauna (defaunated streams) with mussels placed in streams that continue to support mussels (occupied streams). Mussels in defaunated streams had lower growth and exhibited a distinctive metabolomic profile potentially indicative of starvation; this profile was characterized by low TCA cycle activity (e.g., elevated pyruvate) and increased fatty acid oxidation. We conducted an experiment under hatchery conditions to evaluate starvation as a mechanism for this metabolomic profile. We assigned juvenile *Lampsilis cardium* to one of two treatments: one group was fed the standard hatchery ration and the other group was not fed. We ran the experiment for 20 days at 26 degrees C. Starved mussels had significantly lower glycogen and higher pyruvate than fed mussels, which supports starvation as a mechanism for the metabolomic profile seen in the wild. We will also discuss patterns of glycogen and pyruvate seen in juvenile mussels exposed to ambient conditions in 20 different streams in Kentucky during 2018, and we will examine relationships of those biomarkers to various environmental factors.

Session 14: Propagation I
Tuesday (2:20 – 3:20)

62. METAMORPHOSIS OF MUSSEL LARVAE WITHOUT A HOST FISH: ADVANCES IN IN VITRO CULTURE USING A COMBINATION OF SERUM MIXTURES IN A PHYSIOLOGICAL NUTRIENT SOLUTION.

Monte A McGregor & Julieann Jacobs
Kentucky Dept of Fish and Wildlife Resources, Frankfort, KY

Freshwater mussel propagation has advanced over the last few decades to now include transformation of juvenile mussels without the use of a host fish. In vitro culture is a process by which glochidia are removed from the adult mussels, placed in nutrient solutions in incubators, and allowed to metamorphose to the juvenile stage. Over 75 species have been cultured in vitro, including several rare species. However, few mussels have been transformed that grow on the gills of the host. We tested multiple species using Medium 199 and a combination of serum types from rabbit, buffalo (fish), and common carp at different proportions. We examined *Potamilus capax*, *Plethobasus cooperianus*, *Margaritifera monodonta*, *Venustachoncha troostensis*, *Epioblasma brevidens*, *Pegias fabula*, and *Epioblasma obliquata* using CO_2 incubators to maintain homeostasis. We tested ratios of serum types from rabbit (R), carp (C), buffalo (B): R only, RB (50:50), RC (50:50), RBC (50:25:25). Metamorphosis took from 14 to 28 days and was successful as follows. *Margaritifera monodonta* had the lowest (3.1%) transformation rate in the experiment, but 9,760 juveniles were produced with RB and B after 33 days. *Venustachoncha troostensis* (RBC formula) had a 27% transformation in 17-23 days. *Epioblasma brevidens*, *Pegias fabula*, *Plethobasus cooperianus*, and *Epioblasma obliquata* were successfully

transformed in R only (33% in 17-23 days, 69% in 17-10 days, 39% in 16-21 days, and 32% in 17-20 days, respectively). *Potamilus capax* was unsuccessful but development did occur for 38 days in R only. This is the first record of transformation in vitro from most of these species. Many of the juveniles successfully transformed were reared for more than one year with a controlled diet to check for development and growth. In vitro culture is an alternative to traditional culture and may enhance mussel conservation efforts even if host fish are not available or unknown.

63. FRESHWATER MUSSEL IN VITRO CULTURE METHOD USING SERUM REPLACEMENTS

Jacqualyn Halmbacher
The Ohio State University, Columbus , OH

Various media formulations, serums, antibiotics and environmental parameters have been used to culture freshwater mussels artificially. The method discussed in this presentation involves three types of Serum Replacements used in conjunction with Medium199 and without an elevated CO_2 environment. Nine species of mussel larvae have been tested and successfully transformed using this method. These concentrated replacements are highly purified, heat-treated bovine serum albumin, transferrin and insulin. Their commercial availability and high concentrations help limit dish contamination, making them the facility's preferred choice with artificial culture.

64. PROPAGATION AND CULTURE EFFORTS AT THE VIRGINIA FISHERIES AND AQUATIC WILDLIFE CENTER

Rachel A Mair[1], Amy Maynard[2], Brian T Watson[3], Michael Odom[1], Benjamin Davis[1], Bryce Maynard[1] & John Moore[2]
[1]U.S. Fish & Wildlife Service, Charles City, VA; [2]Virginia Polytechnic and State University, Charles City, VA; [3]Virginia Department of Game and Inland Fisheries, Forest, VA

The Virginia Fisheries and Aquatic Wildlife Center (VFAWC) at Harrison Lake National Fish Hatchery is a collaborative facility between the United States Fish and Wildlife Service and the Virginia Department of Game and Inland Fisheries. Since 2008, VFAWC has produced over 9.5 million juveniles of 14 mussel species and has released over 218,000 mussels representing 9 species. Additionally, almost 300,000 juveniles of various ages and sizes have been supplied to over 10 state and federal researchers across the country. In 2018, we worked on several large restoration projects, producing over 732,000 juveniles from 13 species. Overall survival to winter from all species and culture systems was 11.2% with 13,578 juveniles remaining indoors, while an additional 74,324 mussels reside in floating baskets in hatchery ponds. Survival by species ranged from 0% to 82.5 %. Additional highlights from 2018 include host fish identification tests for Brook Floater, *Alasmidonta varicosa*, and Triangle Floater, *Alasmidonta undulata*, as well as testing of initial culture system preferences for *A. varicosa*, *A. undulata*, and Green Floater, *Lasmigona subviridis*. This year we also purchased equipment and set-up an in vitro culture lab in space provided by Virginia Commonwealth University. Our initial in vitro trials yielded successful propagation of juveniles for two species: Creeper, *Strophitus undulatus*, and Eastern Lampmussel, *Lampsilis radiata*. Research and development to compare and refine methods using in vitro techniques will occur in the upcoming years.

65. DEVELOPMENT OF EMPIRICALLY-DRIVEN GENETIC GUIDELINES FOR CAPTIVE PROPAGATION OF IMPERILED FRESHWATER MUSSELS

Nichelle M VanTassel & David T Zanatta
Central Michigan University, Mount Pleasant, MI

It has been more than a decade since the publication of two review papers (Jones et al. 2006, Hoftyzer et al. 2008) outlining genetic considerations for captive propagation of imperilled freshwater mussels. Since then, major advancements in mussel propagation have been made, propagation facilities have proliferated, numerous studies on the pattern of genetic diversity and structure for many species have been published, and general advancements in fisheries genetics have occurred. Yet, there has not been similar advancements and accumulation of empirical data on the genetics of captive bred mussels. This study will provide empirical data critical needed for effective, responsible propagation efforts by comparing the genetic diversity of wild and captive bred mussel populations. Our null hypothesis is that wild and captive bred mussel populations have equivalent genetic diversity. Genetic data are being obtained using genotyping of microsatellite loci and single nucleotide polymorphisms (SNPs) generated from double digest random-site associated DNA sequencing (ddRAD) of two mussel species (*Lampsilis faciola* and *Ptychobranchus fasciolaris*). Mantle tissue and foot swabs were collected from adult mussels from each species from the Grand and Sydenham Rivers in Ontario, Canada. Captive propagated juveniles of each species from the same source populations were grown to harvestable size at the White Lake Fish Culture Station in Ontario, Canada. We expect to see some loss of genetic diversity in the captive propagated juveniles by way of loss in number of alleles and heterozygosity, though this loss will likely be mitigated by the contribution of multiple males to the glochidial brood of each female. We will also address and compare the number of effective breeders and effective population size for both species between wild and captive bred populations. It is essential that we understand the effects of captive propagation before mussels are propagated and released into the natural environment.

Session 15: Surveys II
Tuesday (2:00 – 3:20)

66. EVALUATING THE FEEDING ECOLOGY OF ENDEMIC FRESHWATER MUSSELS (UNIONIDAE) IN CENTRAL TEXAS USING STABLE ISOTOPE AND FATTY ACID ANALYSIS

Kaelyn J Fogelman[1], Jim Stoeckel[1], Hisham Abdelrahman[1], Brendan Higgins[1], Haixin Peng[1] & Brian Helms[2]
[1]Auburn University, Auburn, AL; [2]Troy University, Troy, AL

Increasing awareness of freshwater mussel (unionid) ecological function and imperiled status has driven worldwide concern for mussel conservation. Although it is widely assumed that mussels are filter-feeders, much remains unknown regarding their food resources. Understanding mussel feeding ecology is necessary to fully understand their role in ecosystem processes, causes of their decline and to aid in propagation and relocation programs. In this study, we assessed feeding relationships of four Texas species (*Cyclonaias petrina*, *C. necki*, *C. pustulosa* and *Lampsilis bracteata*). We used stable isotope analysis (13C, 15N) to assess the contribution of potential food sources including fine particulate organic matter (FPOM) associated with benthic sediments, suspended particulate organic matter (SPOM), and coarse

particulate organic matter (CPOM). Fatty acid profiles were also quantified to further elucidate microbial contributions to mussel diets. Seasonal samples were collected from all four species and potential food sources across four basins. Mussel 13C and 15N values suggested all four mussel species were feeding similarly. All species exhibited elevated 15N signatures while the majority of assimilated carbon appeared to be derived from detrital CPOM. Fatty acids showed seasonal variation, indicating that different food resources were utilized seasonally.

67. USING STANDARDIZED PROTOCOLS TOWARD IMPROVING RANGEWIDE CONSERVATION OF RARE MUSSEL SPECIES

Allison H Roy[1], Peter D Hazelton[2] & Sean C Sterrett[3]
[1]U.S. Geological Survey, Amherst, MA; [2]Massachusetts Division of Fisheries and Wildlife, Westborough, MA; [3]Monmouth University, West Long Beach, NJ

In the northeastern US, many mussel species have small populations and are at risk of extirpation. These species cross multiple states and thus protection and recovery depend on rangewide coordination of conservation efforts. Unfortunately, data on many mussel species is spatially incomplete and based on inconsistent methods that limit the usefulness for understanding species distributions and threats. We use the example of the brook floater (*Alasmidonta varicosa*), a stream-dwelling freshwater mussel native to the Atlantic Slope of the United States and Canada, to highlight approaches to collecting data to improve conservation decisions. As part of the Brook Floater Working Group, which was established in 2016, we have developed protocols for understanding occupancy and population viability of the species. The rapid assessment protocol uses random selection of sites within watersheds and rapid surveys to assess presence and absence and determine watershed-wide occupancy. These data have potential to greatly improve species distribution models and better identify critical habitats for protection. We also developed a mark-recapture approach that, after multiple seasons, can be used to determine population density and demographics (e.g., growth, age structure) to assess population viability. As these protocols are increasingly applied across the range of brook floater, they can be better used to assess effects of environmental stressors and inform conservation decisions, such as identifying locations for reintroduction and augmentation to aid in species recovery. These protocols are likely adaptable to other species, and we discuss the value and limitations of these methods depending on stream size, mussel densities, and other factors. Lastly, we discuss the critical role of collaborative networks for restoring critically imperiled freshwater mussels.

68. ARE STANDARDIZED PROTOCOLS IN OHIO MEASURING UP? A 5 YEAR REVIEW OF SURVEY DATA

Rebecca Winterringer[1], Megan Michael[2], Lindsey Moss[1] & Sarah Bender[1]
[1]TRC, Cleveland, OH; [2]Ohio Department of Transportation, Columbus, OH

Over the last six years, regulatory agencies implemented mussel survey standards and guidance for surveyors. The Ohio Mussel Survey Protocol was implemented in 2013 and over 400 studies have been performed using these guidelines. Expanding on a previous poster presentation that evaluated efficacy of standardized mussel survey protocols, this presentation reviews protocol application in Ohio with landscape scale observations on unionid species distribution in the state. Over 400 streams were evaluated where survey methods were required to follow a standardized protocol. Factors such as stream drainage and size, species abundance and composition, and effort required to meet survey objectives were evaluated. Our review of the data collected between 2013 and 2018 suggests adjustments to the protocol may

be warranted related to topics including survey need triggers, surveyor efficiency, and detection accuracy. We present observations of this data set with recommendations for strengthening the science behind the protocol. Standardized protocols will become a more important issue for regulators across the United States as human dimensions and their interface with freshwater mussel communities persist. Data for this research were provided by ODOT-Office of Environmental Services, ODNR-Division of Wildlife and USFWS-Ohio Ecological Services Field Office.

69. WHAT IN THE MUCK IS GOING ON? AN OVERVIEW OF SURVEY METHODOLOGY, EFFORT, IMPLEMENTATION, AND REPORTING REQUIREMENTS THROUGH A CONSULTANT'S VIEW BUCKET

David A Foltz, II[1], John P Spaeth[2] & Casey D Swecker[2]
[1]Environmental Solutions & Innovations, Inc. Cranberry, PA; [2]Environmental Solutions & Innovations, Inc., Cincinnati, OH

In many states throughout the contiguous United States, freshwater mussel surveys are required by both state and/ or federal agencies when certain waterbodies are impacted prior to instream construction or removal of projects. These projects involve permanent or temporary instream impacts such as pipelines, bridges, water intakes, dam removals, stream restoration activities, bank stabilization measures, or boat ramp installations. Mussel survey requirements aim to protect these animals. Waterbody classification schemas, sampling protocols, reporting methodologies, and threshold constitutions vary according to state and ecoregion. Here we attempt to help clarify these differences based on our professional experiences as consultants in the Midwest (Mississippi River basin) and eastern United States (Lake Erie and Atlantic slope basins) partially covering states such as Ohio, West Virginia, Pennsylvania, New York, Michigan, Virginia, North Carolina, Kentucky, Indiana, Illinois, Iowa, and Missouri. We also investigate the factors that drive the implementation of these protocols.

Session 16: Management I
Tuesday (3:40 – 5:40)

70. SCIENTIFIC RIVER DIVING SAFETY: A NEW PADI SPECIALTY CERTIFICATION TO COMPLEMENT THE FRESHWATER MUSSEL CURRICULUM AT THE NATIONAL CONSERVATION TRAINING CENTER (NCTC).

Matthew A Patterson[1], Heidi Dunn[2], Mitch Osborne[3], Tyler Hern[4], Nathan Eckert[5] & Ryan Hagerty[1]
[1]US Fish & Wildlife Service, Shepherdstown, WV; [2]EcoAnalysts, O'Fallon, MO; [3]USFWS, Fairbanks, AK; [4]USFWS, White Sulphur Springs, WV
[5]USFWS, Neosho, MO

The imperiled status of native freshwater mussel populations in the United States an has led to a significant increase in funding for surveys, research, translocations and propagation. Many of these projects require the collection of freshwater mussels in flowing water using SCUBA. Unfortunately, most SCUBA training provided by training organizations like PADI, NAUI, and SSI address safe diving practices in clear water environments with little or no current while maintaining neutral buoyancy. River diving, like all specialty environments, has a unique set of conditions including diving in areas of low or no visibility with a directional current that may require divers to be weighted to maintain a negative position. Each of these conditions (low or no visibility, current, and negative buoyancy) require a set of skills and safety measures that

are not addressed by current training programs. As a result, the NCTC is developing a new Scientific River Diving Safety specialty under PADI to help ensure the safety of divers collecting mussels (and other organisms) in the field. During the course, divers will practice and show mastery in the following skills: diving with a full-face mask, communicating verbally with full-face mask divers from the surface and collecting data, communicating using tactile and line signals, diving on a tether, tending divers on a tether, diving with a hookah, briefing a dive, and creating a dive plan. If students demonstrate mastery, this 4.5 day course will provide certifications in Scientific River Diving and Full-Face Mask through PADI. The pilot course is scheduled for October of 2019 at the NCTC in Shepherdstown, WV. If you are interested in this course, please contact Matthew Patterson at matthew_patterson@fws.gov. Please note: Due to the unique hazards involved with river diving, certification as a Rescue Diver will be a prerequisite for this course.

71. RESTORATION AND MONITORING OF MUSSELS IN THE CLINCH AND POWELL RIVERS, VIRGINIA AND TENNESSEE: RECONCILING EXPECTED VERSUS MEASURED ABUNDANCES AT RELEASE SITES

John M Hyde[1] & Jess W. Jones

[1]Department of Fish and Wildlife Conservation, Virginia Tech, Blacksburg, VA; [2]US Fish & Wildlife Service, Department of Fish and Wildlife Conservation, Virginia Tech, Blacksburg, VA

The Certus, Inc. and Lone Mountain Processing, Inc. Natural Resource Damage Assessment and Restoration cases in the upper Clinch and Powell rivers of Virginia and Tennessee, respectively, are among the first and largest cases involving injury to freshwater mussels due to release of hazardous substances in the United States. Settlement money from both cases was used by the Virginia Department of Game and Inland Fisheries' Aquatic Wildlife Conservation Center and Virginia Tech's Freshwater Mollusk Conservation Center to propagate and release 140,000 mussels 1-3 years old of 23 species at restoration sites from 2003-2018. We compiled data of mussel releases from 2007–2017 and used a Leslie matrix model to estimate expected abundance of the mussel assemblage at nine sites in the Clinch and Powell rivers. We compared the expected number of mussels to density estimates from quadrat and mark-recapture surveys conducted at these sites from 2015 to 2017. Estimated abundance from field sampling was on average 75% lower than expected abundance across all years at all sites, although this effect was especially pronounced at the two sites in the upper Clinch River, VA in the Certus, Inc. impact zone. Possible explanations for this lower than expected abundance at restoration sites includes lower than expected survival of mussels at these sites, dispersal of released mussels downstream of the immediate release and monitoring areas, newly transformed juveniles excysting from host fish outside the sites, or negative sampling bias. Regardless, restoration efforts for these NRDAR cases were successful in that species impacted by both spills have been restored to multiple sites in each river, including the endangered Golden Riffleshell (*Epioblasma aureola*) and Tennessee Bean (*Villosa trabalis*), as well as populations of other *Epioblasma* species and numerous non-endangered species.

72. ESTIMATING APPALACHIAN ELKTOE (*ALASMIDONTA RAVENELIANA*) ABUNDANCE AND OCCUPANCY IN THE SOUTH TOE RIVER, NC

Chantelle L Rondel[1], Michael M Gangloff[1] & Jason Mays[2]
[1]Appalachian State University, Boone, NC; [2]US Fish & Wildlife Service, Asheville, NC

Understanding how environmental factors affect species abundance and occupancy is an important but under-appreciated aspect of endangered species management and yet surprisingly few studies have attempted to quantify the size of freshwater mussel populations or examine differences in detectability. The Appalachian elktoe (*Alasmidonta raveneliana*) is an endangered freshwater mussel endemic to the upper Tennessee River Drainage. Beginning in 2014, we began annual monitoring of Appalachian elktoe populations at six sites in the South Toe River and starting in Summer 2015 these sites were sampled multiple times each year to quantify seasonal differences in detectability. Appalachian elktoe abundance was highly variable among years and was typically highest during late spring and lowest during fall surveys. In order to obtain more robust estimates of elktoe abundance we began a 3-pass mark-recapture study at 6 long-term monitoring sites and a more broadly focused study designed to elktoe occupancy in 17 additional reaches of the South Toe River. Preliminary population estimates at the 6 long-term monitoring sites ranged from 458-580. The occupancy study revealed 9 new populations in the South Toe River. Appalachian elktoe were detected at 15 of 23 sites (65%) across the South Toe River and a total of 634 mussels at all 23 sites. Three-pass mark-recapture estimates produced population estimates that were 43-225% higher than single-pass estimates. These findings have important implications for South Toe elktoe populations. First, it appears that single-pass estimates substantially underestimate mussel abundance and that additional large populations exist in this stream. Second, the discovery of additional populations in the middle reaches suggests that population resiliency may be greater than previously thought. Finally, because most of the newly-detected populations were found in relatively isolated and well-forested reaches they may be buffered against the impacts of development occurring elsewhere in the South Toe watershed.

73. DENSITY-DEPENDENT EFFECTS OF FRESHWATER MUSSELS ON GROWTH OF EMERGENT AQUATIC PLANTS

Jonathan W Lopez, Thomas B Parr & Caryn C Vaughn
University of Oklahoma & Oklahoma Biological Survey, Norman, OK

Hotspots of nutrient cycling created by dense, multispecies aggregations of freshwater mussels have cascading effects on foodwebs and ecosystem function. Mussel-derived nutrient hotspots contribute nitrogen (N) and phosphorus (P) to various compartments of the foodweb, including emergent aquatic plants. Such plants may form a nutrient-rich food resource for terrestrial animals, especially on sediment bars at the margins of aquatic ecosystems. This represents another path for mussel-derived effects on foodwebs and ecosystem function to impact the terrestrial environment. Our objective was to determine the effects of mussel density on growth and nutrient composition of emergent freshwater plants that inhabit riverine gravel bars. We varied the density of two common unionid mussel species, *Amblema plicata* and *Actinonaias ligamentina*, in 100 L recirculating mesocosms to investigate the effects of a mussel density gradient on American water willow (*Justicia americana*). We measured responses in Justicia growth as dry mass gained over 9 weeks, and nutrient composition as percentages of C, N, and P in the plants' tissues. Justicia growth increased significantly with mussel density but was lower than control treatments at the lowest mussel densities. Water column NH4-N showed no relationship with mussel biomass, but SRP was higher in high density treatments. We conclude that on small spatial scales, for example at the margins of gravel bars, bioturbation by mussels may reduce Justicia growth by

disturbing the root system. However, increased P availability at higher densities likely created a fertilization effect, overriding this negative effect and increasing plant growth.

74. EVALUATING HOST FISH MOVEMENT FOR THE WINGED MAPLELEAF MUSSEL (*QUADRULA FRAGOSA*): WHY PROXIMITY MATTERS

Michelle Bartsch[1], Diane Waller[1], Wi Brent Knights[1], Jon Vallazza[1], Eric Lord[2], Mark Hove[3] & Byron Karns[4]
[1]USGS-UMESC, La Crosse, WI; [2]USGS-UMESC, La Crosse, WI; [3]University of Minnesota, St. Paul, MN; [4]National Park Service, St. Croix Falls, WI

The St. Croix National Scenic Riverway (SACN) is one of the last best refuges for rapidly declining populations of native unionids in the United States and supports the only known self-sustaining population of the federally endangered winged mapleleaf mussel (*Quadrula fragosa*) in the upper Mississippi River basin. Channel catfish (*Ictalurus punctatus*) are the only known host for winged mapleleaf in the SACN. Although channel catfish are common in the river, little is known about the frequency of winged mapleleaf infestation and dispersal on their host fish. Our research was designed to characterize the movements and habitat use of channel catfish near a known winged mapleleaf population during glochidial release, encapsulation, and juvenile release periods. In August 2016 and July 2017, we collected a total of 83 channel catfish (N=35, mean length 605 mm and N=48, mean length 583 mm, respectively) by hoop net near the mussel bed and implanted them with acoustic transmitters. Catfish were passively tracked using Lotek submersed data loggers (model 3250) that were clustered in an array near the mussel bed and dispersed singularly along the 84 kilometer river reach between St. Croix Falls, WI to the confluence with the Mississippi River at Prescott, WI. Lake St. Croix (near Hudson, WI) served as an overwintering location for several tagged catfish that returned upstream into the river during late March. Overall, two catfish moved near the confluence with the Mississippi River. Catfish movement patterns will be discussed in relation to the mussel bed and the delineated study area.

75. ANTIBIOTIC TREATMENT AND BACTERIAL CHALLENGE CAUSES CHANGES IN OVERALL BACTERIAL DIVERSITY AND COMPOSITION IN THE FRESHWATER MUSSEL *VILLOSA NEBULOSA* (CONRAD, 1834)

Alison Aceves[1], Paul D Johnson[2], Francisca A Burgos[3], Stephen A Bullard[1] & Cova R Arias[1]
[1]Auburn University, Auburn, AL; [2]Alabama Department of Conservation and Natural Resources, Alabama Aquatic Biodiversity Center, Marion, AL; [3]Escuela Superior Politécnica del Litoral, Campus Gustavo Galindo Perimetral, Guayaquil, Ecuador

The gut microbiome is a community of symbiotic microbes that is important for many host physiological processes. When the homeostatic equilibrium between the host and its' gut microbial symbionts is disrupted, the gut can become dysbiotic. Dysbiosis is characterized by an unbalanced gut microbiome, typically associated with an observed decrease in overall bacterial diversity and an increase in pathogens. In an effort to understand the dysbiosis of the digestive gland ('gut') of freshwater mussels, we performed gut microbial disruption using two broad-spectrum antibiotics. We hypothesized that if dysbiosis did occur, then freshwater mussels would become more susceptible to bacterial infection caused by the opportunistic pathogen *Aeromonas hydrophila*. Our previous research in characterizing the gut microbiome of *Villosa nebulosa* (Alabama Rainbow) showed that the bacterial class Mollicutes (Phylum: Tenericutes) had the highest abundance in the gut. We chose tetracycline as a selective antibiotic to eliminate (or reduce) the Mollicutes present in the digestive gland of *V. nebullosa*, and we used ampicillin as a broad-spectrum antibiotic, not selective for Mollicutes. Mussels were treated with antibiotics for 10 consecutive days and had a

withdrawal period of 5 days (no antibiotic treatment) before the first sampling point (t = 15 days). The withdrawal period extended for another four days. At that point, each treatment was divided into two sub-treatments (challenge and not-challenge). Mussels were challenged by immersion with a cocktail of two strains of *A. hydrophila* that has been proved pathogenic for fish, and sampled 24 hours later (t = 20 days). The gut microbiome was analyzed using 16S rRNA gene sequencing and data were analyzed by treatment. Our results showed that tetracycline-treated mussels had a significantly lower abundance of Tenericutes (3.6%), than ampicillin-treated (37.5%) and control (33.9%) mussels. After challenge, with no mortalities, there was an observed increase of bacterial diversity in tetracycline-challenged mussels.

Session 17: Propagation II
Tuesday (3:40 – 5:40)

76. EFFECTS OF DIET SUPPLEMENTS ON JUVENILE FRESHWATER MUSSEL SURVIVAL AND GROWTH

Andrew T McDonald[1], Meghan W Owings[1], Monte McGregor[1] & Wendell Haag[2]
[1]Kentucky Dept of Fish and Wildlife Resources, Frankfort, KY; [2]US Forest Service, Frankfort, KY

Improved diet formulations have produced dramatic increases in juvenile mussel survival and growth in propagation facilities. However, standard algal-based diets may not reflect the breadth of wild diets and often support lower growth than seen in the wild. We conducted two experiments to evaluate effects on juvenile survival and growth of diet supplements intended to increase detrital and bacterial energy sources. In our first experiment, we supplemented an algal-based diet with two bacterial food sources: pond sediment and a commercially available probiotic mixture. We tested this supplement with newly-transformed *Lampsilis cardium*. Survival and growth after 3 weeks were significantly higher in pond sediment treatments relative to controls (algal diet) but survival and growth in probiotic treatments did not differ from controls. Despite higher survival in pond sediments, survival was low (about 50%) probably due to system-wide water quality problems. In our second experiment, we supplemented with worm castings to provide more consistent detrital and bacterial food sources. We added worm castings as solids and as a tea made by steeping the castings; this experiment used 3-4 month old *Utterbackia imbecillis* and *Venustaconcha troostensis*. Survival after 30 days was near 100% for both species and did not differ among treatments. For both species, growth was higher in treatments supplemented by worm casting solids than in controls, but growth in the worm casting tea treatment was significantly higher than controls and worm casting solids. Worm casting tea may be a valuable and easily standardized source of nutrition for mussel propagation.

77. STANDARDIZING A NON-LETHAL METHOD FOR CHARACTERIZING THE REPRODUCTIVE STATUS AND LARVAL DEVELOPMENT OF FRESHWATER MUSSELS.

Caitlin E. Beaver & Nathan A Johnson
U.S. Geological Survey, Gainesville, FL

Reproductive stages of freshwater mussels are typically reported as either ‘gravid’ or ‘not gravid’ and few studies have characterized stages of larval development (e.g., egg, immature, fully developed). The latter approach is more informative and better facilitates future life history

research, species management, and recovery efforts. This methodology, however, has neither been standardized nor evaluated for lethal and sublethal impacts. This study aimed to: 1) standardize a protocol for sampling gill contents of gravid females, 2) provide categories for describing larval development, and 3) evaluate lethal and non-lethal impacts of the protocol on a diverse community of mussels. The protocol describes gently opening the valves, inserting a sterile syringe into a single water tube of the marsupial gill, and extracting a subsample of gill contents. In the field, gill contents can be preserved in 70% ethanol for later assessment or examined for maturity immediately using a microscope and NaCl solution. Lethal and sublethal effects of the protocol were evaluated during a 13-mo mark-recapture study with sampling events at 30-day intervals. Ninety gravid individuals representing a wide taxonomic breadth of common and imperiled species were collected, tagged, gill sampled, and recaptured with a high survivorship of 97%. Results showed 51% of gravid individuals were found gravid during consecutive sampling events, demonstrating the protocol is unlikely to induce premature release of gill contents. Another 10% of individuals were recaptured gravid, non-gravid, and gravid again during non-consecutive sampling events, providing evidence that the protocol did not inhibit individuals from becoming gravid after gill sampling. We are developing a video demonstrating the gill sampling protocol and categories for describing larval developmental stages to promote standardization of the methodology. Additionally, efforts are underway to compile information on periods of gravidity and larval development within a publicly available database to facilitate future research and conservation.

78. ESTIMATING DEMOGRAPHIC VITAL RATES OF *EPIOBLASMA BREVIDENS* AND *EPIOBLASMA CAPSAEFORMIS* FROM ANNUAL POPULATION CENSUSES IN THE CLINCH RIVER, TENNESSEE, FROM 2004–2014

Tim Lane[1], Brett Ostby[2], Don Hubbs[3], Robert Butler[4] & Jess Jones[5]

[1]Virginia Department of Game & Inland Fisheries Marion, VA; [2]Virginia Tech Department of Fish and Wildlife Conservation, Blacksburg, VA; [3]Tennessee Wildlife Resources Agency, Camden, TN; [4]US Fish & Wildlife Service (Retired), Asheville, NC; [5]US Fish & Wildlife Service, Blacksburg, VA

In response to monitoring and recovery planning needs, demographic vital rates of two endangered freshwater mussels—the Cumberlandian combshell (*Epioblasma brevidens*, Lea 1831) and oyster mussel (*Epioblasma capsaeformis*, Lea 1834)—were estimated and compared using quadrat sampling. Annual variation in population density and abundance, recruitment rate, mortality rate, sex ratios, and female fecundity of both species were quantified from 2004–2014 at three fixed sites, spanning a 33.8 kilometer (KM) reach of the Clinch River, Hancock County, Tennessee. Mean population size of *E. brevidens* estimated from 11 censuses was 2,598 individuals at Swan Island (KM 277.1), 8,744 at Frost Ford (KM 291.8), and 879 at Wallen Bend (KM 309.6); collectively, these demes grew at an annual rate of 7%. Mean population size of *E. capsaeformis* was 7,846 individuals at Swan Island, 265,442 at Frost Ford, and 11,704 at Wallen Bend; collectively, these demes grew at an annual rate of 6%. Population size, variability in population growth, recruitment, mortality, and signals of negative density dependence were higher for the shorter-lived *E. capsaeformis* (maximum age=16 yrs, rarely >10 yrs) than those of longer-lived *E. brevidens* (maximum age=25 yrs). Recruitment was high for *E. capsaeformis* during years when stream discharge was low and it was correlated (p=0.0118; R2=0.6224) to the number of low mean discharge days (<300 ft3/s) occurring between censuses. Fecundity of female *E. brevidens* averaged 34,947 (SE=2,492) glochidia and ranged from 18,987 to 56,151, whereas fecundity of female *E. capsaeformis* averaged 9,558 (SE=603) glochidia and ranged from 3,456 to 22,182. Estimated vital rates indicated *E. brevidens* exhibit a periodic life history strategy (between K- and r-selected)

and *E. capsaeformis* an opportunistic strategy (r-selected). These strategies are likely influenced by each species' longevity, habitat preference, and the population dynamics of their primary fish hosts. These data can be used to manage and predict population performance of each species as they are restored to their native ranges throughout the Tennessee and Cumberland river basins.

79. THE PHENOLOGICAL RELATIONSHIP BETWEEN MUSSEL GLOCHIDIA AND SPAWNING RIVER HERRING

Julia S. Cox[1] & Allison Roy[2]
[1]University of Massachusetts Amherst, Amherst, MA; [2]Massachusetts Cooperative Fish and Wildlife Research Unit, University of Massachusetts Amherst, and U.S. Geological Survey, Amherst

Glochidia of the alewife floater (*Anodonta implicata*) have been found attached to migratory alewives (*Alosa pseudoharengus*) and blueback herring (*Alosa aestivalis*), collectively known as river herring, but it is unknown whether river herring serve as host fish for other freshwater mussels. Given that river herring are only in freshwater systems for ~2 months, any mussels using river herring as hosts must time glochidia release based on river herring densities, which vary annually based on temperature and other cues. This study focused on understanding the phenological relationship between river herring and freshwater mussel glochidia infestation, including the alewife floater. Between the months of March and June of 2018 during the adult spawning run, river herring were collected from five tributaries in the Connecticut River watershed via electrofishing. The most distal right gill of each fish was removed and frozen, and glochidia were later enumerated under a stereomicroscope. A subsample of glochidia were photographed and measured to help determine their species. Glochidia of at least four mussel species were found on river herring gills, two of which have never been documented as river herring parasites. Preliminary results suggest a correlation between glochidia densities and peak herring densities in mid to late May, such that the highest glochidia infestation per individual river herring occurred during the peak river herring densities. A temporal relationship between glochidia attachment and river herring migration suggests that female freshwater mussels may time their larvae release based on river herring phenology, but analysis across multiple years is needed to determine whether mussels use cues to adjust timing of glochidia release. The presence of multiple glochidia taxa on river herring gills suggests that alewives and blueback herring may be host species to several freshwater mussel taxa, although future studies are needed to demonstrate successful transformation.

80. PHYLOGENETIC AND FUNCTIONAL TRAIT DIVERSITY DRIVES STREAM ECOSYSTEM FUNCTION

Carla L Atkinson[1], Brian C Van EE[1] & John M. Pfeiffer[2]
[1]University of Alabama, Tuscaloosa, AL; [2]Florida Museum of Natural History, Gainesville, FL

Substantial evidence exists for the positive influence of biodiversity on ecosystem functioning in both terrestrial and aquatic ecosystems. Community composition can influence ecosystem functioning through a variety of mechanisms. Ecological stoichiometry provides a framework to understand the balance of multiple key elements [traditionally carbon (C), nitrogen (N) and phosphorus (P)] in ecological interactions and is typically employed to model the coupled flow of elements between consumers and their environment at various spatial and temporal scales. Animals tend to be homeostatic in their nutrient requirements and thus preferentially sequester the element in shortest supply relative to demand, and release relatively more of the element in excess. This enables predictions of relationships among the elemental composition of

animals, their diet, and their waste products, with important effects on the cycling and availability of nutrients in an ecosystem. Here we examined the stoichiometric niches (C:N:P) and nutrient recycling rates (N and P) of a diverse assemblage of freshwater mussels in the Sipsey River, Alabama. We found that each species occupied a distinct stoichiometric niche and that the ordinal distances between species stoichiometry was related to their phylogenetic relatedness. Tissue stoichiometry and excretion stoichiometry were negatively correlated as predicted by stoichiometric theory. Thus, when scaled to the ecosystem, more diverse mussel communities led to greater functional diversity as indicated by a greater range of community-level nutrient recycling stoichiometry. The relationship between phylogenetic diversity and functional diversity in these communities is grounded in the idea that trait diversification occurred as a result of evolutionary processes to enhance niche complementarity within communities. Our results suggest that conserving diverse mussel communities is key in maintaining ecological function. The inclusion of other traits such as filtration rates needs to be included in functional diversity metrics of mussel communities to inform both ecological theory and managers.

81. SPECIES BOUNDARIES AND LEVELS OF INTERMIXING BETWEEN *LAMPSILIS SILIQUOIDEA* AND *L. RADIATA*

Isabel P Hannes[1], Lyubov L. Burlakova[2], Howard R. Lasker[3] & David T. Zanatta[4]
[1]University at Buffalo, Buffalo, NY; [2]Great Lakes Center, Buffalo State College, Buffalo, NY; [3]University at Buffalo, Buffalo, NY; [4]Central Michigan University, Mount Pleasant, MI

After the last glaciation, freshwater mussel species (Family Unionidae) range expansion led to secondary contact between species that were isolated in the past, and if these species had incomplete reproductive barriers, gene flow could have occurred (hybridization with or without introgression). There is some evidence that two closely related species, *Lampsilis siliquoidea* and *L. radiata* can potentially hybridize; however the prevalence, direction and geographic extent of the potential hybrid zone is not well known. Hybridization was suggested due to the presence of morphological and genetic intermediate forms where their geographic range overlap in the lower Great Lakes, St. Lawrence River and Lake Champlain watersheds in the United States and Canada. The objectives were to determine 1) the molecular phylogenetic relationship and 2) levels of intermixing of the two closely related unionid species, *L. siliquoidea* and *L. radiata*. Mitochondrial sequence divergence (maternally and paternally inherited cytochrome oxidase subunit I, COI) supports the distinctiveness of the taxa; however, based on incongruences in COI assignments and from seven microsatellite loci, the presence of admixed individuals indicated that these species hybridize where their geographic range overlaps in the lower Great Lakes, the St. Lawrence River and Lake Champlain basins. Lastly, there is strong population genetic structure within *L. siliquoidea* that can affect the detection of purebred individuals of this species overestimating the number of hybrids. The geographic range and proportion of hybrids need to be considered when implementing local biodiversity inventories, identifying waterbodies as source of organisms for relocation and restoration projects and when setting appropriate conservation policies.

Session 18: Southwestern Freshwater Mollusks III
Tuesday (3:40 – 5:40)

82. GROWTH RATES IN THREE POPULATIONS OF LOUISIANA PIGTOE, *PLEUROBEMA RIDDELLII*, IN THE NECHES RIVER OF NORTHEASTERN TEXAS

David F. Ford[1] & Neil B. Ford[2]
[1]EcoAnalysts, Inc. O'Fallon, MO; [2]University of Texas at Tyler, Tyler, TX

The Louisiana Pigtoe, *Pleurobema ridellii*, is up for potential listing by USFWS. Population information is critical to the listing process to determine whether a species warrants protection. The upper Neches River is the only northeast Texas River with substantial populations of *Pleurobema Ridellii*. We used records from previous surveys in the Neches River to identify 3 sites with the greatest abundance of this species. In the fall of 2014 we selected a 25 m^2 area around the quadrat with the highest density of animals and then surveyed the area by tactile searches. We marked all individuals with bee and pit tags and measured length. We returned yearly through the summer of 2017 and repeated the measurements. We used the inverted von Bertalanffy to obtained growth rates for each population over the 3 years and compared them to growth rates in other mussels in the Pleurobemini. One site had a higher growth rate and smaller individuals and was apparently a younger population. One population matched up well with other species growth rates and the last site had bigger individuals and slower growth rate. This suggests that populations vary even within the same river and suggest that multiple sites need to be examined to have accurate growth rates for conservation purposes.

83. IDENTIFICATION OF POTENTIAL FISH HOSTS FOR FRESHWATER MUSSELS OF EAST TEXAS USING COMMUNITY MODELING TECHNIQUES

Robert A Francis[1], Ashley D Walters[2], Neil B Ford[3] & David J Berg[4]
[1]Department of Biology Miami University, Oxford, OH; [2]National Genomics Center for Wildlife and Fish Conservation Forest Service, Missoula, MT; [3]Department of Biology University of Texas at Tyler, Tyler, TX; [4]Department of Biology Miami University, Hamilton, OH

Understanding the obligate parasitic relationship between freshwater mussels and fish hosts is critical to the survival and conservation of unionid mussels. Yet, there is limited knowledge of potential freshwater hosts for numerous species of freshwater mussels. Often, the hosts that have been identified do not fully represent the biodiversity of potential hosts available. Additionally, many investigations of freshwater mussel host-relationships are done in mesocosm settings that tend to misrepresent natural relationships and metamorphosis rates due to artificially high infestation rates. To gain a better understanding of this unique relationship at a larger spatial scale, we implemented a novel approach to identify potential freshwater mussel hosts using Joint Species Distribution Models (JSDM). We utilized presence data collected for freshwater mussels throughout East Texas combined with freshwater fish data acquired from fishesoftexas.org at a sub-watershed spatial scale. JSDMs use generalized linear modeling and latent variable modeling to examine pair-wise comparisons; therefore providing information of a single species presence on the predicted presence of another species within the community. Generalized linear models describe the contributions of abiotic factors on a species' distribution, while latent variable models attribute remaining variation to biotic interactions. We

found 34 unique mussel species and 165 unique fish species throughout East Texas. We predicted that freshwater mussel presence will be positively correlated with presence of their obligate fish hosts. Comparisons of these results with those of currently predicted or known fish hosts will provide information necessary for conservation of imperiled mussel communities. These findings will allow for the development of effective conservation for freshwater mussel communities at a scale that is useful for management implementation.

84. EVALUATION OF THE LETHAL AND SUBLETHAL EFFECTS OF MUSSEL TRANSLOCATION: TWO CASE STUDIES FROM THE SOUTHWESTERN UNITED STATES

Michael Hart[1], Charles R. Randklev[1], Eric Tsakiris[2] & Mark Fisher[3]
[1]Texas A&M University Natural Resources Institute, Dallas, TX; [2]USFWS NCTC, Shepherdstown, WV; [3]TXDOT, Austin, TX

Translocation is widely used in managing and conserving mussel populations yet its merits as a conservation tool is often debated. This debate is rooted in the fact that mussel translocation has had mixed results due to a variety of issues relating to biased mark-recapture techniques, inadequate handling/transport procedures, inability to identify suitable habitat, and poor understanding of the effects translocation has on physiological health and reproduction. Despite these issues and debate, translocation is often the first tool managers use for mitigating both local and widespread impacts. Because of this, case-studies involving different species from disparate regions are needed to develop more accurate and predictive generalizations of how mussels will respond to translocation. The overall goal of this project was to evaluate lethal and sublethal effects of mussel translocation on two mussel populations from the East Fork of the Trinity River and the Llano River of central Texas. Mussels at each site were collected using multiple-pass-depletion surveys and were marked and transported following published guidelines. For the East Fork, we used a reciprocal transplant study design and for the Llano a common garden design was used. Translocated mussels were initially monitored monthly and then quarterly for survivorship (East Fork and Llano populations) and sublethal stress (East Fork) for one year. For the East Fork, survivorship was high (97-100%) with no evidence of sublethal stress, although we did observe high incidence of trematodes. We also had difficulty recovering mussels due to extreme high flow events. For the Llano sites, survivorship at the source site was high (91-100%) but at the recipient site it was low (5-82%) due to raccoon predation. The results of our study show that translocation can be successful, however other factors such as disease, predation and flow should be considered before implementing.

85. USING LIFE-HISTORY STRATEGY AND HISTORICAL BASELINE INFORMATION TO EVALUATE THE CONSERVATION STATUS OF FRESHWATER MUSSELS (FAMILY: UNIONIDAE) IN THE NAVASOTA RIVER, TEXAS

Jennifer M Khan[1], Jack Dudding[2], Michael Hart[1], Eric Tsakiris[3] & Charles R. Randklev[1]
[1]Texas A&M University Natural Resources Institute, Dallas, TX; [2]Utah Division of Wildlife Resources, Logan, UT; [3]US Fish & Wildlife Service, Shepherdstown, WV

Human impacts on aquatic ecosystems are causing shifts in the composition and distribution of species, leading to subsequent changes in community structure. However, these changes may not be fully realized because of inadequate baseline information. In Texas, such baseline information is generally lacking for cryptic aquatic species such as unionid mussels, which will likely impede identification of impacted populations and the setting or achieving of management goals. The Navasota River, located in central Texas, is an exception having been

comprehensively surveyed more than 40 years ago, prior to large-scale impoundment of this system. Thus, the goal of this study was to compare survey data from 1975 to that of a recent survey in 2016 at similar sampling locations to see if community structure has changed during the last 40 years. We found no significant differences between the number of taxa and species present; however, we found significant filtering of mussel assemblages based on life history theory predictions. Specifically, we found a longitudinal shift in life-history strategy, beginning near the location of two impoundments, one of which was constructed after 1975. This shift appears to represent a "discontinuity," wherein river impoundment alters physical parameters of the hydrologic regime and these changes in turn modify biotic patterns and processes. Our results provide another example of the negative impact of large dams on downstream mussel populations and highlight the importance of incorporating reference or baseline conditions wherever possible when evaluating the conservation status of aquatic biota.

86. HOW REGULATORY COMPLIANCE HAS GUIDED CONSULTANT CONTRIBUTION TO TEXAS FRESHWATER MUSSEL CONSERVATION

Jacob D Owen, Jeremy D Maikeotter, David McBee & Krista McDermid
Zara Environmental, LLC, Austin, TX

Zara Environmental, LLC has been conducting freshwater mussel studies throughout Texas since 2010. We have conducted mussel surveys for over 50 projects and across a diverse set of clients, including federal, state, and local governments; engineering firms; and private landowners. Listing petitions for several Texas species have encouraged development projects, transportation authorities in particular, to take a proactive stance in their approach to compliance when proposing improvements to bridges and dams, which often require dewatering, channel modifications, and 404 permits. Consultants are inherently compelled to work within client-driven safety, budgetary and geographical constraints; however, these same constraints provide opportunities to survey in areas that may be otherwise inaccessible or considered to have undesirable conditions for conducting surveys or for mussel habitation that support mussel conservation efforts. We have utilized a wide variety of survey methods to supplement protocols that may be difficult to carry out in some situations (e.g. surveys in zero visibility and/or in conditions with heavy debris cover that restricts access to substrate). We have logged over 500 hours of effort using multiple survey types, five major river basins covering 16 counties, over 7,600 live individuals of 30 different species, and a range of habitat parameters. We have recorded seven species of concern and documented new ecological data for those species, including observations at locations, depths, and substrate that were unexpected and not previously recorded. Overall, Texas freshwater mussel conservation benefits from both regulatory driven and research driven surveys contributing to robust inferences as demonstrated through our efforts.

87. UPDATE ON FRESHWATER MUSSEL SPECIES CURRENTLY UNDER REVIEW FOR POSSIBLE ENDANGERED SPECIES ACT PROTECTIONS IN TEXAS

Gary Pandolfi
US Fish and Wildlife, Austin, TX

Texas Parks and Wildlife Department consider fifteen mussel species state-threatened. Of these fifteen, five are candidates for Endangered Species Act (Act) protections by the U.S. Fish & Wildlife Service (Service). In October 2011, the Service published a 12-month finding for five central Texas mussel species indicating that listing the species as threatened or endangered under the Act is warranted; however, their listing

at that time was precluded by higher priority listing actions. The Service uses the Species Status Assessment (SSA), an analytical tool to summarize the best available science for any given species, to appropriately inform decisions made under the Act. Since 2011, the Service has completed its SSA in June 2016 for the Texas Hornshell (*Popenaias Popeii*) and listed the species as endangered under the Act in March 2018. The Service has completed a draft SSA report for six Central Texas mussel species and a decision to withdrawal, propose as threatened, or endangered with critical habitat is due in 2019. Additionally, the Service recently began an SSA for three freshwater mussel species in East Texas, with a timeline for completion in 2019. The Service is actively working with other federal agencies, state and local governments, and academic institutions in obtaining additional biological information about these species in Texas. Current and ongoing research projects continue to inform the scientific community and the Service. Included in these research projects are genetic and genomic studies that have informed species identity and taxonomic placement for several of these mussel species.

Session 19: Mussel Kills and Die-offs
Wednesday (9:40 – 12:00)

88. METABOLIC FINGERPRINTING AS A HEALTH ASSESSMENT TOOL: CHARACTERIZING TISSUE RESPONSE

Diane L Waller, Joel Putnam & Jeff Bernardy
USGS Upper Midwest Environmental Sciences Center, La Crosse, WI

Metabolomic fingerprinting identifies metabolites linked to biochemical and functional processes, providing insight into biological pathways disrupted by differences in environmental conditions including toxicant exposure, starvation, and pathogens. However, interpretation of metabolomic studies requires baseline information to identify sources of variability in metabolomes and an optimal tissue sampling strategy. We evaluated the response of the Eastern pond shell (*Ligumia nasuta*) to niclosamide, the active ingredient in the molluscicide Bayluscide The pesticide is used in combination with 3-trifluoromethyl-4-ntirophenol (TFM) to control sea lamprey and is linked to disruption of the electron transport chain. The objective of our initial trial was to determine the tissue(s) that yielded the most responsive and informative metabolomic fingerprint. Mussels were exposed to a sublethal concentration of niclosamide and sampled at 0, 8, 24 and 48-h exposure and 48 h postexposure. Immediately after removal from the test and control tanks, a 0.2 mL sample of hemolymph was collected from the anterior adductor muscle and ~10 mg of each tissue (gill, foot, mantle, kidney, and digestive gland) was removed and flash frozen in liquid nitrogen. Gonadal tissue was fixed for histological determination of sex. We measured metabolomic profiles of each tissue using high performance liquid chromatography and mass spectroscopy (HPLC-MS) methodology. Results suggest the metabolic responses to niclosamide (Bayluscide) exposure and subsequent recovery varied by tissue. The application and interpretation of metabolomics to health assessment of freshwater mussels and future research needs will be discussed.

89. EXPLORING MUSSEL POPULATION IMPAIRMENT IN THE ELK RIVER, WEST VIRGINIA

Janet L Clayton
WV Division of Natural Resources, Elkins, WV

The Sutton Dam on the Elk River in West Virginia, Kanawha Watershed, was completed in 1961 and had a coldwater release until 1980. Coldwater release temperatures were moderated in 2009 but still occur. Over the past three decades the area in Sutton below the dam has maintained a relatively intact mussel community (18 species). A long-term monitoring site was established here in 2004. Since that time very limited reproduction of any species has been noted. The mussel community is dominated by Amblema plicata and in 2014 over 35% was found fresh dead and dying. Further impaired mussel communities have been observed in at least the upper third of the 160km from Sutton Dam to Charleston. Potential sources of impact include: continued coldwater releases from the dam, wood treatment facility located near dam, nutrient inputs (direct effects or potential indirect effect causing harmful algal blooms), mining related impacts, and habitat degradation. In 2017 an in-situ bioassay was conducted using propagated *Ligumia recta* in Barnhart silos. Silos were placed at six locations (3 along each bank) all upstream of the long-term monitoring site and bracketing potential problem areas. Limited mortality occurred throughout the study and growth at all sites was significantly better than the control site on the Little Kanawha River. In 2018 White Sulphur Springs National Fish Hatchery placed propagation cages upstream of Sutton Dam on the Elk River and upstream of Burnsville Dam on the Little Kanawha River. Recovery of juveniles was successful at both locations and again, the growth demonstrated at Sutton was significantly greater than the Little Kanawha River. Further investigation is needed. Long-term monitoring is scheduled again for 2019.

90. IDENTIFICATION OF BACTERIA CULTURED FROM MUSSEL MORTALITY EVENTS

Sara M Erickson[1], Eric Leis[2], Diane Waller[3], Susan Knowles[4], Tony Goldberg[5], Joel Putnam[6], Richard Jordan[7], Emilie Blevins[8] & Jesse Weinzinger[9]
[1]U.S. Fish & Wildlife Service; Midwest Fisheries Center, Onalaska, WI; [2]U.S. Fish & Wildlife Service; Midwest Fisheries Center, Onalaska, WI; [3]U.S. Geological Survey, La Crosse, WI; [4]U.S. Geological Survey; National Wildlife Health Center, Madison, WI; [5]University of Wisconsin, Madison, Madison, WI, [6]U.S. Geological Survey; Upper Midwest Environmental Sciences Center, La Crosse, WI;, [7]U.S. Fish & Wildlife Service; Virginia Field Office, Abingdon, VA; [8]Xerces Society for Invertebrate Conservation, Portland, OR; [9]Wisconsin Dept. of Natural Resources Mussel Monitoring Program, Madison, WI

Freshwater mussels are among the most imperiled groups in the world. When mortality events involving these animals occur, contaminants and source pollutants are typically the priority of causative investigations. Conversely, mussel pathogens have been given little attention and their role in these events is understudied. To this end, a mussel health task force was developed with the overall goal being the identification of etiological agents associated with mussel disease, ultimately resulting in the development of diagnostic techniques for their detection. Since 2017, we have utilized a comparative, epidemiological approach to examine mussel populations in various stages of health, including those experiencing large-scale mortalities. We investigated mortality events in the Clinch River (Tennessee and Virginia), Crooked River (Oregon), Chehalis River (Washington) and Embarrass River (Wisconsin). Samples were also collected from apparently stable mussel populations in the St. Croix and upper Mississippi River (Wisconsin). A primary component of our research was analyzing the bacterial composition of mussel hemolymph. Hemolymph was aseptically collected from mussels involved in mortality events and from apparently stable populations and

streaked onto tryptic soy agar. After incubation, individual bacterial colonies were picked and extracted using molecular techniques. To determine the bacterial genus, the 16s gene was targeted using polymerase chain reaction and Sanger sequencing. Here, we will discuss our findings along with trends amongst bacteria isolated during mortality events and, conversely, in apparently healthy populations.

91. CASES AND REASONS OF FRESHWATER MUSSEL DIE-OFFS IN POLAND

Maria Urbańska[1], Agnieszka Pękala-Safińska[2], Wojciech Andrzejewski[1], Małgorzata Ożgo[3], Ewa Paździor[4] & Joanna Szablewska[1]
[1]Institute of Zoology, Poznań University of Life Sciences Poznań, Poland; [2]Department of Fish Diseases, National Veterinary Research Institute, Puławy, Poland; [3]Department of Evolutionary Biology, Kazimierz Wielki University, Bydgoszcz, Poland; [4]Department of Fish Diseases, National Veterinary Research Institute, Puławy, Poland

In 2018 during workshops organized by FMCS in La Crosse it was postulated to take attention to a problem of mass mortality events - known as "die-offs" and "mussel kills" - observed recently years in order to develop procedures that will allow identifying reasons of such incidents.
In Poland publications and records of die-offs in subsequent years are rare and have been reported mostly by the media that informed about "dead mollusks floating on the surface of the water". That is why we decided to determine a scale of the phenomena and collect information about incidents of this type as well as about actions undertaken by environment protection services and oriented to discover reasons behind this. For ten last years over 10 cases of mass mollusks die-offs have been recorded. The news have been published mainly in local newspapers. In those described cases only freshwater mussels died off and they were usually of one species. The sanitary services made efforts to find reasons of such facts. Their activities were especially detailed when the discoveries took place in waters used intensively by inhabitants (e.g. for recreation). The analyses done focused mainly on evaluation of quality of the water and bottom sediments. The results obtained did not show presence of contaminants that might have affected mussels lethally. However, these ill mussels were not a subject of detailed microbiological examinations. In July 2018 we had an opportunity to examine the ongoing die-off of *Sinanodonta woodiana* that floated initially. We will present results of that examination during the presentation, too.

92. DOCUMENTING ENIGMATIC MUSSEL DIE-OFFS IN WESTERN U.S. RIVERS

Emilie Blevins[1], Cynthia Tait[2] & F Teal Waterstrat[3]
[1]Xerces Society for Invertebrate Conservation, Portland, OR; [2]U.S. Forest Service Ogden, UT; [3]U.S. Fish and Wildlife Service Lacey, WA

Unexplained die-offs at mussel beds have been reported from at least 18 sites in Oregon, Washington, California, and Idaho since the 1980s. Members of the Pacific Northwest Native Freshwater Mussel Workgroup are documenting and investigating these die-offs. These events have been observed to impact multiple genera of western mussels including populations of western ridged (Gonidea angulata), western pearlshell (*Margaritifera falcata*), and multiple species of floaters (*Anodonta* sp.). Many western species have declined from their historic distribution and abundance, and enigmatic die-offs are likely stressing already vulnerable populations. In 2018, we observed a large scale die-off affecting multiple species in the Chehalis River in Washington. Similarly, a die-off first reported by workgroup members in 2014 at the Crooked River in Oregon, was observed continuing to affect mussels in 2018. To investigate these continuing die-offs, we are collaborating with staff at USFWS, USGS, UW-Madison, and WDNR to better understand the potential roles of pathogens. Additionally, we are working with researchers at USFS

to evaluate the potential role of water temperature and climate change on die-off events. These and other efforts to track and investigate mussel die-offs are intended to improve our understanding of the causes of enigmatic die-offs and our potential to conserve western mussels.

93. ASSESSING A SUSPECTED MASS MORTALITY EVENT OF PHEASANTSHELL (*ACTINONAIAS PECTOROSA*) IN THE CLINCH RIVER USING LONG-TERM MONITORING DATA

Caitlin Carey[1], Andrew Phipps[2], Jordan Richard[3], Brett Ostby[4], Tim Lane[5] & Jess Jones[6]
[1]Conservation Management Institute, Department of Fish and Wildlife Conservation, Virginia Tech, Blacksburg, VA; [2]Department of Fish and Wildlife Conservation, Virginia Tech, Blacksburg, VA; [3]U.S. Fish and Wildlife Service, Southwestern Virginia Field Office, Abingdon, VA; [4]Daguna, LLC, Rochester, MN; [5]Department of Game & Inland Fisheries, Aquatic Wildlife Conservation Center, Marion, VA; [6]U.S. Fish and Wildlife Service, Department of Fish and Wildlife Conservation, Virginia Tech, Blacksburg, VA

Originating in southwestern Virginia (VA) and flowing southwest into northeastern Tennessee (TN), the Clinch River supports a globally significant assemblage of freshwater mussels. Over an 11-year period from 2004–2014, the status and distribution of the mussel fauna in the Clinch River were quantitatively assessed at 18 sites; including 3 long-term monitoring (LTM) sites (Wallen Bend, Frost Ford, Swan Island) in TN that were surveyed annually. Data from these LTM sites have increased our understanding of mussel population dynamics, have been used to guide on-going population restoration efforts throughout the Upper Tennessee River Basin, and serve as a baseline for evaluating temporal and spatial trends on ecological changes and emerging threats to the fauna. In 2016, several independent accounts of a suspected die-off of Pheasantshell (*Actinonaias pectorosa*) in the Clinch River below the VA-TN border were reported; prompting the need to reinitiate the LTM program. To determine the spatial extent and quantify the severity of the die-off—if one was occurring—demographic data were collected at the 3 LTM sites by quadrat sampling in 2017 and 2018. Additional data were collected from a 4th TN site, Kyles Ford, from 2016–2018. Species-specific densities were estimated and compared to historical, baseline levels. Supporting conclusions drawn from 2016 field observations, our results indicate Pheasantshell experienced a 45–90% population decline since 2014 at TN sites. Similar to 2016 observations, we encountered an unusually high number of fresh-dead and dying mussels. While the spatial extent appeared to be restricted to TN in 2017, by 2018, we documented substantial numbers of fresh-dead and dying Pheasantshell in an upstream VA site. Ongoing assessments indicate this mortality event is ongoing and may not be restricted to Pheasantshell. Maintaining LTM is essential to distinguishing population dynamic noise from signal and mobilizing time-sensitive responses needed to save imperiled species.

94. DO YOU NEED A FAT POCKETBOOK? CATALOGING MUSSEL PRODUCTION CAPABILITIES AND COSTS FOR USE IN NATURAL RESOURCE DAMAGE ASSESSMENT

Serena Ciparis[1], Susan Lingenfelser[1] & Anthony Velasco[2]
[1]U.S. Fish and Wildlife Service, Gloucester, VA; [2]Department of the Interior, Washington, DC

The Natural Resource Damage Assessment and Restoration (NRDAR) program provides a legal framework for restoration of natural resources and related services impacted by oil spills or releases of hazardous substances. The assessment phase of a NRDAR case involves injury determination and quantification followed by determination of damages, which are the costs of restoring the injured resources and/or

services. For NRDAR cases involving freshwater mussels, determination of damages involves assessment of the feasibility of propagation for each injured species as well as the costs of production, restocking, and monitoring of successful restoration. However, this information is not currently available to NRDAR case managers in a centrally maintained, standardized format and is routinely obtained through requests to individual facilities. This method presents potential disadvantages to NRDAR case managers developing mussel claims and to hatcheries with rapidly developing capabilities. Given the recent intensive effort by FMCS to collect data for the "Investigation and monetary values of fish and freshwater mollusk kills" publication, there appears to be an opportunity for FMCS and NRDAR practitioners to work together to develop a searchable database of production capabilities. The ideal components of this database will be presented from the perspective of a NRDAR case manager to initiate a conversation around feasibility of each component, utility of data that have already been collected, and the applicability of data related to production to both NRDAR and broader conservation efforts. The overall goal is to foster the relationship between the Department of the Interior's NRDAR program and FMCS, as continued collaboration and information sharing will benefit restoration of freshwater mussels and their supporting ecosystems.

Session 20: Restoration Tools I
Wednesday (9:40 – 12:00)

95. EXPLORING THE EFFECT OF SHELL DEFORMITY ON AGE AND GROWTH OF MUSSELS FROM THE NASHUA RIVER, MA

Andrew M Gascho Landis[1], Kyle Olivencia[1], Peter D Hazelton[2], Andrew McElwain[3]
[1]SUNY Cobleskill, Cobleskill, NY; [2]Massachusetts Division of Fisheries and Wildlife, Westborough, MA; [3]SUNY Oswego, Oswego, NY

Shell deformities have been observed on a several mussel species throughout the northeastern United States. David Strayer (2008) reported shell deformities from five species across five different drainages in southern New York. More recently, a similar pattern was observed in mussels from the Nashua River, Massachusetts. The cause of the deformity, a truncated posterior shell margin, is largely unknown; however, it may be related to poor water quality due to industrial or agricultural pollution or as the result of parasitic infection. It is also unknown if this deformity influences mussel physiological function and ultimately ecosystem services. As a first step in understanding the impact of shell deformities, we compared age and growth of deformed shells to normal shells from the same reach of the Nashua River. In 2017, we collected 106 deformed mussels from 4 species having different deformity prevalence and sample size (*Elliptio complanata*, 38%, n = 95; *Lampsilis radiata*, 33%, n = 3; *Strophitus undulatus*, 100%, n = 1; and *Margaritifera margaritifera*, 57%, n = 7). The severity of this deformity ranged from slight to severe. *Elliptio complanata* was the only species with adequate sample size for comparing thin-sectioned shells. Mussels with slightly and moderately deformed shells are of younger age (10.8 yrs), versus severely deformed (16.5 yrs). Preliminary analysis indicates little difference in the von Bertalanffy growth rate of mussels with deformed (n = 29; L = 65.5) and normal shells (n = 28; L = 65.8). It appears that *Elliptio* does not show signs of deformity until at least five years of age and that the severity increases with age. A delayed onset of this shell deformity indicates that it may be an accumulation of an environmental stressor for some individuals in the population.

96. TEMPERATURE DEPENDENCE OF FUNCTIONAL TRAITS AND THERMAL THRESHOLDS OF FRESHWATER MUSSELS

Brian C Van EE & Carla L Atkinson
University of Alabama, Tuscaloosa, AL

Consumers play a significant role in the uptake, transformation, and storage of nutrients and organic matter in aquatic ecosystems. By creating hotspots of bioavailable nutrients consumers can stimulate ecosystem processes essential to the natural functioning of a system. In addressing the impacts of global climate change it is imperative to understand how these consumer-driven processes might be altered, though this can often be difficult due to variation in species-level traits relevant in these processes. For consumers, such as freshwater mussels, which are already experiencing drastic declines, studies into ecosystem function can also provide valuable information for conservation efforts. In our study we investigated how physiological rates relevant to ecosystem functions (i.e. functional traits) vary with temperature in 11 species of freshwater mussels. We measured filtration rate (capture of chlorophyll), metabolism (O2 consumption), excretion rate (ammonia and phosphorus), and biodeposition rate (feces and pseudofeces production) at a range of temperatures (10, 20, 30°C) for 11 species of freshwater mussels native to the Sipsey River, Alabama. Using the measured rates, we calculated temperature coefficients (Q10) and scope for growth to determine which species could maintain positive growth at the highest temperature and which had to start burning energy stores to sustain their metabolism. From this we created two classifications, temperature tolerant and temperature sensitive. Using thermal tolerance classification, associated functional traits, and abundance data from Sipsey River surveys we estimated mortality during a drought induced extreme temperature event, and modeled the short-term effects on community composition and ecosystem functions. Under current climate predictions droughts will become more frequent, and understanding the short- and long-term affects on freshwater mussels and the ecosystem functions they support, is imperative to their conservation.

97. SHIFTING HOTSPOTS: OVERLAPPING AGGREGATIONS OF MUSSELS AND FISH INTERACT TO INFLUENCE RESOURCE HETEROGENEITY AND FLUXES IN STREAMS

Caryn C Vaughn[1], Keith B Gido[2], Thomas B Parr[1], Traci P Dubose[1] & Garrett W Hopper[2]
[1]University of Oklahoma, Norman, OK; [2]Kansas State University, Manhattan, KS

Mussels and fishes both occur as multispecies assemblages in rivers, can make up the majority of consumer biomass, and act as biogeochemical hotspots that influence food webs and ecosystem function. Long-lived, sedentary mussels are patchily distributed in beds that should provide relatively stable, localized, constant nutrient subsidies. Shorter-lived fishes are mobile, widespread, short-term hotspots that provide nutrient subsidies more dependent on hydrologic conditions. How these two consumer groups overlap and interact to influence the functioning of streams is unknown. We asked: (1) Where and when do fish and mussel hotspots overlap? and (2) How does overlap between mussels and fish influence nutrient recycling and the distribution of resources? We compared mussel and fish distribution and biomass at 7 sites with paired reaches with and without mussel beds in 3 rivers across 2 seasons for 2 years. We found that mussel biomass was consistently higher than fish biomass, which could be concentrated in stream reaches with mussel beds following periods of low flow, but was otherwise homogenously distributed. Mussels had greater areal nutrient excretion rates than fish and excretion N:P stoichiometry varied longitudinally for mussel communities but not fish communities. A field experiment with enclosures containing live mussels, shells alone, and

controls found that fish preferred mussels and empty shells to areas without mussels. Mesocosm experiments examined the effects of overlapping vs. non-overlapping mussel and fish hotspots on ecosystem function (nutrient dynamics, primary production, community respiration) and ecosystem structure (algal and invertebrate biomass, benthic organic matter, nutrient concentrations) under normal flows (2016, 8 weeks) and drought conditions (2017, 16 weeks). In general, we found that overlapping aggregations of mussels and fish had stronger and less variable effects than either fish or mussels alone. Overall, our results suggest that adding more levels of community complexity stabilizes ecosystem function in streams.

98. USING BAYESIAN DECISION NETWORKS TO GUIDE RESTORATION OF FRESHWATER MUSSELS IN ILLINOIS

Sara Andree, Alison Stodola & Sarah Douglass
Illinois Natural History Survey, Champaign, IL

There is a need for adaptive management tools which can aid in decision-making regarding restorative action for freshwater mussels in rehabilitated systems. Bayesian decision networks allow the inclusion of both empirical data and expert evaluation to account for uncertainty and determine optimal management action under specific conditions. We used Bayesian decision networks to determine best management options for the recently improved West Branch DuPage and South Branch Kishwaukee Rivers in northern Illinois. Management options were no action, propagation of juveniles, relocation of adults, release of inoculated host fish, or dam removal. Models were built for two target species, Ellipse (*Venustaconcha ellipsiformis*) and Spike (*Eurynia dilatata*), and tested for sensitivity to 1) dataset (long term presence, current presence, and current abundance), 2) stream subset (two target streams, six non-target streams, or both), and 3) expert opinion metrics (median, minimum, or maximum). Models using maximum values tended to choose No Action less often, and predicted higher likelihood of mussel establishment after management action. Models were also more sensitive when using only target streams. Propagation of juveniles was most often recommended for Ellipse, while optimal decision for Spike fluctuated between propagation of juveniles and no action. Use of all stream data and median expert opinion values resulted in the most balanced models. Bayesian decision networks offer a useful tool for restoration of freshwater mussel species. However, consideration should be given to empirical data type used to determine prior probabilities and expert opinion bias when using this approach.

99. ORDINATION ANALYSIS REVEALS THREE DISTINCT FRESHWATER MUSSEL ASSEMBLAGES CORRELATED WITH RIVER MILE AND AGRICULTURE IN THE BLACK RIVER, MISSOURI AND ARKANSAS

Alan D Christian[1], Sean T McCanty, Thomas Dimino, Helenmary Hotz, Stephan E McMurray[2] & John L Harris[3]
[1]University of Massachusetts Boston, Boston, MA; [2]Missouri Department of Conservation, Columbia, MO; [3]Arkansas State University, Jonesboro, AR

Biogeographical classification and macro-ecology pattern analyses can be useful in understanding distributions of organisms and aid in conservation and management actions. The objectives of this study were to determine if there are distinct freshwater mussel assemblage community patterns along the upstream to downstream gradient of the Black River in Missouri and Arkansas and to determine if there were any environmental parameters that correlated with these community patterns. To meet our objectives, we conducted a Non-Metric Multi-

Dimensional Scaling (NMDS) analysis on 63 mussel survey sites sampled between 1990 and 2003 from river mile 50.6 to 265.5. Our NMDS results were then correlated with sub-watershed characteristics (e.g. geology, hydrology, and land use). Our results revealed three distinct Black River mussel assemblages generically representing an upstream Ozark Highlands (UOH) grouping, a midstream upper Mississippi Alluvial Plain (MUMAP) grouping, and a downstream lower Mississippi Alluvial Plain (DLMAP) grouping. These distinct assemblages correlated primarily with river mile (0.6315) and river mile plus percent agriculture (0.6690). These results are consistent with our biogeographical expectations that mussel distributions are indirectly related to fish distributions due to the fish and mussel host-parasite relationship, respectively, and are influenced by watershed drainage area.

100. A REVIEW OF COLLABORATIVE DECISION-MAKING PROCESSES: HELPING TO FIND A PATH TO COEXISTENCE

David R Smith[1] & Michelle A Haynes[2]
[1]U.S. Geological Survey Kearneysville, WV; [2]U.S. Fish and Wildlife Service, Falls Church, VA

Collaborative decision making is often required to find ways for human activity and ecological processes to coexist, which is the goal of this year's FMCS symposium. Successful collaboration utilizing decision analysis not only builds trust among parties and fosters joint learning, but also focuses on multiple objectives, integrating decision analysis techniques to evaluate tradeoffs. These practices result in durable and effective solutions – meaning solutions that are accepted, implemented, and most likely to achieve desired outcomes. However, collaborative decision making in natural resources is challenging because of conflicting values (e.g., ecological versus budgetary or socioeconomic concerns), uncertain knowledge (e.g., prediction with limited data), and the time required for adequate communication. The approaches of collaboration and decision analysis emphasize different aspects of durability and effectiveness. Collaboration focuses on reaching the consensus needed for acceptance and implementation of a solution; whereas, decision analysis seeks to clarify the objectives and identify the optimal solution, as defined by outcomes that best meet the multiple objectives. We review collaborative decision-making processes at the interface of conflict resolution and decision analysis as applied to natural resource management. We present a series of key considerations useful for preparing a group for a successful collaborative decision process.

101. WIDELY AVAILABLE DATA CURRENTLY UNDER UTILIZED FOR SPECIES ASSESSMENTS, LISTING DECISIONS, AND DETERMINING THE TRAJECTORY OF RIVER CONDITIONS INTO THE FUTURE

Thomas G Jones, Nathan Hoxie & Erica Pauley
Marshall University, Huntington, WV

The Clean Water Act (CWA) requires a regulatory framework for assessing waters in every state. Since 1972, significant amounts of money/time have produced protocol development, data collection and refinement to protocols across the USA. CWA assessment organizations' are required to develop these 5 year statewide summaries to the Environmental Protection Agency (EPA), but both historic and current underfunding results in data being under-utilized. The amount and complexity of the data tethered to the systematic separation of the CWA agencies, state conservation programs, and the Endangered Species Act (ESA) oversight agencies results in the very minor usage of this data for mussel/mollusk conservation. The West Virginia Department of Environmental Protection (WVDEP) is in its fourth round of systematic

sampling of state watersheds. Their assessment protocol includes basic water chemistry testing, habitat assessment, and biomonitoring. A graduate student in my lab compared the first five year sampling period with the second five year sampling period using ArcMap. An undergraduate utilized a portion of his results in her assessment of mussel populations in a small watershed. The most simplistic utilization of this data would be a calculation of mean habitat and biomonitoring index scores between years. Additional relationships within the data could be elucidated by comparing specific metric mean scores for a watershed. However, the spatial information is not considered within the dataset. The two projects combined illustrate how CWA biomonitoring data could enhance various conservation assessments.

Session 21: Gastropoda
Wednesday (9:40 – 12:00)

102. A STUDY ON THE DIVERSITY OF SNAIL SPECIES WITHIN NNAMDI AZIKIWE UNIVERSITY AWKA NIGERIA

Charles Obinwanne Okoye[1] & John Joseph Okeke[2]
[1]University of Nigeria Nsukka, Nsukka, Nigeria; [2]Nnamdi Azikiwe University Awka, Awka, Nigeria

Four sample sites were studied for diversity of snail in Nnamdi Azikiwe University and a total of 245 specimens were collected, 243 specimens were identified to species level giving 8 species and 2 out of 245 were not identified. The species of snail found from the four sites are; *Achatina achatina*, *Limicolaria mortensis*, *Achatina marginata*, *Achatina fulica*, *Limicolaria aurora*, *Achatina immaculate*, *Lanistes varicus*, *Achatina fulica hamillei* (albino). *Limicolaria mortensis* was found to be more diverse in site C, B and A respectively, and more abundant with a total number of 95 (37.78%) having the highest diversity index, using Shannon Weiner diversity index but was not found in site D (aquatic habitat); *A. achatina* was found to be the second most diverse snail species while *A. marginata* is the least diverse snail specie in this study.

103. WHAT IS *PRISTINICOLA*?

David C Campbell[1] & Edward Johannes[2]
[1]Gardner-Webb University, Boiling Springs, NC; [2]Deixis Consultants, Seattle, WA

The genus *Pristinicola* currently includes a single species, *P. hemphilli* (Pilsbry, 1907), reported to range from Idaho west through Washington and south to northern California in spring habitats. The distribution is discontinuous, with unexplained gaps in the Umpqua and Chehalis rivers, Oregon and Washington, and in most of the Rogue and Klamath rivers, Oregon and California. It was originally described as *Bythinella hemphilli*, based on the shell shape, but *Bythinella* is from southeastern Europe. Anatomical study (Hershler et al., 1994) determined that the species does not match any other genus. Reproductive anatomy is a key feature distinguishing truncatelloidean families, but *Pristinicola* has simple, relatively generic anatomy. Only one DNA sequence has been generated, a cox1 sequence that is divergent from all known truncatelloideans. We generated additional sequences from several populations. Sequence divergence between the published sequence from the lower Columbia River drainage and populations around Puget Sound is minimal, but the divergence between these and an eastern Washington population is more significant. New sequences for 28S and histone H3 confirm that Pristinicola is divergent from the as-yet

studied truncatelloideans, although the published taxonomic coverage for those genes is not as extensive as for cox1, for which several thousand sequences were available to analyze. Determination of the placement of *Pristinicola* within Truncatelloidea remains problematic.

104. DETERMINING THE SPECIFIC STATUS OF AN UNUSUAL, PHREATIC, TEXAS CAVESNAIL (MOLLUSCA; GASTROPODA; HYDROBIIDAE)

Dominique A Alvear[1], Pete Diaz[2], Randy Gibson[2], Benjamin Hutchins[3], Benjamin Schwartz[3] & Kathryn E Perez[4]
[1]University of Texas Rio Grande Valley, Edinburg, TX; [2]U.S. Fish & Wildlife Service, San Marcos, TX; [3]Texas State University, San Marcos, TX; [4]University of Texas Rio Grande Valley, Edinburg, TX

Limited research has been done on the freshwater snail family Hydrobiidae across the Edwards Aquifer region of Texas, besides the initial description of species 40-140 years ago. The Texas members of this family are mostly phreatic, meaning they are found in freshwater springs and underground aquifers. Some of the Edwards Aquifer freshwater snails appear to be derived from southwestern U.S. and Northern Mexico freshwater fauna but others are potentially marine relicts. Texas has 16 described hydrobiid species, 14 of which are of conservation concern. In recent surveys of the Edwards aquifer fauna in Comal, Travis, and Val Verde counties, we encountered populations of a snail with unusual shell features that do not resemble any of the existing named species. We use examination of the shell and phylogenetic analysis of mitochondrial (CO1) and nuclear genes (LSU) of this unusual snail to determine if it is an undescribed species endemic to Texas and to place it into the broader phylogenetic context of the Hydrobiidae.

105. UPDATING THE KNOWN RANGES OF TEXAS'S ENDEMIC, FRESHWATER CAVESNAILS (MOLLUSCA; GASTROPODA; "HYDROBIIDAE")

Kathryn E Perez[1], Dominique Alvear[1], Pete Diaz[2], Randy Gibson[2], Benjamin Hutchins[3] & Benjamin Schwartz[3]
[1]University of Texas Rio Grande Valley, Edinburg, TX; [2]USFWS, San Marcos, TX; [3]Texas State University, San Marcos, TX

Endemic to one of the world's most ecologically-diverse groundwater systems, the Edwards-Trinity Aquifer System of Texas, are 13 species (across 5 genera) of snail that are extremely poorly known. Their underground habit and microscopic size make them difficult to study and identify. Most of the published records are from the original species descriptions and some have not been seen since they were described more than 100 years ago. Here we use ~150 new collections from across the Southern Edwards Plateau to update the ranges of 11 of these species. Two described species, *Pyrgophorus spinosus* and *Phreatodrobia imitata*, were not re-collected in these samples and four morphological types were encountered that are not assignable to named species. Other notable findings include re-discovery and greatly expanded range of *Stygopyrgus bartonensis*, the Barton Cavesnail, and range extensions of 100+ km for several species.

106. DOCUMENTING RARE AQUATIC SNAILS (COCHLIOPIDAE, LITHOGLYPHIDAE & HYDROBIIDAE) FROM THE HYPORHEIC ZONE OF TEXAS STREAMS: A NEW HABITAT FOR POORLY KNOWN SPECIES

Benjamin T Hutchins[1], Aaron P Swink[1], Benjamin F Schwartz[1], Dominique Alvear[2] & Kathryn E Perez[2]
[1]Texas State University, San Marcos, TX; [2]University of Texas Rio Grande Valley, Edinburg, TX

Minute, freshwater 'hydrobiid' snails are often small-range endemics confined to groundwater-dependent habitats (e.g. spring-runs and aquifers). No fewer than 26 species classified by the Freshwater Mollusk Conservation Society as vulnerable, threatened, or endangered occur in Texas. Most of these are known from fewer than five locations. In surface waters, these snails are usually collected from rock substrate or vegetation using benthic sampling methods whereas subterranean species are usually collected at springs and flowing artesian wells using drift nets. We report on the use of a Bou-Rouch pump to sample for snails in shallow, interstitial groundwater in gravel and cobble sediments of surface streams (i.e. the hyporheic zone). Although the Bou-Rouch pump is commonly used to sample for groundwater invertebrates, particularly in Europe, it has rarely been used to sample for aquatic gastropods in North America. From 2015 – 2017, we collected 132 samples from 31 sites along an E-W transect in Texas. Live animals or recently dead shells of 10 rare and three unidentified species were recovered in 31 samples (23%) from 10 sites (32%). Species richness ranged from one to five (mean = 1.4), and both epigean and hypogean species were recovered. Particularly for aquatic subterranean snails, the hyporheic zone affords a more continuous and more accessible sampling opportunity relative to discrete and relatively uncommon springs and wells. The hyporheic zone may also serve as an important refuge for surface species during drought and other extreme weather events.

107. MESOHABITAT ASSOCIATIONS AND TROPHIC ECOLOGY OF ENDEMIC AND ENDANGERED SNAILS IN DESERT SPRING

Weston H Nowlin[1], Nina E Noreika[1], Pete H Diaz[2] & Chad Norris[3]
[1]Texas State University, San Marcos, TX; [2]U.S. Fish & Wildlife Service, San Marcos, TX; [3]Texas Parks and Wildlife Department, Austin, TX

In arid regions, springs represent ecologically important habitats that are patchily distributed across the landscape. Springs often contain endemic populations with limited spatial distributions which are adapted to local environmental conditions. Consequently, organisms in these springs are also frequently of high conservation priority. This study examined invertebrate community structure and habitat associations at seven sites in the Davis Mountains in west Texas. The overall purpose of this study was to determine mesohabitat associations and estimate local and regional population sizes of three federally endangered aquatic invertebrates found in the region: the Phantom springsnail (*Pyrgulopsis texana*), the Phantom tryonia (*Tryonia cheatumi*), and the diminutive amphipod (*Gammarus hyalleloides*). Results indicate that the occurrence and abundance of endemic species were strongly influenced by site location (i.e., specific spring location) and that mesohabitat conditions were less important in influencing species density. We also found that two species of non-native and invasive snail (*Melanoides tuberculata* and *Tarebia granifera*) occurred at most sites at densities sometimes greater than the endemic snails. In addition, stable isotope analysis indicated a substantial amount of niche overlap between endemic and invasive snails at some sites. These results suggest that regionally distributed invertebrates with low dispersal potential (i.e., snails) exhibit high site-specific occurrence. Additionally, these results indicate that conservation of these populations in the wild should focus on site-specific objectives to preserve water quality and mesohabitat conditions. However, this management strategy is further complicated by the fact that these spring systems are linked via regional

groundwater sources. With agriculture and oil and gas development increasing water demand in the Trans-Pecos region, the risk for groundwater over-pumping and contamination may place site-specific and collective regional populations at risk.

108. MORE IS BETTER: HUNDREDS OF NUCLEAR GENES IMPROVE UNDERSTANDING OF PLEUROCERIDAE (GASTROPODA: CERITHIOIDEA) RELATIONSHIPS

Nathan V Whelan[1], Nicole Garrison[2], Paul D Johnson[3], Jeffrey T Garner[3] & Ellen E Strong[4]
[1]U.S. Fish & Wildlife Service, Auburn, AL; [2]Auburn University, Auburn, AL; [3]Alabama Department of Conservation and Natural Resources, Florence, AL; [4]National Museum of Natural History, Washington, DC

The systematics of Pleuroceridae has been a source of confusion that hinders understanding of an ecologically important group of freshwater mollusks. Relationships within Pleuroceridae are unresolved, owing to the absence of reliable molecular tools that can be used to elucidate relationships. Previous phylogenetic studies have relied heavily on one or two mitochondrial genes, but recent work highlighted unprecedented amounts of interspecific diversity in mitochondrial genes. Thus, mitochondrial gene trees likely do not represent evolutionary history. As such, a phylogenomic method employing hundreds of nuclear genes is needed to resolve pleurocerid relationships. We used a target capture, Illumina approach to sequence 630 nuclear genes for 192 individuals representing over 70 species. Taxon sampling spanned the majority of the family's geographical range and taxonomic diversity. Phylogenetic inference was performed with standard concatenation and species tree methods. Our results show that all pleurocerid genera, except two monotypic genera, are polyphyletic. Thus, the family requires extensive systematic revision at the genus level. The analysis also reveals many surprising biogeographic implications. For example, the sister clade to all other Pleuroceridae is comprised of Leptoxis species from the Alabama River drainage. Some species such as *Elimia bellacrenata* and *E. cochliaris* that are native to the Cahaba drainage in the Mobile River Basin are more closely related to species from Tennessee than other Mobile River Basin natives. Our results support phylogenomics as a promising avenue in pleurocerid research and in promoting conservation efforts for this highly imperiled family.

Session 22: Invasive Species
Wednesday (2:40 – 3:40)

109. DISCOVERY OF A SILICATE ROCK-BORING ORGANISM AND MACROBIOEROSION IN FRESH WATER

Ilya V Vikhrev[1], Ivan N Bolotov[1], Olga V Aksenova[1], Torkild Bakken[2], Christopher J Glasby[3], Mikhail Yu Gofarov[1], Alexander V Kondakov[1], Ekaterina S Konopleva[1], Manuel Lopes-Lima[4], Artyom A Lyubas[1], Yu Wang[5], Agniya M Sokolova[6], Kitti Tanmuangpak[7], Sakboworn Tumpeesuwan[8], Bruce H Shyu[9] & Than Win[10]

[1]Federal Center for Integrated Arctic Research, Arkhangelsk, Russia; [2]Norwegian University of Science and Technology, NTNU University Museum, Trondheim, Norway; [3]Museum and Art Gallery of the Northern Territory, Darwin, Australia; [4]Interdisciplinary Centre of Marine and Environmental Research, Porto, Porugal; [5]Earth Observatory of Singapore, Nanyang, China; [6]A.N. Severtsov Institute of Ecology and Evolution, Moscow, Russia; [7]Department of Science, Faculty of Science and Technology, Loei Rajabhat University, Loei, Thailand; [8]Department of Biology, Faculty of Science, Mahasarakham University, Maha Sarakham, Thailand; [9]Department of Geosciences, National Taiwan University, Taipei City, Taiwan; [10]Department of Zoology, Hpa-An University, Hpa-An, Myanmar

Macrobioerosion is a common process in marine ecosystems. Many types of rock-boring organisms break down hard substrates, particularly carbonate rocks and calcareous structures such as dead corals and shells. In paleontology, the presence of rocks with boreholes and fossil macroboring assemblage members is one of the primary diagnostic features of shallow marine paleo-environments. Here we describe a silicate rock-boring organism and an associated community in submerged siltstone rock outcrops in Kaladan River, Myanmar. The rock-boring mussel Lignopholas fluminalis is a close relative of the marine piddocks, and its borings belong to the ichnospecies Gastrochaenolites anauchen. The neotectonic uplift of the area leading to gradual decrease of the sea level with subsequent shift from estuarine to freshwater environment was the most likely driver for the origin of this community. Our findings highlight that rocks with macroborings are not an exclusive indicator of marine paleo-ecosystems, but may also reflect freshwater habitats. This study was supported by the Ministry of Science and Higher Education of the Russian Federation (no. - 18-118012390161-9), the Russian Foundation for Basic Research (no. 18-34-20033_mol_a_ved) and Russian Science Foundation (no. 18-77-00058).

110. CHARACTERIZING NONINDIGENOUS MOLLUSKS OF THE UNITED STATES

Wesley M Daniel[1] & Cayla R Morningstar[2]

[1]U.S. Geological Survey, Gainesville, FL; [2]Cherokee Nation Technologies, contracted with U.S. Geological Survey, Gainesville, FL

The U.S. Geological Survey's Nonindigenous Aquatic Species (NAS; https://nas.er.usgs.gov/) database is the national repository for spatially referenced biogeographic accounts of introduced aquatic species. The program tracks the distribution of >1,270 nonindigenous species across the United States (contiguous US, Alaska, Hawaii, and US territories), and contains over half a million spatially-referenced and expert-verified biogeographic records. The NAS Database is an unparalleled source of non-native data and a potentially underutilized tool for mollusk conservation work. The NAS database tracks 69 exotic, native transplant or invasive freshwater mollusks, including 26 bivalves and 43

gastropods. Those species represent >40,000 records from across the U.S., with the majority occurring in the Great Lakes Region/Midwest. The NAS database houses greater than 100 occurrence records for *Bithynia tentaculate*, *Cipangopaludina japonica*, *Dreissena rostriformis*, *Melanoides tuberculatus*, *Perna viridis*, *Pomacea maculata*, *Radix auricularia*, and *Viviparus georgianus*. The database has greater than 1,000 records for *Cipangopaludina chinensis*, and *Potamopyrgus antipodarum*, > 7,000 records for *Dreissena polymorpha*, and >24,000 records for *Corbicula fluminea*. This presentation will characterize the status (established, failed, etc.) and distribution of the above dozen mollusk species in the United States, along with describing the potential impacts from the invaders on native mollusk diversity. The presentation will also introduce malacologist to the NAS database website and provide them with resource information and instructions on how to report a non-native species sighting to the program.

111. SHOULD I STAY OR SHOULD I FLOW? THE CLASH BETWEEN *CORBICULA* E-DNA AND STREAM FLOW

Jeremy S Tiemann[1], Amanda N Curtis[2], Sarah A Douglass[1], Mark A Davis[1] & Eric R Larson[2]
[1]Illinois Natural History Survey, Champaign, IL; [2]University of Illinois, Urbana, IL

Environmental DNA (eDNA) has been shown to be an effective tool for detecting low abundances of invasive or imperiled species. Its efficacy hinges upon understanding the covariates influencing fate and transport. In lotic systems, these covariates may include biotic (e.g. species abundance, seasonal activity patterns, etc.) and abiotic (e.g. stream discharge, temperature, ultraviolet irradiation, pH, etc.) factors, as well as their complex interactions. To better understand fate and transport of eDNA in complex lotic systems, we assessed eDNA copy number for invasive *Corbicula fluminea* in two east-central Illinois streams equipped with USGS streamflow gages. We collected eDNA samples every two weeks, as well as during periods of high and low discharge, during the calendar year of 2018. At each sampling period, we collected data for a number of physicochemical variables, including pH, temperature, turbidity, conductivity, total dissolved solids, salinity, and discharge. Finally, we conducted mid-summer quadrat sampling at each site to estimate *Corbicula* densities. We anticipated that high stream flow events could either dilute eDNA concentrations or increase eDNA concentrations by mobilizing *Corbicula* DNA from the sediments. Preliminary analyses showed *Corbicula* eDNA copy number increased with rising water temperatures, likely reflecting biological activity and reproduction in late spring and early summer. We also found a negative relationship between stream flow and *Corbicula* eDNA copy number, with eDNA detections nearly vanishing at peak flows, thus suggesting stream flow dilutes eDNA and sampling during high flows could result in a decreased ability to detect a very abundant species. Our study presents novel findings that temperature and stream discharge may be substantial drivers of eDNA abundance for common stream species like the invasive *Corbicula* taxa. For those desiring to use eDNA as a monitoring tool, timing of collecting events and life history characteristics of study organisms are critical considerations in formulating sampling designs.

Session 23: Restoration Tools II
Wednesday (2:40 – 3:40)

112. STOCKING THE EASTERN PEARLSHELL (*MARGARITIFERA MARGARITIFERA*) IN NORWAY: EXPERIENCES FROM THE FIRST FEW YEARS

Jon H. Magerøy[1], Steinar Kålås[2], Ingrid Wathne[2], Anton Rikstad[3] & Kristian Julien[3]
[1]Norwegian Institute for Nature Research, Oslo, Norway; [2]Rådgivende Biologer, Bergen, Norway; [3]County Governor of Trøndelag, Steinkjer, Norway

Norway is one of the last strongholds of the eastern pearlshell (*Margaritifera margaritifera*), with about two thirds of the remaining European populations. However, the species is also declining in Norway, with ca. one third of populations having gone extinct, one third likely going extinct and only one third being viable. To counter this trend, a cultivation program was started in 2012 and stocking of cultivated mussels started in 2016. Currently, 18 threatened populations have been stocked with juveniles. The mussels were placed in Hruska boxes for a year or more, before complete release in the river/stream. Mussels of varying sizes (1.1-17.4 mm) and ages (1-5 years old) were stocked in the different populations, but the overall pattern was that survival was much greater among mussels 4 mm and 2 years old. This survival pattern was significant in populations stocked with mussels of two different age groups, which also differed in mean size. Stocking of mussels at different times during the year resulted in significantly higher survival among mussels stocked in summer than spring. Using a single population for testing the effects of cultivation of mussels on different host fish, survival was significantly higher among stocked mussels cultivated on brown trout (*Salmo trutta*) than Atlantic salmon (*S. salar*). However, the difference in survival is most likely explained by differences in size at stocking between the two groups. Based on our findings, we recommend that cultivated eastern pearlshells should be stocked at a minimum size and age of 4 mm and 2 years, respectively, and that the mussels should be stocked during the summer months. These recommendations are likely applicable to populations in northern temperate regions, with natural conditions similar to those in Norway.

113. HABITAT SUITABILITY AND POPULATION ASSESSMENT OF THE COLLAPSED LITTLE BLACK RIVER MUSSEL FAUNA, MISSOURI.

Matthew C Schrum[1], Amanda E Rosenberger[2] & Stephen E McMurray[3]
[1]Tennessee Cooperative Fishery Research Unit, Tennessee Technological University, Cookeville, TN; [2]U.S. Geological Survey, Tennessee Cooperative Fisheries Research Unit, Tennessee Technological University, Cookeville, TN; [3]Missouri Department of Conservation, Central Regional Office and Conservation Research Cente, Columbia, MO

The Little Black River in southeast Missouri and northeast Arkansas once hosted a diverse mussel fauna, including the Curtis Pearlymussel (*Epioblasma curtisii*). A precipitous die-off of the mussel fauna was documented in 1988, with declines in abundance averaging 80% between 1982 and 1988. To determine the feasibility of a possible whole-assemblage mussel reintroduction and restoration in this system, we assessed multiple characteristics of the watershed pertinent to mussel survival and persistence. Longitudinal thermal and water quality profiling showed mostly positive results, however we observed some potentially lethal temperatures and ammonia concentrations, and values outside of state-mandated standards for pH and dissolved oxygen. Macroinvertebrate bioassessments, as a surrogate for water quality and habitat

suitability, indicated stable to improving conditions between 1993 and 2017. Contaminant spill and fish kill records did not reveal the cause of the die-off or any ongoing, contaminant-related threats. We resurveyed historical mussel beds and conducted searches for undocumented beds. Mussel catch-per-unit-effort in 2017 was approximately 30% of that observed in 1979/1980 but has remained stable since the initial decline in 1988. Our surveys, taken together with previous work, indicate that nine mussel species found in 1979/1980 have not been detected in recent years. Our investigation of land cover changes between 1992 and 2012 revealed little change within the watershed. However, we documented actively eroding banks along the 26 km stretch of the upper Little Black River that historically held the most diverse mussel fauna and the last known occurrences of *E. curtisii*, possibly due to legacy effects of historical logging activity. We therefore conclude habitat restoration work would benefit and allow the recovery of the Little Black River mussel fauna in conjunction with future reintroduction of extirpated species. Future work should include quantitative surveys to determine if reproduction and recruitment of extant populations are taking place.

114. INVESTING IN FRESHWATER MUSSEL BEDS FOR WATER QUALITY ENHANCEMENT: THE MUSSELS FOR CLEAN WATER INITIATIVE

Danielle A Kreeger[1], Angela Padeletti[1], Kurt Cheng[1], Roger Thomas[2] & Lance Butler[3]
[1]Partnership for the Delaware Estuary, Wilmington, DE; [2]The Academy of Natural Sciences of Drexel University, Philadelphia, PA; [3]Philadelphia Water Department, Philadelphia, PA

Bivalve shellfish perform many important ecosystem services in areas where they are abundant. For example, both natural and farmed populations can filter and transform substantial particulate pollutants in areas where the population biomass is high relative to the water's residence time and particle load. Their efficacy for removing pollutants also depends on seasonal temperature and the animal's nutritional status, but does not vary widely among diverse freshwater and marine bivalve species. In response to emerging literature documenting such services, water quality managers are increasingly joining with the conservation community in seeking ways to sustain, restore and enhance bivalve populations, including a variety of fresh and saltwater species. Like elsewhere, populations of native bivalves have been in decline in mid-Atlantic watersheds such as the Delaware and Susquehanna River basins, and this complicates our efforts to sustain water quality. Since 2007, the Freshwater Mussel Recovery Program has worked to survey, conserve and restore native mussel populations in the Delaware River Basin, including a variety of habitat, reintroduction, research and outreach programs. The Mussels for Clean Water Initiative is a new extension of the program that will strive to enhance or restore mussel assemblages that promote the greatest ecosystem services, such as functional dominant species at sites that are impaired for water quality. With construction funding from the Pennsylvania Infrastructure Investment Authority, a new mussel hatchery will be built at Bartram Gardens in Philadelphia. Mussel seed that are produced will be reared in suitable ponds at satellite facilities throughout the area until they are ready to be used for restoration, research, assessment, and education projects. A technical workgroup will help establish regional restoration priorities, frame and address research needs, and furnish advice on genetic preservation and hatchery practices. Funding and new partnerships to promote mussel-mediated ecosystem services are being sought in the mid-Atlantic.

Session 24: Management II
Wednesday (2:40 – 3:40)

115. A DECADE OF EFFORTS TO GAIN ENDANGERED SPECIES ACT PROTECTION FOR IMPERILED FRESHWATER MOLLUSK

Tierra R Curry
Center for Biological Diversity, Portland, OR

Since 2007 the Center for Biological Diversity and other conservation groups have petitioned for Endangered Species Act protection for 166 imperiled freshwater mollusks from around the United States. Petitioned species include 48 eastern mussels, 11 western mussels, 45 southeastern freshwater snails, and 62 western freshwater snails. The species face a variety of threats including water pollution, groundwater withdrawal, and global climate change. Despite the high imperilment and extinction rates of freshwater mollusks, only 14 of these species have gained ESA protection. Markedly, none of the snails have gained protection. Of the remaining species, one is proposed, four are warranted but precluded, and 46 are under status review, most of which have been waiting for a 12-month finding for nine years or longer. Two species are believed extinct. This talk will examine by geography and administration the efforts and outcomes of campaigns to gain protection for freshwater mollusks, compare decision timelines and media coverage to those for more charismatic fauna, and cover ongoing initiatives to gain listing, critical habitat designation, increased recovery funding, and increased awareness for underappreciated species.

116. MUSSEL SALVAGE AND RELOCATION EFFORTS ASSOCIATED WITH A LARGE-SCALE REMEDIATION PROJECT IN THE KALAMAZOO RIVER, MICHIGAN, U.S.

Adam K Benshoff[1], John Spaeth[2] & Casey Swecker[2]
[1]Environmental Solutions & Innovations Ravenna, OH; [2]ESI, Cincinnati, OH

The Kalamazoo River (Michigan) historically supported a diverse freshwater mussel fauna including approximately 23 species. Over time, damming and pollution from urbanization, agriculture, and paper mill discharges negatively impacted the mussel community, reducing diversity to 16 extant species. One of the largest inland petroleum spills in U.S. history occurred in 2010, with release of more than a million gallons of diluted butman, an oil sands product, in Talmadge Creek, a tributary to the Kalamazoo River. The pipeline rupture and subsequent release directly impacted 25 miles of the River. In addition, a series of water control structures (i.e., dams) associated with the paper industry, were installed in the lower 81 miles of the Kalamazoo River and facilitated deposition of polychlorinated biphenyls (PCBs), a paper mill residual product, in reservoirs, floodplains, and lotic instream margins. Multiple private, state, and federal stakeholders cooperatively launched large-scale remediation efforts to alleviate impacts via removal of water-control structures and PCB-contaminated sediments. Remediation and restoration efforts include mussel salvage and relocation along 1.97 stream miles, and to date resulted in relocation of 1,075 live mussels representing 9 species to upstream monitoring sites. Each salvaged individual was tagged with a unique numeric tag and the relocated population was subsequently monitored to determine short-term recovery rates. Despite adverse historical impacts and a recent spill event,

large-scale remediation efforts are ongoing to protect indigenous mussel populations, improve water quality, restore natural riverine hydrology, and remediate legacy contaminants.

117. RECOVERY ADVANCEMENT OF THE PALE LILLIPUT, *TOXOLASMA CYLINDRELLUS*: A FEDERALLY ENDANGERED FRESHWATER MUSSEL

Paul Johnson[1], Todd Fobian[1], Michael Buntin[1], Don Hubbs[2], Dan Hua[3], Jesse Holifield[1], Thomas Tarpley[1] & Jeff Garner[4]
[1]Alabama Department of Conservation and Natural Resources, Marion, AL; [2]Tennessee Wildlife Resources Agency, Camden, TN; [3]Tennessee Wildlife Resources Agency, Gallatin, TN; [4]Alabama Department of Conservation and Natural Resources, Florence, AL

Toxolasma cylindrellus (Pale Lilliput), a Tennessee River basin endemic, remains extant in two small populations. The species occupies a 12 km reach of Estill Fork in the Paint Rock River, Alabama and a highly localized occurrence in Lick Creek, a tributary of the Duck River, Tennessee. Listed under the Endangered Species Act in 1976, multi-state recovery efforts have recently focused on establishing new populations. Multiple host trials identified *Fundulus catenatus* (Northern Studfish), as the primary host. Female *T. cylindrellus* have relatively low fecundity (mean = 11,663 glochida per female), yet juveniles respond well to standard culture techniques. Annual *T. cylindrellus* production can support multiple reintroduction efforts each year. Regional *T. cylindrellus* recovery planning identified the Duck River as a priority reintroduction stream and ADCNR donated 802 juveniles to TWRA for the first stocking in September 2014. Eleven subsequent stockings at five Duck River basin localities have released 4,016 mussels. Additional ADCNR stockings have occurred in the middle Paint Rock River (two sites, four stockings, 2,687 individuals) and Bear Creek (one site, two stockings, 764 individuals). Finally, TWRA stocked 563 in the Elk River (one site, one release) with individuals cultured at their new C-RAC facility in 2017. Post reintroduction monitoring has repeatedly recaptured several persisting tagged adult animals indicating good growth and survivorship. In addition to tagged animals, 2018 qualitative monitoring by TWRA located a young untagged *T. cylindrellus* approximately 200 meters upstream of the Duck River stocking site at Venable Spring. Routine quantitative monitoring by ADCNR verified a newly recruited individual at a Paint Rock locality. These successful reintroduction efforts along with habitat recovery projects implemented by Tennessee Valley Authority and The Nature Conservancy are meeting stated recovery goals under the Endangered Species Act. If successful reintroduction efforts continue over the next decade, down-listing or delisting maybe possible.

Session 25: Management III
Wednesday (4:00 – 5:00)

118. LARGEST EVER ENDANGERED RAYED BEAN RELOCATION UNCOVERS FIRST RECORD OF NORTHERN RIFFLESHELL MUSSEL FROM NEW YORK.

Casey Swecker[1], John Spaeth[1], Doug Locy[2], Adam Benshoff[3], David Foltz[4], Mitchell Kriege[1], Aaron Prewitt[1] & Tom Jones[5]
[1]Environmental Solutions & Innovations, Inc., Cincinnati, OH; [2]Aquatic Systems, Inc., Pittsburgh, PA; [3]Environmental Solutions & Innovations, Inc., Ravenna, OH; [4]Environmental Solutions & Innovations, Inc., Pittsburgh, PA;, [5]Environmental Solutions & Innovations, Inc., Huntington, WV

Within the malacological community, the Allegheny River in Pennsylvania is iconic for freshwater mussel surveys and large-scale relocation events. Relocations for the Hunters Station Bridge Project comprised only four individuals of the federally endangered rayed bean (*Villosa fabalis*), as compared to more than 64,000 clubshell (*Pleurobema clava*) and 26,000 northern riffleshell (*Epioblasma rangiana*). Alas, the holy grail of rayed bean populations in the Allegheny River has been found though not in Pennsylvania, rather 100 miles upstream, in the state of New York. Within the mussel assemblage surveyed in 2017-18, rayed bean comprised the dominant species, exhibiting densities up to 18 individuals per square meter. These findings fill data gaps regarding rayed bean survivorship and evoke discussion on salvage effort efficiency for one of North America's smallest unionids. The same survey efforts also identified, what is believed, the first recorded northern riffleshell collected from the state of New York. This presentation includes hypothetical data supporting how this individual potentially appeared and survived in this portion of the Allegheny River.

119. SEMI-NATURAL INFESTATION OF HOST FISH AND REINTRODUCTION OF A THREATENED MUSSEL

Martin Osterling[1], Lena Andersson[1], Maria Stjernlöf[1], Anders Nilsson[2], Johan Hojesjo[3] & Niklas Wengstrom[3]
[1]Karlstad University, Karlstad, Sweden; [2]Lund University / Karlstad University, Lund, Sweden; [3]University of Gothenburg, Gothenburg, Sweden

Common methods to support recruitment and reintroduction of unionoid mussels include captive breeding and translocation of adult mussels and/or host fish infested with mussel. The freshwater pearl mussel (*Margaritifera margaritifera*) is endangered across its distribution, and its larvae live as gill parasites on brown trout (*Salmo trutta*). In this study, by using a semi-natural infestation method, we investigated if trout growth, body condition and habitat selection differed between infested and non-infested trout. PIT-tagged trout were placed in cages together with gravid adult mussels and in control cages without mussels. When the mussels had released their larvae, the trout were released back into the streams. Trout growth, body condition and habitat selection were investigated by PIT scanning and electrofishing over a five-week period. The study shows that growth of infested trout was lower than for non-infested trout after the period in the cages. Infested trout were recaptured in areas with low water flow and fine sediment composition, while there were no effects on growth or body condition after five weeks in the streams. In summary, this method appears to be a cost-effective and non-detrimental way of enhancing the recruitment of the freshwsater pearl mussel.

120. MUSSEL ASSEMBLAGE DYNAMICS OF A HIGGINS EYE PEARLYMUSSEL (*LAMPSILIS HIGGINSII*) ESSENTIAL HABITAT AREA IN THE UPPER MISSISSIPPI RIVER, USA

John P Spaeth[1], Mitchell Kriege[1] & Joseph Jordan[2]
[1]Environmental Solutions & Innovations, Inc., Cincinnati, OH; [2]US Army Corps of Engineers, Rock Island, IL

Higgins eye pearlymussel (*Lampsilis higginsii*) is a federally endangered species inhabiting the Upper Mississippi River System (UMRS). As part of the original USFWS recovery plan, seven locations where reproducing Higgins eye populations persisted in high-quality mussel beds were designated as "Essential Habitat Areas" (EHAs). The Cordova mussel bed, in Pool 14 of the Mississippi River, is one of the original EHAs designated and comprises a portion of a long-term monitoring site (LTMS) established in 2000 by an inter-agency Mussel Coordination Team (MCT). Systematic mussel monitoring efforts at the Cordova EHA were completed at regular intervals to track and evaluate the status of federally endangered Higgins eye pearlymussel, native mussel densities, assemblage compositions and abundances, population demographics, distributional patterns, and zebra mussel infestation on native unionids. This investigation examines the temporal dynamics of a significant mussel resource that, although threatened by contemporary abiotic and biotic stressors, persists in a large river system.

Session 26: Restoration Tools III
Wednesday (4:00 – 5:00)

121. USING REMOTE SENSING TECHNOLOGIES TO ASSIST IN DETERMINING AND MITIGATING EFFECTS OF ANTHROPOGENIC ACTIVITIES ON MUSSEL HABITAT AND ASSEMBLAGES

Charlie Morgan
Mainstream Commercial Divers, Inc., Murray, KY

Remote sensing technologies have been used to varying degrees of effectiveness within the last several years to investigate the effect that anthropogenic actions have had, or estimate the effect they will have, on freshwater mussels and their habitat within the North American commercial inland waterway system and the tributaries of those major waterways. Technology such as acoustic Doppler current profiling (ADCP) has been used to quantify the wheel wash disturbance that commercial vessels cause at varying speeds, engine horsepowers, and water depths in an attempt to determine the extent of effect this has on mussel habitat. More frequently, side scan sonar and supplementary ground truthing surveys have been used, generally in conjunction with single beam bathymetric soundings, to classify general areas of differing substrate and topography on the river bottoms. First utilized to conveniently delineate river bottom substrates for commercial river dredging operations, it was realized that similar methods could be used to find substrates that may be more suitable or unsuitable for mussels. Such methods have only improved as the technology used for it has improved over the years. Using this technology, large sections of rivers that would be costly in both time and resources to survey using traditional surveying methods can be surveyed in a much shorter duration and provide information on which areas of the river bottom are not ideal for mussel habitat, such as unstable shifting sand, and which substrates are likely ideal for mussels, allowing for more targeted and efficient traditional surveys. In certain locations where discrete interactions of both

substrate and topography exist that particular listed mussels reside at, such as *Quadrula cylindrica* in the lower Tennessee River, refined and highly precise multibeam sonar soundings can be used to quickly and thoroughly survey these areas in detail, providing large-scale information about the mussels' habitat and allowing for more efficient applications of traditional survey methods. In this way, the information gleaned from such remote sensing technologies can be used to better understand the effects that human activity may or do have on mussels and their habitat, to provide information leading to more targeted and efficient applications of traditional surveys, and to allow for more informed regulatory decisions that would benefit both human needs and mussels.

122. EFFICACY OF SIDE SCAN SONAR PREDICTING SUITABLE MUSSEL HABITAT IN DEEP AND TURBID CONDITIONS IN THE OHIO RIVER

Daniel E Symonds[1], Elizabeth K Dilbone[2], James D Kiser[3] & W. Cody Fleece[2]
[1]Stantec Consulting Inc. Columbus, OH; [2]Stantec Consulting Inc., Cincinnati, OH; [3]Stantec Consulting Inc., Louisville, KY

Identifying suitable mussel habitat over large areas in waters with low visibility and large depths is a concern when attempting to determine the presence or probable absence of listed species. This mussel survey consisted of side scan sonar surveys of 35.3 km^2 of the Ohio River near the confluence of the Green River. Substrate ground truthing of the side scan sonar classifications via Van Veen samples further refined substrates into eight discrete classifications (e.g., sand, silt/clay, cobble, etc.). SCUBA/SSA diving attempted to corroborate side scan sonar substrate classifications, as well as sample mussel communities. During 47 hours of searching at 109 search cells throughout the survey area, divers collected mussels and substrate data. Approximately 55 percent of cells were properly classified by the side scan sonar when verified by divers. Acoustic classifications were particularly poor (37% accurate) at predicting silt/clay substrates. However, the acoustic classifications were highly accurate for predicting sand (89%) and gravel/hardpan/bedrock (87%) substrates. This proved important, as the gravel/hardpan/bedrock substrate was a dense mussel bed consisting of 310 individuals from 16 species. During this survey, sampling effort for each substrate classification was determined based on predicted mussel habitat quality (suitable vs. unsuitable), a methodology which was somewhat corroborated by high prediction ability in both unsuitable (shifting sand) and suitable (gravel/hardpan/bedrock) habitats. Catch per unit effort was significantly higher in the gravel/hardpan/bedrock substrate (49.59 mussels/hour) compared to other 'potentially suitable' acoustic classes (sand/gravel, silt/clay, cobble) indicating that mussel occupancy is inherently difficult to predict even when substrates are known. Overall, side scan sonar was accurate at predicting certain substrate types, of which one type was shown to be a dense mussel bed, indicating this may be a useful tool when preliminary data is unavailable, unobtainable, or prohibitively expensive.

123. BRIDGING THE DATA GAP IN THE PENNSYLVANIA DEPARTMENT OF TRANSPORTATION PROGRAMMATIC AGREEMENT

Ryan Schwegman[1], Dale Dunford[1], Toni Zawisa[2] & Gregory Zimmerman[1]
[1]EnviroScience, Inc., Stow, OH; [2]Pennsylvania Dept. of Transpotation, Environmental Policy and Development Section, Clearfield, PA

Western Pennsylvania has a large concentration of rare mussels including six federally threatened / endangered(T&E) species. Transportation improvement actions are a fundamental component of PennDOT's annual portfolio but inevitably encounter conflicts with T&E species. The Federal Highway Administration and PennDOT, in coordination with PFBC, FEMA, and the USACE, consulted with USFWS on a tiered programmatic biological assessment/biological opinion. Subsequent to issuance of the Tier 1 biological opinion, project specific, Tier 2

consultations have been completed. This approach has provided project streamlining benefits for PennDOT and the agencies at stake as well as conservation and recovery progress. A range of avoidance and minimization, conservation and recovery measures, identified in the Tier 1, are applied depending on the which of the five Management Units a project falls within. Based on existing survey data Management Unit 1 and 2 streams have high to moderate densities of T&E mussels, while Management Unit 3 (MU-3) stream are within the range of T&E mussels limited recent survey information exists to confirm the presence / absence of T&E species. PennDOT has provided funding to complete comprehensive surveys of these stream reaches as part of their Tier 1 commitment to research. In total, 11 streams accounting for over 200 miles of surveyed stream are included in the project. Survey methods utilize a multi-phase approach with triggers for each phase, so that survey efforts are focused on stream reaches most likely to support T&E species. In 2018 nearly half of the survey work was completed, and the presence of T&E species was limited. Data provided by these survey efforts will be provided to resources agencies to help better define those streams currently classified as Management Unit 3 in the Tier 1 programmatic.

Session 27: Ecology
Wednesday (4:00 – 5:00)

124. INFECTION OF FRESHWATER PEARL MUSSEL (*MARGARITIFERA MARGARITIFERA*) GLOCHIDIA AFFECTS BROWN TROUT (*SALMO TRUTTA*) PREY HANDLING TIME AND GROWTH

Niklas Wengstrom[1], Johan Hojesjo[1], Karl Filipsson[2], Hampus Kvarnliden[1], Lisa Loeb[1] & Martin Osterling[2]
[1]University of Gothenburg, Gothenburg, Sweden; [2]Karlstad University, Karlstad, Sweden

Gill parasites on fish, such as glochidia larvae of the freshwater pearl mussel (*Margaritifera margaritifera*), have previously been shown to reduce foraging efficiency and competitive ability, and to increase physiological costs on their brown trout (*Salmo trutta*) host. Glochidia infection may have other fitness-related costs such as behavioral alterations and effects on growth. Here, we present some novel results on the effect of glochidia infection on prey handling time and growth of juvenile brown trout. In a short-time experiment, we showed that the prey handling time was longer for infected than for uninfected trout for large but not for small prey. In a nine week long experiment, we showed that infected trout had significantly lower growth rates compared to uninfected trout. Combined with the previously known effects of glochidia infection, the results from our experiments suggest that negative effect of glochidia infection on prey handling time and growth also affects the fitness of brown trout, at least under sympatric conditions.

125. ARE MASS DIE-OFF EVENTS ACTUALLY A GOOD THING FOR MUSSEL HEALTH?

Jordan Richard[1], Eric Leis[2], Diane Waller[3], Susan Knowles[4], Tony Goldberg[5], Joel Putnam[3], Sara Erickson[2], & Emilie Blevins[6]
[1]US Fish and Wildlife Service, Southwestern Virginia Field Office, Abingdon, Virginia, [2]US Fish and Wildlife Service, La Crosse Fish Health Center-Midwest Fisheries Center, Onalaska, Wisconsin, [3]US Geological Survey, Upper Midwest Environmental Sciences Center, La Crosse, Wisconsin, [4]US Geological Survey, National Wildlife Health Center, Madison, Wisconsin, [5]University of Wisconsin, Madison, Wisconsin,& [6]Xerces Society for Invertebrate Conservation, Portland, Oregon

No, they aren't. However, determining the causes of mass mortality events ("die-offs") may finally serve as a long-overdue impetus for filling important knowledge gaps about mussel health. Die-offs have been documented for more than 50 years, but determination of causes has remained an elusive – and generally unachievable - goal. Baseline data defining key parameters for what constitutes a "healthy" or "normal" mussel are critically important for determining what causes a die-off. Here, we describe a two-pronged approach that simultaneously works towards defining key parameters related to mussel health and serves as an investigative framework for die-off events. First, we used retrospective analysis to describe the prevalence, extent, potential triggers, and resulting data for historical die-offs. Then, we combined numerous disciplinary experts in virology, mycology, bacteriology, histopathology, parasitology, and water quality modeling to assess multiple active die-off events in the United States with a "super battery" of diagnostic techniques. Here we describe our work to date, and our results as they emerge in real time. Significant advances in descriptions of mussel microbiomes, histological parameters, and host-parasite relationships are emerging as a result of the rush to investigate die-offs.

Posters – Contaminants & Toxicology

1. EXCESS NITROGEN IN STREAMS: A POTENTIAL STRESSOR TO FRESHWATER MUSSELS?

Serena Ciparis[1], Zachary Martin[2], Andrew Phipps[3] & Susan Lingenfelser[1]
[1]U.S. Fish & Wildlife Service, Gloucester, VA; [2]Department of Fish and Wildlife Conservation, Virginia Tech, Blacksburg, VA; [3]Department of Fish and Wildlife Conservation, Virginia Tech, Blacksburg, VA

Elevated nitrogen concentrations are pervasive in North American streams. However, nitrogen is often overlooked as a potential stressor to freshwater mussels, unless present as ammonia. Copper Creek (Virginia, USA) currently supports several federally listed mussel species, but mussel densities and species diversity have declined over time. Watershed characteristics include agricultural land use, predominantly grazing cattle, and karst terrain. The purpose of this study was to initiate measurement of nitrogen dynamics in the Copper Creek watershed to determine if potential risks to freshwater mussels exist. Ammonia (NH3-N), nitrate-nitrite (NO3-N) and total Kjeldahl nitrogen (TKN), concentrations were measured in surface and pore water samples from nine mainstem sites and 15 tributary sites over three seasons. Ammonia-N was only detected in three pore water samples, with a maximum concentration of 0.32 mg/L, indicating minimal direct risk to mussels. Nitrogen as NO3-N dominated tributary and mainstem surface water samples; NO3-N concentrations had significant positive relationships with watershed proportions of agricultural land use and were significantly lower in October compared to March and July. Pore water NO3-N concentrations were similar to surface water concentrations, and had similar significant relationships with agricultural land use and seasonal patterns. The majority of pore water samples also had measurable TKN. Maximum pore water TKN concentrations exceeded 7 mg/L in several samples, which would require over 30 mg/L of oxygen for complete nitrification, the nitrogenous biochemical oxygen demand (NBOD). There was no relationship between pore water TKN concentrations and the watershed proportion of agricultural land use. Interstitial storage of nitrogen in Copper Creek may pose an indirect risk to freshwater mussels due to NBOD, and is not simply predicted by land cover, likely due to groundwater transport. Implications of measured nitrogen concentrations for algal community composition and bioavailability of trace elements in sediment to freshwater mussels, will also be discussed.

2. LONG-TERM EFFECTS OF ZINC AND ZINC-LEAD-CADMIUM MIXTURES IN WATER ON JUVENILE FRESHWATER MUSSELS

James Kunz, John Besser, Chris Iveyning Wang, Jeff Steevens & Danielle Cleveland
U.S. Geological Survey, Columbia, MO

Field studies have found that the abundance and diversity of freshwater mussels were reduced in metal-contaminated streams in the Tri-State Mining District (TSMD) watershed of Missouri, Kansas, and Oklahoma. However, previous laboratory toxicity studies found that juvenile mussels (fatmucket, *Lampsilis siliquoidea*) were less sensitive than other benthic taxa in short-term (4-week) toxicity tests with TSMD sediments (MacDonald et al. 2009). In this study, we conducted a series of long-term (12-week) water-only tests to evaluate the contributions of metals in stream water to toxic effects on juvenile mussels. A 2016 survey of TSMD streams in Spring River watershed found that dissolved zinc (Zn) concentrations in surface water and interstitial water of mussel habitats frequently exceeded 10 µg/L at sites downstream of mining

activities. Lead (Pb) and cadmium (Cd) were detected in fewer samples, with these metals occurring at ratios of about 200 (Zn): 2 (Pb): 1 (Cd). We conducted 12-week tests with juvenile fatmucket (*L. siliquoidea*) to compare toxic effects of zinc exposure with the effects of a zinc-lead-cadmium mixture. Results of these studies indicated that toxic effects on juvenile mussels (reduced biomass) occurred at lower zinc concentrations in the metal-mixture test, with a 20% effect concentration (EC20) value of 7.2 µg Zn/L for the three-metal mixture, compared to 21 µg/L for the zinc-only test. These results demonstrate that juvenile fatmuckets showed reduced growth and biomass at concentrations of zinc and other metals occurring in mussel habitats of TSMD streams. Ongoing studies in our laboratory will characterize the relative contribution of metals from sediment and overlying water to toxic effects on juvenile mussels, with the goal of establishing reliable thresholds for injury to freshwater mussel communities of the TSMD caused by toxic metals.

3. COMPARISON OF SURFACE AND PORE WATER QUALITY BETWEEN TWO MARYLAND STREAMS WITH THE ENDANGERED DWARF WEDGEMUSSEL (*ALASMIDONTA HETERODON*)

Alfred E Pinkney[1], Matthew J Ashton[2], Kathleen M Kine[3] & Raymond P Morganii[4]

[1]Chesapeake Bay Field Office, U.S. Fish & Wildlife Service, Annapolis, MD; [2]Maryland Department of Natural Resources, Resource Assessment Service, Annapolis, MD; [3]University of Maryland, Appalachian Laboratory, Frostburg, MD; [4]University of Maryland, Appalachian Laboratory, Frostburg, MD

We investigated whether the contraction in dwarf wedgemussel (*Alasmidonta heterodon*) distribution that occurred between 2002 and 2012 within Browns Branch, a stream with a predominantly agricultural watershed on the Coastal Plain of Maryland may have been related to water quality. Degraded water quality, particularly elevated concentrations of ammonia, chloride, and toxic metals, can be harmful to freshwater mussels. Thus, for seven months in 2014, we measured surface and pore water concentrations of different forms of nitrogen, orthophosphate, ions, and metals at two locations in Browns Branch. Water was sampled at the downstream extents of the current (BBUP) and former (BBDO) dwarf wedgemussel population. We also sampled one location in Nanjemoy Creek, a largely forested Coastal Plain watershed, as a comparison because its dwarf wedgemussel distribution exhibited no change over the same 10-year period. Thus, the hypothesis for a relationship between toxicants and contraction was that a toxic analyte would be significantly higher at BBDO vs. BBUP, which would be similar to NANJ. The only analyte consistent with the hypothesis was un-ionized ammonia (UIA) in pore water. Although concentrations were below the U.S. Environmental Protection Agency's Ambient Water Quality Criteria, pore water UIA concentrations in BBDO were consistently higher than 0.2 µg/L, a concentration that has been associated with a lack of freshwater mussel recruitment. It is possible that toxic conditions resulted from a combined effect of UIA and low pore water dissolved oxygen. Uncertainty results from the single year of sampling and the lack of data on pulses of contaminants that may be acutely toxic.

Posters – Genetics & Phylogeny

4. ASSESSING HYBRIDIZATION BETWEEN *PYGANODON GRANDIS* AND *P. LACUSTRIS* (BIVALVIA: UNIONIDAE) USING F- AND M-LINEAGE MTDNA SEQUENCES AND GEOMETRIC MORPHOMETRICS

Kate Beauchamp, Tyler Beyett, Mariah W Scott & David T Zanatta
Central Michigan University, Mount Pleasant, Mi

Hybridization between unionid species has been shown in past studies, yet it is not entirely clear how common hybridization is among closely related, coexisting species. *Pyganodon grandis* and *P. lacustris* are widespread and common species in North America that co-occur in parts of their distributions. These mussels are genetically distinguishable with a sequence divergence between 9% and 13% at the COI mtDNA barcoding region; well beyond thresholds for distinct species. The objectives for this study were: 1) to determine the existence and the extent of hybridization between co-occurring *P. grandis* (Giant Floater) and *P. lacustris* (Lake Floater) in two inland lakes on Beaver Island in northern Lake Michigan and 2) to determine if shell shape can be diagnostic for assigning specimens to lake and species of origin. Hybridization was assessed using maternally (f-lineage, from mantle tissue) and paternally (m-lineage, from gonad tissue) inherited mtDNA sequences and geometric (landmark-based) morphometric analyses. The COI sequences generated from 148 specimens were compared to those available on NCBI Genbank using BLAST and identified to species. A mismatch in identity from the f- and m-lineage COI sequences was found in 21 specimens (14.2%), with these being considered putative hybrids. The proportion of hybrids was significantly below Hardy-Weinberg expectations: if the two species were freely interbreeding (no pre-zygotic isolation) and selection was not occurring against hybrids or for purebreds. Geometric morphometric analyses of shell shape significantly separated specimens between species (identified using COI sequences) and between lakes, correctly assigning 97.5% of purebred specimens to lake and species of origin. The shapes of hybrids mostly resembled the shape that corresponded with the f-lineage sequence that was recovered. This study confirms that hybridization does occur and should be considered when assessing unionid diversity and that modern morphometric techniques are valuable in distinguishing among morphologically variable and similar species.

5. MORPHOMETRIC ANALYSES AND DNA BARCODING DISTIGUISH *TRUNCILLA DONACIFORMIS* AND *T. TRUNCATA* (BIVALVIA: UNIONIDAE)

Tyler W Beyett & David T Zanatta
Central Michigan University, Mount Pleasant, MI

Closely-related unionid species often overlap in shell shape and can be difficult to accurately identify. Ambiguity in identification can have serious impacts on conservation efforts and population surveys of endangered species. *Truncilla donaciformis* and *T. truncata* are sister species that overlap in their distribution and frequently co-occur in central North America. *T. donaciformis* is endangered in Canada and imperiled in some U.S. jurisdictions, and co-occurrence with the morphologically-similar *T. truncata* means that misidentification could have serious impacts on status assessment and conservation efforts. The objectives of this study were: 1) to quantify morphological differences in shell shape between *T. donaciformis* and *T. truncata*, 2) to confirm the presence of *T. donaciformis* in its Canadian distribution, and 3) to

investigate and support the use of geometric morphometrics as a means of unionid identification. Truncilla specimen photos and mantle swabs were gathered by Fisheries and Oceans Canada staff from four Ontario rivers. Positive identifications of all specimens were obtained through sequencing a fragment of COI mtDNA. Generated sequences were compared to published data from NCBI Genbank using BLAST. Traditional morphometrics using ratios of shell length, width, and height were visualized and analyzed using PCA and DA. Images of each mussel's left valve had landmarks digitized for geometric morphometric analyses. Digitized shell shapes, controlled for size using a Procrustes transformation, were visualized and analyzed using PCA and CVA including a Jackknife assignment test. Assignments generated were compared to the mtDNA identifications, with traditional and geometric morphometric analyses found to be 90% and 95% accurate in species identifications, respectively. This study confirmed the presence of *T. donaciformis* in Ontario's Thames River, and revealed that all surveyed organisms from the other three rivers were *T. truncata*. This study reinforces the utility of geometric morphometric analyses and DNA barcoding for identifying problematic unionid specimens.

6. USING SNP SEQUENCING TO EXPAND THE UNIONID GENETIC TOOLKIT: WHAT CAN SNPS TELL US ABOUT SPECIES RELATIONSHIPS AND POPULATION STRUCTURE OF TWO CLOSELY RELATED UNIONIDS?

Katie Bockrath[1], Maren Tuttle-Lau[1], Emy Monroe[1], Nathan Eckert[2] & Tam Smith[3]
[1]USFWS Onalaksa, WI, [2]USFWS, Neosho, MO, [3]USFWS, Bloomington, MN

With many of the native unionids mussel species in decline, identifying species and populations of most concern is important for the long-term conservation and future restoration of North American Unionids. Molecular markers for species identification and population assessment have historically been limited in Unionids, but with the ever-decreasing cost of next-generation sequencing techniques, generating large sequence datasets across multiple individuals, populations, and species is increasingly more obtainable. Using these next-generation sequencing techniques, specifically Genotyping-by-Sequencing, can generate thousands of nuclear Single Nucleotide Polymorphisms, allowing us to assess the population structure and species resolution of two threatened unionids (*Lampsilis higginsii* and *L. abrupta*) across their range. Here we discuss how genetically distinct these two species are and identify populations of most conservation concern.

7. AN EVALUATION OF GENETIC VARIABILITY AMONG ALEWIFE FLOATER (*UTTERBACKIANA [ANODONTA] IMPLICATA*) POPULATIONS TO INFORM CAPTIVE PROPAGATION CONSERVATION EFFORTS IN VIRGINIA

Caitlin Carey[1], Brian Watson[2], Miluska Olivera-Hyde[3] & Eric Hallerman[4]
[1]Conservation Management Institute, Department of Fish and Wildlife Conservation, Virginia Tech, Blacksburg, VA; [2]Virginia Department of Game & Inland Fisheries, 1132 Thomas Jefferson Road, Forest, VA; [3]Department of Fish and Wildlife Conservation, Virginia Tech, Blacksburg, VA; [4]Department of Fish and Wildlife Conservation, Virginia Tech, Blacksburg, VA

Alewife Floater (*Utterbackiana implicata*) is a wide-ranging and relatively common Atlantic Slope species; however, widespread loss and decline of its anadromous host fishes have made this species particularly vulnerable to extirpation. Without intervention, the loss of *U. implicata* host fishes will result in fragmented, aging, and relict populations, with little likelihood of recovery. Captive propagation is a recovery tool that has shown promise at restoring mussel populations to historically occupied habitats and augmenting declining populations.

Nonetheless, consideration must be given to potentially harmful impacts on the genetic diversity and viability of wild populations before selecting broodstock and introducing captively-bred individuals. In Virginia, there is interest in using *U. implicata* broodstock from the Rappahannock and Pamunkey drainages to captively propagate individuals for augmentation efforts in the Chowan drainage. However, we need to know how genetically similar or divergent these populations are and whether introductions would impact the genetic structure. To assess genetic differentiation within and among the *U. implicata* populations, we analyzed mitochondrial and nuclear genetic markers. Amplification of ND1 gene sequences for 58 individuals revealed 13 unique haplotypes with 20 variable sites. While unique haplotypes were identified within each river population, shared haplotypes were well distributed among the respective drainages. Population-by-population FST values ranged from 0.0091 between the Rappahannock and Nottoway river populations to 0.0903 between the Pamunkey and Nottoway river populations. The 13 microsatellite loci developed for western *Anodonta* species did not prove useful for screening *U. implicata*. Given the similarity among these populations, using broodstock from the Rappahannock and Pamunkey rivers for augmentation efforts in the Nottoway River may be advisable, particular where natal river broodstock are unavailable or occur in low numbers. Development and utilization of nuclear markers for *Utterbackiana* would improve our understanding of population genetic differentiation and the likelihood of successful captive propagation conservation efforts.

8. MARGARITIFERA MARGARITIFERA: A GENETIC STUDY OF POPULATIONS IN THE NORTHEASTERN UNITED STATES.

Curt L Elderkin & Thomas Busek
The College of New Jersey, Department of Biology, Ewing, NJ

The preservation of freshwater ecosystems from human destruction and encroachment is of critical importance. Therefore, it is particularly important to preserve existing genetic diversity in species essential to those ecosystems. This study examines the endangered species *Margaritifera margaritifera* focusing on populations in the Locust Lake and Pine Creek Pennsylvania, as well as populations is Massachusetts and Rhode Island. Mantle tissue was collected from these populations and using this tissues a fragment of COI (mtDNA) was amplified, and sequenced. These sequences were compared among and within populations in different geographic areas to determine the genetic diversity and the genetic relationships among populations. Genetic diversity indices were relatively low and genetic structure was also low indicating populations between geographic locations were the same. No significant relationship was found to exist between location and genotype at the COI locus. This relationship will be further investigated using analysis of eight microsatellite loci. With no significant population structure between Rhode Island and Massachusetts populations, results suggests that these populations are not distinct evolutionarily significant units. The significant difference in structure between Locust Lake and Pine Creek indicates possibility of inbreeding and genetic drift in Pine Creek, due to small population size.

9. PHYLOGENETIC STRUCTURE OF *VILLOSA* SPECIES WITHIN GULF TAXA

Colleen Hurley, Victoria C Fowler, Jonathan D Wells & Michael M Gangloff
Appalachian State University, Boone, NC

Freshwater mussel population studies provide valuable information on the health of lakes and rivers throughout the eastern United States. Mussels are responsible for filtering the water they live in and are excellent indicators of environmental stressors and general water quality. It is therefore essential to understand the genetic relationship of mussel species to gain a more complete historical understanding of the vital water bodies flowing out into one of the most unique bodies of water in North America, the Gulf of Mexico. The mussel genus *Villosa* (Family Unionidae) is quickly growing into new populations, and there is evidence of intraspecies mutation across different rivers and drainages. Through the use of genetic sequencing, data from each species can be compared. The objective of this study is to examine the phylogenetic structure of *Villosa* species within the gulf area of the southeastern United States. By analyzing the mitochondrial gene COI and the nuclear gene 28s of these species, a larger picture was built and provided clarity regarding the effect of geography on the relationship between these species. This was done through DNA extraction of the adductor muscle, amplification of the relevant genes, and the use of PopArt and other software to statistically analyze the relationship between geography and variation within a species. This research revealed an interesting cryptic diversity in *V. lienosa* and *V. vibex* withinghe Mobile and Eastern Gulf Drainage, Haplotyping indicated sharing among drainages but little structuring between taxa.

10. THE GENETIC DIVERSITY OF *FUSCONAIA ASKEWI* ACROSS TWO RIVER BASINS IN EAST TEXAS USING MICROSATELLITES

Danielle Joerger, Srinivas Kambhampati, Neil Ford & Josh Banta
University of Texas at Tyler

Genetic health can be a powerful tool in predicting the sustainability of a species, as the more genetically diverse a population, the less likely it is to suffer from negative mutations or population collapse. Random genetic drift and inbreeding affect allelic and genotypic variation within populations as a function of the effective size of these populations. By measuring the level of inbreeding, the levels of gene flow, and estimates of random mating, the genetic health of imperiled populations can be inferred. Previous research in Europe and China has shown microsatellites to be useful tools for monitoring the genetic diversity of freshwater mussels, as the microsatellites are highly variable, relatively easy to use, and are loci-specific. However, very little has been conducted in North America despite the prevalence of freshwater mussel species compared to the rest of the world.

This study investigates the patterns and levels of genetic diversity of *Fusconaia askewi*, the Texas pigtoe mussel, in the Sabine and Neches River drainage systems of Eastern Texas. We estimated various population genetic parameters that are relevant to the conservation of *F. askewi*, such as effective population size, F-statistics (in regards to inbreeding), and gene flow patterns in terms of hierarchical variance estimates. Using microsatellite primers and DNA extracted from approximately 200 *F. askewi* individuals from 11 sites along 2 drainage systems, polymorphic loci were analyzed within and between sites, streams, and drainage systems. Results will be discussed.

11. MORE NON-MONOPHYLY AND CRYPTIC DIVERSITY FOUND IN SOUTHEASTERN GULF DRAINAGES (*LAMPSILIS*)

Sean M Keogh & Andrew Simons
University of Minnesota/Bell Museum, St. Paul, MN

The comparative biogeography of southeastern North America has been intensively studied (Avise, 2000) but most work has focused on aquatic vertebrates and biogeography of freshwater mollusks has largely been neglected. Freshwater mollusks may provide finer resolution of biogeographic patterns due to their different modes of dispersal and diversification rates. For example, Smith et al. 2018 uncovered at least two previously unrecognized lineages associated to isolated gulf drainages in southeastern North America using molecular and morphological data. We found almost identical results in the *Lampsilis straminea* (Conrad, 1834) species complex using similar data and sampling. We sampled *L. straminea* from the Pearl, Pascagoula, Mobile, Escambia, Choctawhatchee, Apalachicola, Ochlockonee, and Suwannee river drainages. We recovered at least three previously unrecognized lineages that were found to be allopatric with one exception. In one Escambia drainage population, we found some individuals that were nested within a clade of Mobile Basin specimens and others nested in a clade of Escambia and Choctawhatchee specimens. Conversely, we find populations from the Mobile and Apalachicola drainages to be very closely related to each other providing more evidence for a historical connection between these two currently isolated drainages. More robust sampling and the inclusion of morphological characters are needed to delineate cryptic variation found herein. Despite this, we see clear biogeographic differentiation in southeastern Gulf drainages that has not been found using aquatic vertebrate taxa.

12. SURVEY OF POPULATION GENETIC VARIATION IN VIRGINIA YELLOW LAMPMUSSEL, *LAMPSILIS CARIOSA*

Miluska Olivera Hyde[1], Eric Hallerman[1] & Brian Watson[2]
[1]Virginia Tech, Blacksburg, VA, [2]Virginia Department of Game & Inland Fisheries, Forest, VA

The yellow lampmussel (*Lampsilis cariosa*) is declining throughout its Atlantic slope range and has been identified as imperiled or critically imperiled in most states and provinces where it occurs. In Virginia, the species is known from the Potomac, Roanoke, and Chowan river basins. The Potomac basin population is in decline, and is at risk of hybridization with the non-native plain pocketbook (*Lampsilis cardium*). Within the Chowan system, it is uncommon in the Nottoway and Meherrin Rivers, and the Dan River population, with only a few individuals, was only recently discovered. Propagation of *L. cariosa* is ongoing at the Virginia Fisheries and Aquatic Wildlife Center, posing the option of augmentation of existing populations or reestablishment of extirpated populations. We genetically characterized individuals from the Dan River, Nottoway River and South Flat River utilizing mitochondrial (ND1) and microsatellite DNA markers (6 loci). The results suggested that mixing of *L. cariosa* populations among the Nottoway and Dan rivers would pose benefits exceeding any risks. However, historical isolation of these populations has been sufficiently long that we advise against mixing among the South Flat River and Nottoway/Dan River *L. cariosa* populations.

13. PHYLOGENETIC IDENTIFICATION OF SPECIES BELONGING TO THE GENERA *FUSCONAIA* AND *PLEUROBEMA* IN THE GREEN RIVER, KENTUCKY.

Miluska Olivera-Hyde[1], Jess W Jones[2] & Eric M Hallerman[1]
[1]Virginia Tech, Blacksburg, VA; [2]U.S. Fish & Wildlife Service, Blacksburg, VA

Species belonging to the genera *Fusconaia* and *Pleurobema* are difficult to identify because of phenotypic plasticity and convergence of morphological characters. Proper identification of these mussels in field settings is necessary, particularly for *P. plenum*, which is listed as federally endangered. Molecular identification of these species will lead to proper morphological description and to proper implementation of management plans and actions. Our objective was to genetically identify species of *Fusconaia* and *Pleurobema* in the Green River, Kentucky using mitochondrial COI+ND1 (1215 bp) and 16S rRNA (477 bp) sequences. In addition, sequences for nuclear ITS1 (442-452 bp) from *P. sintoxia*/*rubrum* individuals were obtained to assess whether this clade includes one or two species. Among 258 individuals collected from sites in Pool 4 and Mammoth Cave National Park in the river, our results showed a clear differentiation of five clades for *F. flava*, *F. subrotunda*, *P. cordatum*, and *P. sintoxia*/*rubrum*. Our results suggest that individuals morphologically identified as *P. sintoxia* or *P. rubrum* comprise only one species in the Green River.

14. DEVELOPMENT OF MICROSATELLITE LOCI FOR THE ENDANGERED PURPLE CAT'S PAW PEARLYMUSSEL *EPIOBLASMA OBLIQUATA OBLIQUATA*

Katlyn M Ortiz, Jess Jones & Eric Hallerman
Virginia Polytechnic Institute and State University, Blacksburg, VA

Management of freshwater mussels includes genetic analysis of populations to determine genetic diversity, population differentiation, and genetic relatedness. This information is needed to determine appropriate source and receiving populations for propagation and translocation actions to restore populations and recover species. The Purple Cat's Paw Pearlymussel (*Epioblasma obliquata obliquata*) historically occurred in the Tennessee, Cumberland, and other systems throughout the Ohio River basin. The species is listed as endangered under the U.S. Endangered Species Act, and today, only one wild population is known to exist, in Killbuck Creek in Coshocton County, Ohio. Genetic samples were collected using buccal swabs from 48 individuals in Killbuck Creek and from 31 progeny propagated at the Kentucky Center for Mollusk Conservation in Frankfort and reared at Minor Clark Fish Hatchery, Kentucky. Genetic samples were screened at 60 candidate nuclear microsatellite loci, of which 14 loci were polymorphic and used for further analyses. A key management question being addressed with these loci is how the propagation process affects genetic diversity of the progeny compared to the parental-stock. We used 14 polymorhpic loci to assess heterozygosity, allelic diversity, and frequencies of rare alleles in wild-stock collected from Killbuck Creek and in progeny held at the Minor Clark hatchery. Wild-stock heterozygosities (He=0.76 and Ho=0.93) and mean allelic richness (A=11.9) were slightly higher than progeny heterozygosities (He=0.72 and Ho=0.79) and mean allelic richness (A=8.4), but generally genetic diversity metrics were similar between the two samples. These polymorphic microsatellite loci will be useful for genetic diversity assessments of *E. obliquata* and other *Epioblasma* species, especially for monitoring and maintaining genetic diversity at hatcheries throughout propagation and stocking process.

Posters – Life History & Ecology

15. EPIDEMIOLOGY OF THE PARASITIC RELATIONSHIP BETWEEN *POPENAIAS POPEII* AND ITS FISH HOSTS

Jacob Almeda[1], Timothy Wilson[2], David Berg[3] & Steven Hein[1]
[1]Department of Biology, Miami University, Oxford, OH; [2]Department of Microbiology, Miami University, Oxford, OH ; [3]Department of Biology, Miami University, Hamilton, OH

It is critical to understand an organism's interactions with its environment; this is the foundation for adaptation and the key to understanding a species' evolutionary history. However, indirect methods of study must be developed as direct observations of species interactions are often impossible. Immune mechanisms used by fish likely evolved in response to environmental stimuli, such as the presence of a parasite, providing an opportunity for studying the co-evolutionary relationship between multiple species. Freshwater unionid mussels utilize morphological or behavioral adaptations to disperse glochidia (the parasitic larval stage) to hosts' gills and skin, where they mature into free-living juveniles. *Popenaias popeii*, an endangered unionid endemic to the Rio Grande basin, releases a glochidia-entangled mucus web that ensnares a host fish to disperse glochidia. The objective of this study is to assess the feasibility of using immunological methods for conservation efforts. This study consists of two major components: development of a system-specific antigen screening protocol and application of the protocol to host fish populations. Blood was taken from 12 fish: eight river-carpsucker (*Carpoides carpio*) and four gray redhorse (*Moxostoma congestum*) for immunoglobin M (IgM) isolation. Protein purification was done using a 2-step column isolation while infection was detected using ELISA, a biochemical technique to detect the presence of an antigen. We found that IgM isolation methods could be used for multiple fish host species with minor modifications. This study's results provide novel data on *Popenaias*' evolutionary relationship with its hosts and demonstrate the ability to utilize the immune system to study responses which can be used for conservation purposes. Fish population infection rates within a river with a healthy mussel population could be compared with those of other rivers and thus, serve as a proxy for mussel population health.

16. UNDERSTANDING THE PHYSIOLOGICAL RESPONSES OF FRESHWATER MUSSELS TO EXCESS NUTRIENTS AND ALGAE AND THEIR INFLUENCE ON NUTRIENT PARTITIONING.

Sean B Buczek[1], W. Gregory Cope[1], Meredith Shehdan[1], Joann M Burkholder[1], Thomas J Kwak[2], Todd Ewing[3], Rachael A Hoch[4], Monte A McGregor[5], Brian T Watson[6], Amy L Maynard[7], Megan Bradley[8] & Rachel Mair[9]
[1]Department of Applied Ecology, NC State University, Raleigh, NC; [2]U.S. Geological Survey, NC Cooperative Fish and Wildlife Research Unit, Dept of Applied Ecology, NC State University, Raleigh, NC; [3]NC Wildlife Resources Commission, Raleigh, NC; [4]NC Wildlife Resources Commission, Marion, NC; [5]Center for Mollusk Conservation, Kentucky Department of Fish and Wildlife Resources, Frankfort, KY; [6]Virginia Department of Game and Inland Fisheries, Forest, VA; [7]Virginia Department of Game and Inland Fisheries, Harrison Lake National Fish Hatchery, Charles City, VA; [8]U.S. Fish & Wildlife Service, Genoa National Fish Hatchery, Genoa, WI; [9]U.S. Fish & Wildlife Service, Harrison Lake National Fish Hatchery, Charles City, VA

Many freshwaters in the US experience water quality impairment from the input of excess sediment and nutrients. Reducing these anthropogenic impacts is vitally important to the conservation of aquatic biota and human health. Therefore, given the current conditions and importance, options to mitigate the nutrient problem warrant investigation. One option is to explore the natural ability of freshwater mussels to biomechanically filter phytoplankton and other particulate organic matter from the water column, thereby, potentially improving water quality. The aim of this research is to evaluate the function of native freshwater mussels in biogeochemical cycling of nutrients and determine their potential utility as an aid to management. In a multi-faceted approach, we first conducted a series of acute (96 h) juvenile mussel toxicity tests to assess the toxic potential of nitrogen (NO2-N [LC50 > 20 mg/L], NO3-N [LC50 = 566 mg/L]), and phosphorous (PO4-P [LC50 = 566 mg/L]). These tests were followed by a robust laboratory evaluation of filtration and clearance potential of juvenile, sub-adult, and adult freshwater mussels (*Lampsilis radiata*, *Utterbackia imbecillis*, *Lampsilis fasciola*) using 4 algal cultures (toxic and non-toxic *Microcystis aeruginosa*, *Nannochloris spp.*, *Chlorella sorokiniana*). Building upon the methodology developed during these evaluations, we plan to assess filtration, clearance rate, and nutrient metabolism (uptake, accumulation, excretion, biodeposition) in mussels exposed to different surface waters and their associated seston under laboratory controlled conditions. Finally, these data will inform future experimental field research planned in two drinking water supply reservoirs with degraded water quality due to eutrophication. Insight from this research will provide much-needed information on the multiple and complex pathways that link nutrients and native freshwater mussels in eutrophic environments. The findings will assist natural resource managers in understanding the quantitative relationships between nutrients and mussels, and their potential utility in nutrient management.

17. DAM EFFECTS ON FRESHWATER MUSSEL GROWTH AND RECRUITMENT IN A MIDWESTERN STREAM

Taylor L. Fagin, Cassi Carpenter & Jeffery Laursen
Eastern Illinois Univeristy, Charleston, IL

North America is home to the richest diversity of freshwater mussels (Order Unionida) in the world; however, many of these species have become imperiled or extinct. Much of their decline can be attributed to habit alterations, notably impoundments. Dams have been typically documented to decrease mussel populations and biodiversity. However, some evidence suggests larger population sizes and higher growth rates immediately downstream of some dams, due to warmer water temperatures and higher nutrient contents. We hypothesize these higher growth rates could lead to increased mussel recruitment, due to higher fecundity rates in larger at-age-individuals. The purpose of this study was to determine the effects of a flow-over dam on length-at-age growth and recruitment of two mussel species in a Central Illinois River. Shells from two species, *Cyclonaias pustulosa* and *Truncilla truncata*, were collected from two upstream reference sites and three downstream sites at varying distances from the dam. Shells were thin-sectioned and aged, based on internal annuli, and these data were used in the Von Bertalanffy growth model. A quantitative survey was performed to estimate recruitment (percent juveniles of the population). Water samples were collected mid-season over a one-year period and 11 water quality parameters were monitored. Our results indicated that both species were larger-at-age at the downstream sites than the upstream reference sites. Recruitment of *Cyclonaias pustulosa* was the same (38%) at combined upstream versus downstream sites. Recruitment of *Truncilla truncata*, was higher downstream (82%) than upstream (75%), however, we had a low sample size of 27 individuals. Water quality parameters showed no significant difference between upstream and

downstream sites. Our data suggest that larger-at-age individuals below this dam may correlate with mussel recruitment in some species. More evidence is needed to confirm the pattern and parse out effects of mussel fecundity versus fish host availability and usage.

18. REPRODUCTIVE PHENOLOGY AND HOST-PARASITE RELATION OF FLORIDA'S NATIVE FRESHWATER MUSSELS (BIVALVIA: UNIONIDAE).

Susan R Geda[1], Sahale N Casebolt[2], Jordan M Holcomb[3], James D Williams[4] & Nathan A Johnson[5]
[1]Florida Fish and Wildlife Conservation Commission, Milton, FL; [2]Florida Fish and Wildlife Conservation Commission, Gainesville, FL; [3]Florida Fish and Wildlife Conservation Commission, Milton, FL; [4]University of Florida, Florida Museum, Gainesville, FL; [5]U.S. Geological Survey, Wetland and Aquatic Research Center, Gainesville, FL

Although large data gaps still limit our understanding of the reproductive timing in North American freshwater mussels (Bivalvia: Unionidae), much has been learned in recent years. A better understanding of this phenology is crucial for effective management and conservation of native unionids. Here we provide a tool to reference updated temporal gravidity data for mussel species in the Greater Floridan Region. A graphical representation of reproductive phenology offers a simple method for identifying interspecific and intergeneric trends, as well as for determining data gaps. From 2013 to 2018, the freshwater mussel program of the Florida Fish and Wildlife Conservation Commission, along with partners at the U.S. Geological Survey and Florida Museum of Natural History, collected temporal gravidity data from Florida's Gulf Coast drainages. Overall, 897 timed tactile surveys were conducted in 9 drainages. During each survey 10 individuals of each species were visually inspected for gravidity. When specimens were vouchered, glochidia were extracted, visually examined, and tested for viability with sodium chloride solution. Additionally, host-parasite relationships between native unionids and freshwater fishes were conceptualized using the R package Circlize v0.4.5, a positional graphics function for multidimensional datasets. The resulting visualizations can aid researchers in the study of these complex reproductive processes and the mechanisms behind them. Ultimately, this will inform decision making concerning the conservation and management of mussel populations in the southeastern United States and can be easily implemented in other regions.

19. GROWTH AND AGE STRUCTURE ESTIMATES FOR MUSSEL POPULATIONS IN CENTRAL TEXAS

Kayla J Hayes, Zachary A Mitchell & Astrid N Schwalb
Texas State University, San Marcos, TX

Freshwater mussels (Unionidae) are one of the most endangered groups of organisms in North America due to a variety of stressors such as habitat loss and pollution. Little is known about population dynamics of mussels in Central Texas, which may differ in species with different life history strategies. Evaluating the age structure of freshwater mussels can give insight into the growth and recruitment of mussel populations and how these dynamic rates are impacted by different environmental conditions. Thus, the objective of this study is to examine size-age relationships of mussels with different life history strategies in central Texas using thin-sectioning techniques of mussel shells. Additionally, the size-age relationships were used to estimate the ages of mussels previously surveyed from 2016-2018 in the Colorado River basin. Furthermore, von Bertalnaffy growth curves were calculated and compared between mussel species. Our preliminary results suggest that life history strategies are important predictors in explaining freshwater mussel growth.

20. FRESHWATER MUSSELS INFLUENCE COMPOSITION OF BACTERIAL COMMUNITIES IN A NITROGEN LIMITED RIVER

Edward Higgins, Caryn Vaughn & Thomas Parr
University of Oklahoma, Norman, OK

Bacteria play critical roles in nutrient cycling, changing biologically unavailable nutrients into accessible forms which supports primary production. The interactions between assemblages of microbes (microbiome), multicellular organisms that host them, and the environment are understudied, especially in freshwater systems. Freshwater mussels (Unionida) are a good study system to investigate microbiome-host-environment interactions as they provide an interface for various microhabitats. Mussels link the water column and the sediment through filter feeding as well as aerobic and anaerobic sediments through burrowing. Freshwater mussels also play important roles in nutrient cycling by biodepositing feces and pseudofeces that are rich in nitrogen and carbon. To investigate linkages between mussels and microbiome composition, we collected mussel fecal samples and sediment samples from 0.25 m-2 plots in the Kiamichi River, Oklahoma, in August 2018. We have sequenced the v4 region of the 16s RNA gene for community analysis. We found that the presence of mussels, regardless of species, significantly changed microbial community composition and increased the relative abundance of microbes known for nitrogen cycling. While we know that mussels influence nutrient cycling where they are found, different species of bacteria possess the capacity for multiple pathways of nutrient cycling. Understanding the players in microbial communities may further our understanding of mussel-influenced nutrient cycling. In addition, because microbes play a critical role in macro-organism health, understanding mussel driven changes in microbial communities may inform why some efforts to restore mussel communities fail and some succeed.

21. FRESHWATER MUSSEL CONSERVATION AT SHEDD AQUARIUM: UPCOMING RESEARCH AND OUTREACH

Kentaro Inoue
Shedd Aquarium, Chicago, IL

Public aquaria are a unique venue for conservation research because they provide an immediate platform for public engagement. Shedd Aquarium has a legacy of freshwater mussel conservation. As a part of new freshwater research team, there is renewed focus on these taxa. The goal of this research is to understand how human activities and rapidly changing environment are affecting current mussel diversity in the Great Lakes region. Specific objectives are (1) to understand distribution and connectivity of current mussel populations using population genomic approach, (2) to examine how historic and current changing environment affect current distribution of mussel fauna, and (3) to establish long-term monitoring program for mussel communities in the Chicagoland area. These results have direct implication for conservation management. Furthermore, through the science-to-public platform, Shedd Aquarium provides various opportunities for public engagement. These include providing a storytelling opportunity for less charismatic species and outreach through local and social media, and fosters conservation partnerships with other stakeholders. Through active research and outreach at Shedd Aquarium, we garner public support for conserving understudied organisms and freshwater ecosystems.

22. MORPHOLOGICAL ANALYSIS OF THE RIO GRANDE MONKEYFACE, *QUADRULA COUCHIANA* (MOLLUSCA: BIVALVIA) USING PHOTOGRAMMETRY

Mary P Jones[1], David J Berg[2], Ned E Strenth[3] & Robert G Howells[4]
[1]Miami University, Oxford, OH; [2]Miami University, Hamilton, OH; [3]Angelo State University, San Angelo, TX; [4]BioStudies, Kerrville, TX

The Rio Grande Monkeyface, *Quadrula couchiana* (Lea 1860), is a relatively small freshwater unionid bivalve endemic to the Rio Grande drainage of Texas and northern Mexico. There is little known about this species and is presumed extinct. However, recent field work in northern Mexico has yielded valves and potential habitat in which live individuals may still exist. This has prompted an examination of current museum collections. The purpose of this study was to compare museum specimens identified as Rio Grande Monkeyface to similarly shaped species, (Golden Orb, *Cyclonaias aurea*, Mapleleaf, *Quadrula quadrula*, and Southern Mapleleaf, *Quadrula apiculata*), and to determine the range of morphological variation within and between these species. Photogrammetry was used to build three-dimensional digital models for geometric morphometric comparisons. The computer software Agisoft was used to align and stitch multiple photos of each specimen to build a fine-scale resolution digital model. The digital models were then statistically compared using a multivariate analysis and PCA using Procrustes distances. Preliminary results indicate that some of the current museum records of *Quadrula couchiana* are misidentified. Plastic replica models were produced using 3D printing and will be donated to institutional malacological collections. These models will provide a useful tool for teaching and training workers on key valve features used for identification. This presentation outlines the workflow used to create photogrammetric digital models and demonstrates the benefits of this technique.

23. LIFE HISTORY STRATEGIES OF FRESHWATER MUSSELS ALONG LONGITUDINAL GRADIENTS IN THE MERAMEC RIVER, MISSOURI

Lauren Mary Kelley[1], Kayla N Key[1] & Amanda E Rosenberger[2]
[1]Tennessee Technological University, Tennessee Cooperative Fisheries Research Unit, Department of Biology, Cookeville, TN; [2]U.S. Geological Survey, Tennessee Cooperative Fisheries Research Unit, Department of Biology, Cookeville, TN

Life history theory provides insight to the adaptive significance of an organism's response to environmental pressures. Understanding the life history strategies within mussel communities can therefore help inform conservation and management actions for vulnerable assemblages. Prior work indicates that dominant life histories of mussel assemblages change with river size, between large and small rivers, and within rivers, from headwaters to downstream. Mid-sized streams act as a transitional zone of mussel life history dynamics between species found in small and large rivers. Our goal in this study was to examine upstream to downstream patterns of mussel life histories in the Meramec River drainage in Missouri, a high-priority conservation area. Using surveys from the Missouri Department of Conservation database and Haag's 2012 descriptions of life history strategies, we investigated proportional changes in life history strategies of freshwater mussels longitudinally, from headwaters to downstream, in the Meramec, Big, and Bourbeuse Rivers in Missouri. We present our findings for each river, and compare patterns of life history strategies within the Meramec River to the proposed patterns by Haag 2012. Our results can help to inform conservation of mussels by increasing the understanding of mussel species' habitat selection, essential information for successful propagation and reintroduction efforts.

24. ANALYZING TEMPERATURE TOLERANCE USING CARDIOVASCULAR STRESS OF *ELLIPTIO COMPLANATA* POPULATIONS

Erica R Levin, Marissa A Pugliese & Curt L Elderkin
The College of New Jersey, Ewing, NJ

The effects of climate change on freshwater habitats can be understood through studies involving bioindicator species, such as freshwater mussels. In this study, the heart rates of *Elliptio complanata* were analyzed as a measure of their metabolism when exposed to environmental stressors such as increasing water temperatures. Mussels were collected from Stoney Brook Creek in suburban New Jersey and were later placed in laboratory aquarium tanks and acclimated to 24°C. Each heart rate was found through the insertion of electrodes into the heart of the mussel and measured using an impedance converter. The mussels were individually submerged in a water bath that increased in temperature by 6°C per hour. On average, a sessile mussel had a heart rate of 14 beats per minute (bpm) which increased 2 bpm per degree centigrade. However, a spike in heart rate to 44 bpm was recorded when the mussel was exposed to temperatures ranging from 34°C-36°C. This increase in heart rate is expected in future trials within this temperature range or higher, resulting in a more accurate determination of the mussels' lethal temperature. Specific populations of mussels may be adapted to different temperatures in their respective habitats. Future research would aim to test this at the population level for *E. complanata*. It is expected that higher annual temperatures could have a detrimental impact on the populations specifically adapted to cooler temperatures. However, there is a possibility for higher annual temperatures to have a very low, if any impact on mussels adapted to survive at similarly high temperatures.

25. LARVAE OF NORTH AMERICAN FRESHWATER MUSSELS

Monte A McGregor & Julieann Jacobs
Kentucky Dept of Fish & Wildlife Resources, Frankfort, KY

We examined representatives from the larvae of all North America mussels (55 genera). We observed individuals from the families Margaritiferidae, represented by 2 genera; and Unionidae, represented by 3 subfamilies, Anodontinae (12 genera), Gonideinae (1 genus), and Ambleminae (41 genera in 4 subfamilies). Most individuals were examined live, but a few species were observed from preserved specimens. The name glochidium comes from the word glochid, which is a botanical word that means a barbed spine or bristle. Leeuwenhoek observed the first larvae in 1695, but it was not until the 1800's that the true fish host relationship was discovered. Unlike marine bivalves and other clams, the glochidia do not develop as a free swimming planktonic form, but rather are parasites on a host organism (mostly fish or salamanders). The larvae can only live outside of the mother for a few days at most and must live on the host for a few days to a few weeks. Common diagnostic features include hooks, larvae threads, and sensory hairs. Some genera have large ventral hooks with serrated margins that can tear into the fins or gills, while others have smooth ventral hooks or no hooks. Most larvae open and close to facilitate attachment to the host. The majority of larvae are oval shaped, slightly longer in dorsal/ventral than in length (anterior/posterior), and their depth is usually 25-50% of their respective lengths, smooth on the surface with no hooks, and must connect to softer tissue, such as the gills of fish. The total length, hinge length, and height, along with the presence of hooks, position and size of the adductor muscle, presence of sensory hairs, as well as the general shape help to identify most genera. Many species within a genus vary in shape and size, while others are virtually identical.

26. A DATABASE TO IMPROVE RISK ASSESSMENT FOR FRESHWATER MUSSELS

Adrian P Moore[1], Nika Galic[2], Richard A Brain[2], Daniel J Hornbach[3] & Valery E Forbes[1]
[1]University of Minnesota Twin Cities, St. Paul, MN; [2]Syngenta Crop Protection LLC, Greensboro, NC; [3]Macalester College, St. Paul, MN

Freshwater mussels are a highly diverse faunal group, and many species are imperiled; of 298 North American species more than 70% are considered threatened, endangered, or of special concern. Population modeling is integral to facilitating pesticide risk assessments, especially for threatened and endangered ("listed") species, but requires large amounts of data. Freshwater mussel data can be difficult to find, access, and interpret and can be highly variable among populations of the same species. The objective of this project is to develop a freely available database of freshwater mussel life-history traits, morphometric and physiological data, and population characteristics for the 298 North American freshwater mussel species. Ultimately this database is intended to inform population modeling development and application, specifically for the purpose of conducting pesticide risk assessment, though the potential uses are numerous. The database is being developed using thorough literature review and agency, academic, and industry partnerships. Examples of traits include life span, age at maturity, growth rates, fecundity, host use, and brooding patterns. Morphometric and physiological data include glochidia, juvenile, and adult size and thermal tolerance. Examples of population characteristics include sex ratio, mortality and recruitment rates, and population density. This database represents an expansion on previous work by others to collect and aggregate important life-history data for freshwater mussels and has the potential to significantly improve and simplify population modeling efforts in the future. Collecting and summarizing available data will reveal existing data gaps to guide future research efforts and help identify species that may serve as surrogates for poorly described species, ultimately improving risk assessment for listed freshwater mussels.

27. INVASIVE BIVALVE DISTRIBUTION AND ASSOCIATIONS WITH UNIONIDS IN THE KALAMAZOO RIVER, MI, US

Nathan S Ring & Daelyn A Woolnough
Central Michigan University, Biology Department and Institute for Great Lakes Research, Mt. Pleasant, MI

Freshwater mussels in the family Unionidae are currently experiencing population declines. Two of the major factors behind the recent decline in unionid populations, especially in the Great Lakes watersheds are contaminants and invasive species. The Kalamazoo River is a >200 km river in Michigan that drains into Lake Michigan. The Kalamazoo River has a history of a variety of anthropogenic contamination, including an oil spill in 2010. Preliminary data suggest the Kalamazoo River supports unionid communities, however, not much is known about the invasive bivalves in the river. To determine the overall habitat quality for freshwater bivalves, a comprehensive survey was performed in the summer of 2018 including surveys for unionids and invasive bivalves. Multiple sediment samples, including invasive species, were collected at 94 randomized sites throughout the Kalamazoo River and its tributaries; concurrently unionid standardized surveys were performed at the sites. Invasive bivalve densities were calculated along with sediment characteristics, unionid densities, and unionid species richness. *Corbicula fluminea*, was the only species of invasive bivalve found in the sediment samples, however, *Dreissena polymorpha* were observed while sampling at four sites. ArcGIS was used to determine *C. fluminea* density and average mass, along with unionid density and species richness. We compared *C. fluminea* density, unionid density, and unionid species richness inside and outside of the oil spill zone, their means were higher outside than inside though not statistically significant, perhaps due to the small number of sampling sites inside the oil spill zone. Based

on the data that has been analyzed so far, the quality of unionid habitat is variable throughout the Kalamazoo River and its tributaries and overlaps with *C. fluminea* habitat. These data can help with conservation efforts of unionids while concurrently helping managers make decisions about invasive species control.

28. SEXUAL DIFFERENTIATION IN SOMATIC GROWTH WITHIN TWO SPECIES OF FRESHWATER MUSSELS, *LAMPSILIS CARDIUM* AND *LAMPSILIS SILIQUOIDEA*, AS A FUNCTION OF ENVIRONMENTAL IMPACT

Mariah W Scott[1] & Rüdiger Bieler[2]
[1]University of Chicago, Chicago, IL; [2]Field Museum, Chicago, IL

Females have to balance their survival and somatic growth with the fitness of their offspring. Somatic growth rate differences between females and males of a given species may provide insight into how costly reproduction is for females, in comparison to their male counterparts. Sexual dimorphism in shell shape is evident in these two species. Are there significant growth rate differences between females and males of *Lampsilis cardium* or *Lampsilis siliquoidea*? If so, does the amount of sexual differentiation in somatic growth differ between habitats? This study plans to make comparisons between female and male *Lampsilis cardium*, as well as female and male *Lampsilis siliquoidea*, from two watersheds for each species to answer these questions. The comparisons of males and females of a single species will be limited to shells taken from a single collection event. Samples from each location will include the right shell valves of up to 30 females and 30 males of the species, utilizing existing museum collections. Optical 3-D scans of the specimens will be combined with cross-sections to determine the amount of external area and shell thickness added annually for a specimen. These measurements will allow specimens to be analyzed morphologically, with simulations of their growth rates over time. The growth of a specimen will be a model of the change in shell volume and shell cavity volume of females, compared to males, over successive years of growth.

29. HOST IDENTIFICATION FOR THE SPECTACLECASE MUSSEL, *CUMBERLANDIA MONODONTA* (MARGARITIFERIDAE)

Bernard Sietman[1], Mark Hove[2], Mike Davis[1], Madeline Pletta[1], Yer Lor[3], Tricia Anderson[1], Morgan Freeburg[1], Anna Scheunemann[1], Zebulin Secrist[1], Christopher Merkes[3], Diane Waller[3], Alex Franzen[2], Cameron Swanson[2], Avery Sampson[2] & Daniel Hornbach[4]
[1]Minnesota Department of Natural Resources, Lake City, MN; [2]University of Minnesota, St. Paul, MN; [3]U.S. Geological Survey, La Crosse, WI; [4]Macalester College, St. Paul, MN

Determining larval-host relationships is perhaps the most fundamental and beneficial life history information for freshwater mussel conservation. Despite concerted efforts over many years, identifying a larval host for the federally endangered Spectaclecase (*Cumberlandia monodonta*) (Margaritiferidae) has been elusive. We identified Mooneye (*Hiodon tergisus*) and Goldeye (*H. alosoides*) as hosts for Spectaclecase through a combination of laboratory trials on a broad selection of fish families and species, and by capturing naturally infected fish adjacent to Spectaclecase colonies on the St. Croix River, Minnesota. Both species successfully produced thousands of juveniles in laboratory trials. Juvenile mussels recovered from naturally infected Mooneye were morphologically similar to juveniles from laboratory trials. Analysis of DNA from developing larvae on Mooneye gills and juveniles released from naturally infected Mooneye confirmed their identity as Spectaclecase. The Hiodontidae, an early lineage of fishes, represent a new host family for the Margaritiferidae.

Posters – Management & Natural Resource Issues

30. POST CONSTRUCTION ASSESSMENT OF UNIONIDS AND HABITAT FOR THE BATCHTOWN UPPER MISSISSIPPI RIVER RESTORATION (UMRR)- HABITAT REHABILITATION AND ENHANCEMENT PROJECT (HREP) IN MISSISSIPPI RIVER POOL 25

Eric J Belt, Heidi L Dunn & Leslie Sneed
EcoAnalysts, Inc., O'Fallon, MO

The St. Louis District U.S. Army Corps of Engineers has constructed the Batchtown Upper Mississippi River Restoration Program (UMRR) and Habitat Rehabilitation and Enhancement Project (HREP) to restore and/or maintain existing riverine habitat diversity for the benefit of fish and wildlife. The purpose of this study was to monitor unionids within the Batchtown project area one year after construction to determine the effect of the HREP on the mussel community within. Unionids were sampled before construction in 2003 and after Phase I and II were completed in 2006 and 2007 to define pre-construction density, age structure, evenness, and richness. Results suggest habitat and unionid distribution have changed since 2003, but these changes do not appear to be due to construction of the HREP. Sedimentation has occurred both within and downstream of the spillway, and density, species richness, species evenness, and species diversity have declined. This community now consists of older thicker shelled unionids. Some unionids are persisting in the Batchtown side channels, but these are also older thicker shelled unionids. Declines were also noted before construction and in the reference area upstream of Lock and Dam 24, indicating construction of the HREP did not cause the declines. Improved flow through the area due to operation of the HREP may improve conditions for unionids after a few years. Future monitoring is suggested.

31. BEST MANAGEMENT PRACTICES TO IMPROVE MUSSEL CONSERVATION IN THE WESTERN U.S.

Emilie Blevins[1], Laura McMullen[2], Sarina Jepsen[1], Michele Blackburn[1], Aimée Code[1] & Scott Hoffman Black[1]
[1]Xerces Society for Invertebrate Conservation, Portland, OR, [2]ICF, Portland, OR

Western freshwater mussels provide many important ecosystem services that support imperiled salmon populations and other freshwater species. Although populations are declining in multiple states, western mussels are largely unprotected by state regulations that safeguard other fish and wildlife species from impacts resulting from construction and natural resource management projects. Although these projects typically must implement standard protocols or Best Management Practices (BMPs) to protect certain aquatic species, existing BMPs do not sufficiently protect mussel beds. To date, freshwater mussels have been generally overlooked in these projects, including aquatic restoration projects aimed at restoring aquatic habitat and communities, with the result that mussel beds are diminished or destroyed. Although mussels ultimately stand to benefit from enhancement of degraded aquatic habitat, there is a need to implement measures that protect mussels in advance of and during construction and restoration implementation. To improve protections for western freshwater mussels, we developed BMP guidance specific to western freshwater mussels. These recommendations are based on the best available science and intended to address a wide variety of practices or projects that intersect with freshwater mussels and their habitat. These BMPs are now being voluntarily implemented at multiple project sites, and they continue to be refined to improve western freshwater mussel conservation efforts.

32. ASSESSMENT OF UNIONID HABITAT CONDITIONS ON RIVER TRAINING STRUCTURES AND RECOMMENDATIONS FOR FUTURE STRUCTURE DESIGN

Ryan Foley & Heidi L Dunn
EcoAnalysts, Inc., O'Fallon, MO

Innovative river training structures are used to improve navigation while maintaining or improving fish and invertebrate habitat. A sampling strategy for assessing unionid habitat conditions at existing training structures and reference sites (existing mussel beds) was developed. Preliminary data from bathymetric and Acoustic Doppler Current Profiler (ADCP) surveys conducted by the U.S. Army Corps of Engineers were used to develop polygons for mussel sampling at 2 reference and 5 structure sites. Mussel beds and areas without mussels were delineated, and quantitative samples were collected in a 3-random start systematic design within these polygons. Data was compared to hydraulic parameters modeled at high and low flow conditions, with the objective of determining a range of conditions suitable for mussels that could be used to modify existing structures and develop new structures that might support freshwater mussels. Mussel sampling and hydraulic results were analyzed using Principal Component Analysis (PCA). Habitat characteristics important to mussel presence include slope (20 to 30%), substrate composition (avoid interlocking rock), particle size (D50 greater than coarse sand), and substrate stability (shear stress/ critical shear stress less than 1). Future river training structures should incorporate these values into the design to improve the likelihood of creating suitable mussel habitat.

33. EXAMINING THE EFFECT OF THERMAL DISCHARGE ON UNIONID ASSEMBLAGES

David F Ford, Nathan Badgett & Heidi L. Dunn
EcoAnalysts, Inc., O'Fallon, MO

North American unionids are a particularly imperiled fauna, which face multiple environmental stressors. Of these stressors, rising water temperatures, caused by climate change and other anthropogenic effects, are and will likely continue to have an impact. Increasing water temperature can cause behavioral changes and adversely affect unionid physiological responses in both adults and glochidia; altering growth cycles, spawning, and other factors. One source of increased water temperature is thermal discharge releases from powerplants. We compared data from several thermal discharge impact studies for trends in unionid species composition, including the presence/absence of species reported to be thermally intolerant, and other community metrics. Our results indicate that thermal plumes do not seem to be impacting unionids, however, thermal effluent could be resulting in internal nonlethal impacts, such as increased oxygen consumption and metabolic rates. Future studies need to investigate the sublethal effects thermal discharges may have on unionid physiological processes to determine what effect, if any, thermal discharge releases have on unionids.

34. THE EFFECTS OF OIL DRILLING ON THE HYDROLOGY OF THE PECOS RIVER DRAINAGE.

Gretchen M Gregor, Robert A Francis & David J Berg
Miami University, Oxford, OH

Spanning west Texas and southeastern New Mexico, the Permian Basin is the largest oil and natural gas producing shale play in the United States. The introduction of hydraulic fracturing requires a substantial volume of water. The main sources of water for oil and gas extraction in Chaves, Eddy, Lea, and Roosevelt counties, New Mexico, are from the Pecos River Drainage (PRD), which potentially affects the availability of water in this arid freshwater ecosystem. The only native freshwater mussel in the PRD is *Popenaias popeii* which was federally listed as endangered in 2018. Because population growth of *P. popeii* is correlated with river discharge, groundwater mining in the PRD poses a threat to survival of this species. Aquatic fauna in arid regions have adapted a tolerance to the fluctuation of seasonal rainfall patterns; however, less is known about the effects of constant anthropogenic withdrawal of freshwater. We gathered historical discharge data from 1938-2018 from 29 stream sites throughout the PRD from the United States Geological Survey. Additionally, oil and gas well operational data from 1900-2018 were collected from the State of New Mexico Oil Conservation Division. There were 14,853 oil and gas wells operationally active from 1999-2018. We are modeling the relationship between increase in active oil and gas well drilling and changes in river discharge using linear mixed models. We predict the PRD discharge will decrease with an increase in operating oil and gas wells. Using the linear mixed model to account for variation due to time, an effective management strategy could be supported that balances the discharge needed to sustain aquatic fauna, while simultaneously meeting the needs for natural resource extraction.

35. VERIFYING GENOMICALLY INFORMED ECOLOGICAL NICHE MODELS

Ava M Laszlo, John Placyk, Lance Williams, Marsha Williams, Kate Hertweck & Joshua Banta
University of Texas at Tyler

Freshwater mussels (Unionidae) are one of the most threatened taxa in North America. They play an important role in freshwater ecosystems, both as a food source and a provider of ecosystem services such as water filtration. This work focuses on two closely-related species found in Texas: the Texas Pigtoe (*Fusconaia askewi*) and the Triangle Pigtoe (*F. lananensis*). Both are protected by the state of Texas, and *F. lananensis* is being considered for federal protection. However, questions remain as to whether these species are being correctly identified. This work builds upon a genomics study that identified specimens from this species group, and found that *F. askewi* and *F. lananensis* should be classified as the same species. We performed ecological niche modeling on the genetically verified specimens to forecast the most favorable habitats for each species. The models' predictions were independently confirmed through extensive field sampling in East Texas. The ground truthing aspect of the field sampling tested the utility of our integrative approach for predicting the presence and absence of these species. The average habitat suitabilities of locations where pigtoes were present was greater than where pigtoes were absent.

36. USING THE USGS NONINDIGENOUS AQUATIC SPECIES (NAS) DATABASE TO TRACK THE THREAT OF INVASIVE SPECIES AND GUIDE CONSERVATION EFFORTS FOR NATIVE MOLLUSKS IN THE UNITED STATES

Cayla R. Morningstar[1] & Wesley M Daniel[2]
[1]Cherokee Nation Technologies, Gainesville, FL; [2]Unites States Geological Survey, Gainesvillle, FL

The introduction of nonindigenous species is an ongoing threat to native mollusk and fish fauna, and is often second only to habitat destruction and alteration. The Nonindigenous Aquatic Species (NAS) Database (https://nas.er.usgs.gov/) is a tool that tracks nonnative aquatic plant and animal occurrences in the United States and maps their distribution. The database provides species profiles for nonnative species, listing the impacts of each species on ecosystems and other groups. Managers can use the database to determine which bodies of water are currently infested or threatened by infestation by non-native and invasive species. Distribution data can be downloaded for any nonnative aquatic species, area, or waterbody of interested. In this presentation I will demonstrate how the NAS database can be used to guide conservation of native, threatened mollusks by using the nonnative distribution for the molluscivorous black carp (*Mylopharyngodon piceus*) and the often dense and parasite-ridden red-rim melania (*Melanoides tuberculatus*) in conjunction with native ranges of mollusk species threatened by these species. The overlapping ranges of the nonnative species with the native/endemic snails and mussels demonstrate how NAS's nonnative range maps can be used to look at areas of invasive species concern on a large and small scale, and guide future species-spreading prevention efforts. We also use GIS modeling to predict the areas that area most threatened from species' spread, based on hydrology and lifecycle information, to find high-priority areas of future concern for mollusks. The modeling demonstrates the way that the NAS database can be used to help in the prediction of invasive species spreading where threated, native mollusks occur, as well as the different tools the database has available to managers and researchers.

37. OHIO PROTOCOL: IS DRAINAGE AREA AN ACCEPTABLE TRIGGER FOR SURVEY NEED IN OHIO STREAMS?

Lindsey Moss[1], Sarah Bender[1] & Megan Michael[2]
[1]TRC, Cleveland, Ohio 44113; [2]Ohio Department of Transportation, Columbus, Ohio

The Ohio Mussel Survey Protocol uses the ten square mile drainage area as a trigger for surveys in Group 1 and unlisted streams in Ohio. However, recent evaluations completed in small streams have indicated presence of mussels in streams with drainage areas less than ten square miles. Based on these findings, adequate justification for the ten square mile drainage limit is increasingly important to address at the regulatory level. In this presentation, we propose alternate survey triggers based on our review of several data sources including Ohio EPA Biological Water Quality reports, survey reports provided by Ohio DNR-Division of Wildlife, TRC survey data, and ODOT ecological survey data. Factors such as stream drainage area, basin of origin, and species presence or absence were evaluated. Data will be presented with recommendations of additional triggers to appropriately determine survey need within a waterbody. Our analyses suggest that drainage area coupled with hydrologic unit code (HUC) and ecoregion may be better qualifiers for survey need in place of a generic statewide drainage size criterion. Clarifying the survey trigger criteria from exclusively drainage area to encompass more refined factors will lead to better protection of mussel communities and habitats and more defensible regulatory actions associated with survey need as well as survey outcomes.

38. USING ENVIRONMENTAL DNA TO IDENTIFY HABITAT REQUIREMENTS AND RESTORATION OBJECTIVES FOR THE ENDANGERED FRESHWATER MUSSEL *LASMIGONA DECORATA* (BIVALVIA: UNIONIDAE)

Benjamin C. Schmidt[1], Stephen F. Spear[2], Amelia Tomi[2],& Catherine Mb Jachowski
[1]Clemson University, Clemson, SC; [2]The Wilds, Cumberland, OH

The Carolina Heelsplitter (*Lasmigona decorata*) is a critically endangered freshwater mussel endemic to North and South Carolina. Because of its rarity, there is a deficit of information regarding the specific habitat requirements for colonization and persistence and where suitable habitat may exist. Understanding these requirements is essential for determining factors driving species decline and for guiding future management and restoration efforts. As part of an ongoing study, we developed a quantitative PCR assay to quantify the presence/absence of the Carolina Heelsplitter and a known host fish throughout the Upper Lynches River sub-basin in South Carolina. We will collect water samples during March of 2019, coinciding with the spring release of mussel larvae by gravid females. We will collect replicate water samples to account for imperfect detection and negative controls to monitor for potential contamination. We will investigate occupancy and detection probabilities as functions of environmental covariates, such as water chemistry, channel morphology, riparian characteristics, and land use attributes. Our preliminary results, which include controls and initial field samples, demonstrate the utility of eDNA as a highly sensitive survey tool, despite the extremely low density of the target species.

39. FMCS PROPOSED FRESHWATER MOLLUSK PROFESSIONAL CERTIFICATION PROGRAM: AN OVERVIEW.

Rebecca Winterringer
FMCS Professional Certification Ad-hoc Committee, Cleveland, OH

In late 2016, the FMCS Board approved establishing the Professional Certification Ad-hoc Committee to explore a professional certification for mollusk professionals. Presently, the certification would encompass freshwater bivalves and snails under one certification. The intent of a Mollusk Professional Certification program is to have an education and experience-based certification that will support the mission of FMCS, support the Society's education strategy, and to recognize experience and education achievements of mollusk professionals. This would not be a taxonomic certification. The Mollusk Professional Certification specifically addresses the National Strategy for the Conservation of Freshwater Mollusks Issue 8. The goals of the program are to: 1) provide recognition of achievements for mollusk professionals, and 2) present minimum standards for key skills and competencies for mollusk conservation professionals. Since 2016, the Committee has polled the membership for interest, volunteered many hours to identify the pros, cons, and challenges of a certification program and how it may be administered, spoken to other organizations who have similar certifications, and preliminarily determined certification rating criteria. In 2019 at the Symposium in San Antonio, the FMCS Membership will be able to cast their vote. Program administration and procedures will be developed upon receiving a passing vote from the membership in 2019.

40. EFFECTS OF ASIAN CLAMS, *CORBICULA FLUMINEA*, ON ADULT FRESHWATER MUSSELS: A PROPOSAL

Kiersten Youngquist[1], Andrea Darracq[1] & Wendell R Haag[2]
[1]Murray State University, Murray, KY; [2]Center for Bottomland Hardwoods Research, Southern Research Station, US Forest Service, Frankfort, KY

The Asian Clam colonized much of the eastern United States in the 1960s, but little is known about their interactions with native mussels, such as potential competition for food. We propose to conduct an experiment in mesocosms to assess interactions between Asian Clams and adult native mussels. The experiment will be conducted at the Hancock Biological Station, and mesocosms will be supplied with constant water flow from Kentucky Lake (Tennessee River). We will use two species of native mussels: *Potamilus alatus* and *Quadrula quadrula*, which will be collected from wild populations in Kentucky Lake. We will use a full factorial experiment with three levels of native mussel treatment (each species alone, and multiple species (*Potamilus alatus*, *Quadrula quadrula*, *Megalonais sp*. and *Plectomerus sp*.); total of 8 mussels/mesocosm) and four levels of Asian Clam abundance, corresponding to densities of 0 10, 100, and 1000/m^2. This design will be replicated twice, so that sample sizes for both main effects are N = 6. Asian Clams and native mussels will be placed in mesocosms in June, 2019, and the experiment will be run for four weeks. At the end of the experiment, we will measure glycogen, pyruvate, total lipid, and total protein in each native mussel, and we will measure growth of Asian Clams. This experiment will evaluate four questions: 1) Does increasing density of Asian Clams result in decreased physiological condition in native mussels?; 2) Do native species differ in their responses to Asian Clams?; 3) Does the presence of another native species influence the response of individual species?; 4) Is growth of Asian Clams influenced by its density?

Posters – Relocation, Reintroduction and Propagation

41. PROPAGATION AND RELEASE OF THE ENDANGERED DWARF WEDGEMUSSEL (*ALASMIDONTA HETERODON*) IN NORTH CAROLINA

Chris Eads & Jay F Levine
NC State University, Raleigh, NC

We compared host efficacy for Tar River Basin *Alasmidonta heterodon* between eleven fish species, two river basins, and with a repeated infection of the same individual fish. Johnny Darters (*Etheostoma nigrum*) were the best fish hosts of those tested with 53.5 to 63.9% of attached glochidia fully transforming. Fantail Darters (*Etheostoma flabellare*) also served as effective hosts in some trials but did not yield consistent results (11.3 to 59.3% transformation). Four other sympatric darter species tested served as fair hosts, yielding from 12.1 to 36.8% transformation. *Etheostoma nigrum* from the Tar River Basin were significantly more efficient hosts for the Tar Basin mussels than *E. nigrum* from the neighboring Neuse Basin in four out of five broods tested. Transformation success dropped slightly upon reinfection of individual *E. nigrum* going from 63.3 to 57.3%, 50.0 to 42.9%, and 64.5 to 37.1% in the first to second trials respectively. All transformed juveniles were initially cultured indoors in aerated aquaria with a thin layer of fine sediment (<200-µm grain size). Commercially-available algae were dosed gradually with an approximate 100% water exchange daily. After 1 year in the laboratory with 12.6% survival (mean length = 15.8 ± 3.0 mm), mussels were placed in floating baskets in one of two reservoirs and monitored. Survival from April to October 2018 was 83% (mean length =

27.5 ± 4.6 mm) in one and 44% (mean length = 21.8 ± 2.0 mm) in the other. Lotic mussel species from other genera have fared better in both reservoirs, but perhaps the extreme temperatures in those systems (up to 32°C) were not ideal for *A. heterodon*. Still, with mussels reaching stockable size in only 18 months, these techniques warrant further refinement and investigation. In total, 126 individuals were released into the wild – the first such augmentation of this species in North Carolina.

42. RESULTS OF FRESHWATER MUSSEL PROPAGATION AND RESTORATION AT THE NORTH CAROLINA WILDLIFE RESOURCES COMMISSION'S MARION CONSERVATION AQUACULTURE CENTER

Rachael A Hoch[1], Lucas J Etchison[1], William T Russ[1], Tyler R Black[2] & Andrew McElwain[3]
[1]North Carolina Wildlife Resources Commission, Marion, NC, [2]R.K. & K., Baltimore, MD, [3]State University of New York at Oswego, Oswego, NY

The North Carolina Wildlife Resources Commission (NCWRC) is responsible for the conservation and management of the state's inland aquatic wildlife, including freshwater fish, mollusks, and crustaceans. In 2015, the NCWRC updated the Wildlife Action Plan priority species. Taxa teams evaluated 52 species of freshwater mussels and designated 32 as Species of Greatest Conservation Need (SGCN). In an effort to restore and conserve NCWRC mollusk SGCNs, the agency invested resources into captive propagation with the construction of the Marion Conservation Aquaculture Center (MCAC) in 2008. Since establishment, the facility has worked with 20 freshwater mussel species, propagating over 259,000 individuals to a taggable size (>15mm) and stocking over 138,000 individuals back into NC inland waters. With the increasing success of the MCAC, the NCWRC constructed an additional propagation facility at Marion in 2017, quadrupling the capacity of the program. With increased production and capacity, the NCWRC is investing in the development of a genetic monitoring program and an animal health initiative to help guide management decisions. In 2018, the MCAC propagated nine species, producing over 19,000 individuals and stocked >36,000 mussels across four major watersheds. Additional results from the 2018 restoration efforts and animal health initiative will be highlighted.

43. PROPAGATION AND CULTURE OF FRESHWATER MUSSELS AT CUMBERLAND RIVER AQUATIC CENTER IN TENNESSEE.

Dan Hua, Dave McKinney, Don Hubbs, Anna Dellapenta, David Sims, Chad Cogburn & Mike Murdock
Tennessee Wildlife Resources Agency, Nashville, TN

Propagation and culture of freshwater mussels for release to natal river has become a primary strategy to recover and restore population of endangered species. In order to mitigate the impacts on mussel population in Cumberland River and Tennessee River, the Cumberland River Aquatic Center (C-RAC) of Tennessee Wildlife Resources Agency was established at Gallatin, TN in 2015. Systems for culture of juvenile mussels, and raising broodstock of freshwater mussels and fish hosts have been developed with the options for recirculating or continuous supply of river water to provide suitable culture environment. A total of 114,000 juvenile mussels including 8 federally endangered species, pale lilliput (*Toxolasma cylindrellus*), Duck River dartersnapper (*Epioblasma ahlstedti*), Oyster mussel (*Epioblasma capsaeformis*), fanshell (*Cyprogenia stegaria*), birdwing pearlymussel (*Lemiox rimosus*), snuffbox (*Epioblasma triquetra*), Cumberland bean (*Villosa trabalis*), dromerdly pearly mussel (*Dromus dromas*), and 3 common species, wavy-rayed lampmussel (*Lampsilis fasciola*), pocketbook (*Lampsilis ovata*) and pink heelsplitter (*Potamilus alatus*) have been produced at C-RAC since 2015. *T. cylindrellus* was considered at the extremely high risk of

extinction in Tennessee. In June 2016, juvenile mussels of *T. cylindrellus* were successfully propagated at C-RAC and 3,882 juveniles of this species have been growing out to tag-able size. The survival rate of this species reached 82.4% during the culture period. Additional to *T. cylindrellus*, a total of 8,538 sub-adult mussels including 4 federally endangered species and 2 common species are being cultured at C-RAC. A total of 1955 sub-adult mussels of *T. cylindrellus* with hallprint tags, black glue dots, bee tags and PIT tags have been released at 3 sites in Duck River, multiple sites in Elk River and 1 site at Lick Creek in Tennessee since 2017. Monitoring program has been also conducted to evaluate the restoration efforts. Released *T. cylindrellus* exhibited fast growth (average growth rate reached 52.4% in 1 year) at Duck River from 2017 to 2018. Released purple cat's paw pearlymussel (*Epioblasma obliquata*) also revealed fast growth (average growth rate reached 46.5 % in 1 year) at Duck River. No mortality was observed for both species.

44. PRODUCTION AND RELEASE OF PROPAGATED MUSSELS IN THE CLINCH AND POWELL RIVERS FOR THE LONE MOUNTAIN PROCESSING, INC. AND CERTUS, INC. NRDAR CASES

John M Hyde[1] & Jess W. Jones

[1]Department of Fish and Wildlife Conservation, Virginia Tech, Blacksburg, VA; [2]US Fish & Wildlife Service, Department of Fish and Wildlife Conservation, Virginia Tech, Blacksburg, VA

Two Natural Resource Damage Assessment and Restoration (NRDAR) cases in the upper Tennessee River basin are among the first and largest cases in the United States involving injury to freshwater mussels due to release of hazardous substances. The Certus, Inc. spill occurred in 1998 in the upper Clinch River in Virginia, killing an estimated 18,000 mussels, including individuals of three endangered species. The Lone Mountain Processing, Inc. spill occurred in the Powell River in Virginia, affecting mussels over a 65-mile section of river. Settlement money from these two cases were used to propagate and release mussels at population restoration sites in the upper Clinch River, VA and in the Powell River, TN and VA. Mussel production and release data were summarized from 2003–2017 for the Virginia Department of Game and Inland Fisheries' Aquatic Wildlife Conservation Center (AWCC) and Virginia Tech's Freshwater Mollusk Conservation Center (FMCC). A total of 8,456,191 juvenile mussels of 34 species were produced by AWCC and FMCC, with a total of 846,501 mussels of 26 species released at sites in Virginia and Tennessee over this time period. Of the released mussels, a total of 136,738 were 20–40 mm long and 1–3 years old. Of these larger and older mussels, 112,130 were released for the Certus, Inc. NRDAR case and 24,608 were released as part of restoration efforts for the Lone Mountain Processing, Inc. NRDAR case. Until 2008, most mussels released were typically a few weeks old and <1 mm long. However, by 2011, both facilities were consistently growing mussels to larger sizes before release. This allowed mussels to settle into substrate more quickly and improved survivability of released mussels at restoration sites.

45. CANCELLED - ESTABLISHING NEW POPULATIONS OF ENDANGERED SPRINGSNAILS AT BITTER LAKE NATIONAL WILDLIFE REFUGE: APPARENT SUCCESS

William P Johnson[1], Jeffrey S Beauchamp[2], Matthew J Butler[3] & Daniel A Trujillo[4], Jeffrey I Sanchez[5] & Paul Tashjian[6]
[1]Division of Biological Sciences, National Wildlife Refuge System, U.S. Fish & Wildlife Service, Canyon, TX; [2]Bitter Lake National Wildlife Refuge, U.S. Fish & Wildlife Service, Roswell, NM; [3]Division of Biological Sciences, National Wildlife Refuge System, U.S. Fish & Wildlife Service, Albuquerque, NM; [4]New Mexico Department of Game and Fish, Santa Fe, NM; [5]Bosque del Apache National Wildlife Refuge, U.S. Fish & Wildlife Service, San Antonio, NM; [6]Audubon New Mexico, Santa Fe, NM

Bitter Lake National Wildlife Refuge rerouted the lower portion of the Rio Hondo in 2014 to isolate a series of springs for the benefit of endangered, spring associated invertebrates. Historically, the lower portion of the river was straightened and channelized to facilitate storm drainage from Roswell, NM. Subsequently, river flow and depth in this section increased greatly during storms, and spring vents were subjected to inundation and heavy siltation. Two target springsnails, *Pyrgulopsis roswellensis* and *Juturnia kosteri*, did not occur in Rio Hondo prior to the project. Pre-construction surveys suggested spring flows, water temperature, pH, and salinity post-construction would be within the tolerance ranges of both species. Approximately 2,750 individuals of each springsnail species were translocated from other locations on the refuge once annually during 2015-2017. In 2015, translocated individuals were divided into groups of 548 and placed at 100 m intervals in the main channel of the spring system. Because few individuals were recovered in subsequent monitoring efforts, individuals moved in 2016-2018 were concentrated in a small (15 m long, 28.2 m^2), partially isolated spring run that flows into the larger spring channel. In July 2018, we took 21 benthic grab samples from the small spring run. *P. roswellensis* and *J. kosteri* densities were estimated to be 3,076±3,725 (SD) springsnails/m^2 and 3,038±3,725 (SD) springsnails/m^2, respectively. The total abundance estimate for the two species combined was 194,692, which is >18 times the number released. Extremely small, translucent springsnails were observed in 2017 and 2018, which suggests reproduction is likely occurring. Density estimates are comparable to those in other refuge spring runs, which are considered critical habitat for both species. Future translocation efforts will focus on small spring runs, adjacent to the larger spring channel.

46. FRESHWATER MUSSEL RESTORATION AND PROPAGATION IN THE LOWER DELAWARE RIVER WATERSHED

Kathryn Longwill[1], Danielle Kreeger[2], Kurt Cheng[2], Angela Padeletti[2], Lance Butler[3] & Roger L Thomas[1]
[1]The Academy of Natural Sciences of Drexel University, Philadelphia, PA; [2]Partnership for the Delaware Estuary, Wilmington, DE; [3]Philadelphia Water Department, Philadelphia, PA

During the last century, there have been dramatic declines in species diversity, range, and population abundance of freshwater mussels throughout the Delaware River watershed. These changes are most likely due to decreased water quality, construction of barriers to fish host migration and increased land development. Sustained efforts to restore and propagate many of these species are needed to preserve their ecosystem services. As part of the Freshwater Mussel Recovery Program (FMRP), replicate groups of *Elliptio complanata* and *Utterbackiana implicata* were relocated from the Delaware River into 12 streams in Pennsylvania and Delaware. Monitoring of these animals has indicated that most streams are capable of sustaining mussels. Frequent flooding and bed scouring have affected bed retention. Propagation and reseeding are important elements of the FMRP because of the limited natural mussel populations that are needed to support these recovery

efforts. During 2017-2018, glochidia from five native species (*E. complanata*, *U. implicata*, *Ligumia nasuta*, *Lampsilis cariosa*, *Leptodea ochracea*) were successfully transformed at the Fairmount Water Works mussel hatchery in Philadelphia. In 2017, more than 50,000 transformed juveniles of *U. implicata* were also produced in partnership with the USFWS Harrison Lake National Fish Hatchery, Virginia, using Delaware River broodstock. Juveniles were then cultured in floating baskets in ponds throughout southeast Pennsylvania and northern Delaware to determine the most suitable locations for rearing mussels in future expanded propagation efforts.
Although laboratory propagation and pond rearing were largely successful, these efforts required substantial maintenance and posed numerous challenges. In vitro methods were also tested for three species (*U. implicata*, *L. ochracea*, and *L. cariosa*) in 2018. Survival of juveniles produced in vitro varied among species. Successful transformation in vitro suggests this method could augment propagation programming, especially for mussel species that are difficult to reproduce or where suitable fish hosts are not available.

47. PROPAGATION AND CULTURE OF *LASMIGONA SUBVIRIDIS* AT VIRGINIA FISHERIES AND AQUATIC WILDLIFE CENTER (VFAWC)

Amy Maynard[1], Rachel Mair[2], Brian Watson[3], Michael Odom[2], Ben Davis[2], Bryce Maynard[2], John Scott Moore[1]
[1]Conservation Management Institute, Charles City, VA; [2]U.S. Fish & Wildlife Service, Charles City, VA; [3]Virginia Department of Game and Inland Fisheries, Forest, VA

Lasmigona subviridis is a unique mussel species that is able to metamorphose to a juvenile with or without the use of a fish host. This species is at risk across its range, which currently extends from New York to North Carolina within the Atlantic Slope, and is extirpated in Alabama and Georgia. In Virginia, *L. subviridis* is listed as State Threatened and nationally, it is under review for federal listing. Since 2009, VFAWC has determined optimal collection time of brooding females, subsequent juvenile release, and has tested a variety of culture systems. At the hatchery, brooding females reside in aerated, static tanks that are fed commercial algae and are given water changes daily. After several days to a week, the females release metamorphosed juveniles spontaneously. In prior years, juvenile survival was typically near 0%. Most mortality occurred when juveniles reached 1-2 mm in length. In 2017, juvenile survival to two-months was 26.0 ± 12.7% in static sediment tanks and 63.3% in mucket buckets (N=1). In 2018, two-month survival was 70.9 ± 7.2% in static sediment tanks after increasing feeding frequency and decreasing mussel density in each tank. Mucket bucket survival was lower at 30.1 ± 7.4% when compared to 2017. Brood condition may likely play a factor in mucket bucket survival, as significantly different survival rates have been observed between individual broods. In 2017, juveniles (12.4± 0.4 mm) placed in floating baskets suspended in a pond exhibited 55.4 ± 4.4% survival after one year. Since 2016, we have tagged and released 3,370 1-year old *L. subviridis* in Virginia. We will propagate *L. subviridis* this coming spring through projects to restore freshwater mussels in the Dan and South rivers. VFAWC will work to increase our understanding of this species, including, how their unique life history affects successful propagation and culture.

48. CHALLENGES IN DEEP WATER MUSSEL CONSERVATION

David McBee, Jeremy D Maikoetter, Jacob D Owen & Krista McDermid
Zara Environmental LLC, Manchaca, TX

Scientists conducting freshwater mussel surveys in deep waterways face methodology, safety and compliance challenges unique to the use of scuba and other life-support systems to access freshwater mussel habitat beyond the reach of traditional survey methods. We have observed freshwater mussels of conservation concern in depths exceeding one meter and in urban survey sites with contaminated water. Conditions in urban and suburban locations present divers with safety challenges related to fast moving water, low to zero visibility, entanglement and exposure to contaminated water. Organizations employing scientific and working divers are also subject to compliance standards covered in Occupational Safety and Health Administration standard 29 C.F.R. Part 1910, Subpart T and/or the scientific diving exemption defined in 29 CFR 1910.402. Our methods draw upon standards developed for both commercial and scientific diving. These methods rely on equipment and staffing redundancy and meet or exceed all Occupational Safety and Health Administration standards for commercial and scientific diving and have been vetted by the American Academy of Underwater Sciences. Our methods have produced effective, efficient and reliable surveys for freshwater mussels of conservation need.

49. GROWING MUSSELS AT CAMP – THE CENTER FOR AQUATIC MOLLUSK PROGRAMS.

Madeline E Pletta, Mike Davis, Bernard Sietman, Zeb Secrist & Morgan Freeburg
Minnesota Department of Natural Resources, Lake City, MN

Restoring mussel populations through captive culture and reintroduction is a powerful tool to mitigate species loss. Nearly half of Minnesota's 51 freshwater mussel species have declined such that protection status is necessary. To meet this need, the Minnesota DNR established the Center for Aquatic Mollusk Programs (CAMP) in 2014. The program uses a five-pronged approach to guide mussel conservation and restoration actions; 1. Surveys to evaluate the status of mussel populations among drainage basins, 2. Identifying basins or river reaches for mussel reintroductions, 3. Researching larval brooding biology and hosts, 4. Juvenile propagation, culture, and grow out for release and 5. Post-release monitoring. CAMP identified three rivers where past pollution events resulted in multiple species losses. Mussel reintroductions in these areas is a viable option due to improved water quality associated with the Clean Water Act. Disjunct populations of extirpated species occur elsewhere in these basins, but isolation and fragmentation by dams prevent these species from recolonizing. Our goal is to restore these species through captive culture using nearby extant populations as the genetic source. We currently have six Minnesota or federally listed species in culture at CAMP, in enclosures at select field sites, or both. Our first release of species raised in captive culture is planned for summer 2019.

50. IN-VITRO PROPAGATION OF THE FEDERALLY ENDANGERED DWARF WEDGEMUSSEL (*ALASMIDONTA HETERODON*)

Jennifer E Ryan[1], Allison H Roy[2], Timothy M Warren[3] & David L Perkins[3]
[1]University of Massachusetts Amherst, Amherst, MA; [2]United States Geological Society, Amherst, MA; [3]U.S. Fish & Wildlife Service, Sunderland, MA

Comprehensive mussel restoration programs are needed to restore the more than 70 federally endangered freshwater mussel species in the US. The dwarf wedgemussel (*Alasmidonta heterodon*) has been federally endangered since 1990. The mussel, which once ranged from the Neuse River in North Carolina to the Petitcodiac River in New Brunswick, Canada, now only exists in few isolated populations throughout its diminished range. These declines have led to concerns about the long-term viability of the species. As part of an effort to restore the species, we are developing new in-vitro propagation techniques for populations of dwarf wedgemussel in the Connecticut River watershed. We will compare glochidia transformation rates and size with four treatments of media, each containing different serums: paddlefish, carp, brook trout and rabbit. Future experiments will focus on growth and survival of juvenile mussels. These propagation efforts are part of a multi-faceted approach, including studies of population genetics, mussel habitat requirements, and fish populations at potential restoration sites. All of these pieces are vital for developing an effective species recovery plan using in-vitro propagation and reintroduction or population augmentation for restoration.

51. SMART PROPAGATION AND REINTRODUCTION PLANNING FOR SPECTACLECASE (*CUMBERLANDIA MONODONTA*, AKA *MARGARATIFERA MONODONTA*)

Tamara A Smith[1], Megan Bradley[2], Mike Davis[3], Heidi Dunn[4], Nathan Eckert[5], Mark Hove[6], Byron Karns[7], Daniel Kelner[8], Lisie Kitchel[9], Madeline Pletta[3], Andy Roberts[10], Bernard Sietman[3], Jeremy S Tiemann[11] & Jesse Weinzinger[12]
[1]U.S. Fish & Wildlife Service, Bloomington, MN; [2]U.S. Fish & Wildlife Service, Genoa, WI; [3]Minnesota DNR, Lake City, MN; [4]EcoAnalysts, Inc., O'Fallon, MO; [5]U.S. Fish & Wildlife Service, Neosho, MO; [6]University of Minnesota, St. Paul, MN; [7]National Park Service, St. Croix Falls, WI; [8]U.S. Army Corps of Engineers, St. Paul, MN; [9]Wisconsin DNR, Madison, WI; [10]U.S. Fish & Wildlife Service, Columbia, MO; [11]Illinois Natural History Survey, Champaign, IL; [12]Wisconsin DNR, Madison, WI

Controlled propagation, augmentation, and reintroduction of endangered organisms is typically a priority action for their recovery, and in many cases is an urgent course of action to either restore or maintain existing population levels. Planning activities to minimize risks to extant populations and their habitats is imperative to avoid harm to existing populations of target and non-target species and to make efficient use of limited resources. The primary purpose of planned augmentations or reintroductions should be to establish free-ranging, self-sustaining wild populations of the species. Once wide-ranging and abundant, the Spectaclecase was listed as Endangered under the Endangered Species Act on April 12, 2012 and a recovery outline was finalized in 2014. The U.S. Fish and Wildlife Service (Service) is cooperating with state, federal, and local agencies, universities, and other partners to develop and implement a propagation and reintroduction plan for this species in order to comply with the Service's controlled propagation policy. As such, we are using International Conservation of Nature (IUCN) guidelines to facilitate our assessment of ecological, social and economic risks, and to aid development of collection, release, and monitoring strategies. The

propagation and reintroduction plan is still in development, but we will describe our process and progress thus far, with a goal to engage a broader group of stakeholders and expertise and to help other partnerships that are pursuing recovery goals for federally endangered species.

52. PRELIMINARY STUDIES ON THE IN-VITRO CULTURE OF YELLOW LANCE (*ELLIPTIO LANCEOLATA*)

Michael J Walter & Jay F Levine
North Carolina State University, Raleigh, NC

The Yellow Lance (*Elliptio lanceolata*) is a federally threatened species of freshwater mussel found in the Atlantic Slope drainage from Maryland to North Carolina. The Yellow Lance was recently the subject of propagation and population augmentation efforts in the Tar and Neuse River basins in North Carolina. Traditionally, propagation is achieved via infestation of host fish in a laboratory. The infested fish are held until glochidia transformation is complete and the resulting juveniles are collected as they drop from the host fish. However, transformation is also possible using cell culture techniques. In-vitro propagation bypasses the host fish requirement of traditional propagation methods by holding glochidia in sterile media consisting of blood serum, basal medium and antibiotics/antimycotics. We present preliminary results of a 2018 Yellow Lance in-vitro propagation effort. Filter sterilized media was made using 25% Horse Serum, 75% M199 Basal Media, 100 µg/mL Gentamicin, 1 µg/mL Amphotericin B and 100 µg/mL Rifampicin. Yellow Lance glochidia were held in a CO_2 infused incubator at 23°C and 3% CO_2 receiving 2/3 media replacement every other day until transformation was completed after 15 days. Upon transformation, media was diluted using buffered dechlorinated water at a rate of 25%/hour before transferring juveniles to nested bucket grow out systems. Overall survival of juvenile Yellow Lance propagated in-vitro and in-vivo was low in 2018. As of 1/16/19, 204 individuals were alive with an average size of 27.19 mm (4.83 mm std dev). Alternative methods to optimize media dilution rate and improve in-vitro propagation success are being assessed and will be presented.

53. FRESHWATER MUSSEL HATCHERY DEVELOPMENT AT SUNY COBLESKILL: VARYING HOST FISH SPECIES AND DENSITY TO MAXIMIZE *PYGANODON GRANDIS* TRANSFORMATION.

Nicholas J Wierman & Andrew Gascho Landis
SUNY Cobleskill, Cobleskill, NY

At SUNY Cobleskill we are in the early stages of building freshwater mussel propagation facilities. We are testing infrastructure and trying to maximize production by using common mussel species. We have done preliminary investigations using Giant Floater (*Pyganodon grandis*), a known host generalist; however, there is little information in literature about host fish stocking density and its relation to successful transformation. This project will compare transformation success between yellow perch (*Perca flavescens*) and pumpkinseed (*Lepomis gibbosus*) at five different stocking densities. Fish were inoculated in aerated buckets with 2000 glochidia per liter for fifteen minutes. Fish were then transferred to drop-off tanks (189 L) at densities of 5, 10, 15, 20, or 25. Standpipes were pulled every other day for five seconds and checked for juvenile mussels. Linear regression was used to assess the relationship between fish density and juveniles produced. Across stocking densities, yellow perch produced 75 juveniles per fish, whereas, pumpkinseed produced 3 juveniles per fish. Both trials show that increases in production did not continue at levels >20 host fish per tank, or the equivalent of 1 fish/9.45 L. The results from this study will be

used as a reference for fine-tuning production in our hatchery. Additional studies should be completed to see if production results are similar with other species of mussels and fish.

Posters – Status, Trends & Monitoring

54. DISTRIBUTION OF UNIONIDS IN THE KALAMAZOO WATERSHED, MICHIGAN, USA USING AN INTENSIVE STRATIFIED RANDOMIZED SURVEY

Kiara C Cushway, Scott M LaValley & Daelyn A Woolnough
Central Michigan University, Biology Department and Institute for Great Lakes Research, Mt. Pleasant, MI

Native freshwater mussels are key parts of river ecosystems and their presence helps to improve water quality. The lack of awareness of native freshwater mussels in any watershed presents a challenge in determining the trajectory for conservation and recovery of a watershed. For the Kalamazoo River, Michigan, USA little is known about native mussels in the main branch of the river and even less is known about the tributaries, with data prior to this study from the 1950's or earlier, the early 2000's, and one small study from our lab in 2012. The 2012 study, only in the main branch, indicated there were still populations of mussels in reaches of the river that were influenced by a bitumen oil spill in 2010. This study provides baseline data to understand the mussel distribution in the Kalamazoo Watershed and used a stratified (stream type and temperature) randomized design across the entire watershed. We sampled using a three-tiered time search approach with additional quadrat surveys if 25 live mussels were found. We visited 165 sites during the summer of 2018 with evidence of mussels found at 56 of the sites visited; 11 additional deep water sites will be SCUBA surveyed in 2019. At 25 of the 56 sites we found at least 25 live individuals and quadrat surveys were performed for more accurate density values. We found 17 species during timed searches and 11 species during quadrat surveys; no unique species were found during quadrat surveys. We also collected shells during timed and quadrat surveys and will report on these findings. We consider the distribution trends observed in tributaries and the main branch as well as area within areas influenced by anthropogenic effects and discuss how providing the citizens and stakeholders of the watershed with this information will inform management decisions.

55. STYGOBITIC SNAIL DIVERSITY IN THE APPALACHIAN RIDGE AND VALLEY OF EASTERN TENNESSE

Nicholas S Gladstone[1], Evelyn B Pieper[1], Evin T Carter[2], Annette S Engel[1], Katherine E Dooley[3], Matthew L Niemiller[3]
[1]University of Tennessee, Knoxville Knoxville, TN; [2]Oak Ridge National Laboratory, Knoxville, TN; [3]The University of Alabama in Huntsville, Huntsville, AL

Despite the economic and environmental importance of subterranean ecosystems, there is a fundamental lack of knowledge regarding the distribution and abundance of the many species that occupy caves and other subterranean habitats. Subterranean habitats can be extraordinarily challenging to access and navigate, and even when biologically sampled, smaller stygobitic (i.e., aquatic cave-obligate) species often go unnoticed. One such group of poorly studied stygobites are freshwater snails, which exhibit considerable taxonomic and

morphological diversity in North America. In the Appalachians karst region in the eastern United States, five stygobitic snails have been described, with all but one species occurring from the more extensively sampled caves of southwestern Virginia and the Greenbrier Valley of West Virginia. The Appalachian Valley and Ridge (AVR) of eastern Tennessee, which comprises over 1/3 of the Appalachians karst region, has received considerably less attention from biologists historically. To address sampling gaps, bioinventories of over 90 caves have been conducted in the AVR of eastern Tennessee since 2012. From these survey efforts, nine new populations of stygobitic snails have been discovered from seven cave systems within Knox, Roane, and Sevier counties. Two of these populations are the only known localities of an undescribed Antrorbis, with the remaining five snail populations representing potentially as many as three undescribed species within the genus Fontigens. Monthly surveys of select caves have been ongoing to understand patterns of abundance and microhabitat associations, and molecular data have been generated for several populations. Here, we update the distributions, monitoring efforts, and genetic relationships of these newly discovered stygobites in eastern Tennessee.

56. UNIONID DISTRIBUTION IN CHANNEL BORDER AND SECONDARY CHANNEL HABITATS IN MISSISSIPPI RIVER POOL 15

Emily Grossman[1], Heidi Dunn[1], Mary Kay Solberg[2], Felecia Hurley[3] & Terry Vandewalle[4]
[1]EcoAnalysts, Inc., O'Fallon, MO; [2]Iowa Department of Transportation, Ames, IA; [3]Illinois Department of Transportation, Springfield, IL; [4]Stantec Consulting Services, Inc., Independence, IA

Many construction projects occur within the Mississippi River. To better evaluate impacts to unionid assemblages in the river, information regarding the location(s) and population size(s) of these assemblages is needed. Poolwide surveys have been completed for Pools 4, 6, and 18. The objective of previous surveys was to generate an overall population estimate within the pool. Recent mitigation for the I-74 bridge construction project in Pool 15 of the Mississippi River afforded an opportunity to conduct a poolwide survey of Pool 15. The objective of the Pool 15 survey was to detect mussel assemblages, as well as develop population estimates. The survey was conducted with a phased approach. Phase 1 included compiling and mapping existing unionid surveys in the pool to generate a spatial database of survey records and to develop the sample size and spacing for Phase 2. Phase 2, completed in 2017, involved systematic sampling in channel borders and secondary channels, where most large-river unionid beds occur. The objective of Phase 2 was to assess unionid assemblage characteristics and map unionid distribution in these habitats. Community metrics suggest Pool 15 harbors high-quality unionid assemblages. Twenty-seven (27) species were collected, a variety of age classes were represented, and mean density was 8/m^2. Hot spot analysis was conducted in ArcGIS to identify potential unionid concentrations. Many hot spots corresponded to unionid concentrations identified in previous surveys, though some known unionid concentrations were not detected in the analysis, and some hot spots were located where unionid concentrations had not been reported previously. The study will conclude with Phase 3, currently proposed for 2021, which will use quantitative sampling throughout the pool to generate a poolwide estimate of unionid density and population size.

57. DEVELOPMENT OF ALTERNATIVE METHODS TO DETECT *SIMPSONAIAS AMBIGUA*

Isabel P. Hannes[1], Todd J Morris[1] & Lauren Sassoubre[2]
[1]Fisheries and Oceans Canada, Burlington, ON, [2]University at Buffalo, Buffalo, NY

Simpsonaias ambigua, the Salamander mussel was designated as Endangered in Canada in 2001 and the status was re-examined and confirmed in 2011. The Salamander Mussel was historically known from several locations from the province of Ontario; currently it is only known to occur in the East Sydenham River. Traditional surveys (e.g., timed searches) to find extant populations of *S. ambigua* at large scales (e.g., within a river) can be time consuming and expensive since this species is very hard to find. There is a critical need for less costly and more effective methods to find locations where *S. ambigua* is present at larger scales. The goals of this project are 1) to develop two additional methods to identify sites (e.g., reach) where live *S. ambigua* are present and 2) compare their effectiveness of each method in detecting *S. ambigua* individuals in contrast with traditional survey methods. The first method consists of finding *S. ambigua*'s host; Mudpuppy (*Necturus maculosus*) and inspecting for signs of encysted glochidia. The second method is based on detection of *S. ambigua* environmental DNA (eDNA). A total 34 live *S. ambigua* individuals were found at four of the six sites that were surveyed using timed searches at the Sydenham River, ON. No *N. maculosus* was found during the months of July and August at any of the surveyed locations; however, *N. maculosus* was trapped during the winter months at one location. *Simpsonaias ambigua* species-specific primer-probes were designed from mitochondrial DNA sequences and were tested in silico and in vitro to validate specificity. Detection of live *S. ambigua* from populations in the wild using eDNA still needs to be conducted, but these two alternative methods seem promising at finding locations where *S. ambigua* is present.

58. NIAGARA RIVER NY MUSSEL SURVEY FINDS HIGH SPECIES RICHNESS IN THE AGE OF ZEBRA MUSSELS

Lee H. Harper[1], Isabel P. Hannes[1], Brandon J. Sansom[1] & David J. Spiering[2]
[1]Riveredge Environmental, Inc., Massena, NY; [2]New York State Office of Parks, Recreation and Historic Preservation, Grand Island, NY

Freshwater mussels have declined dramatically in the Great Lakes and connecting channels, accelerated by the introduction of *Dreissena* mussels. We performed semi-quantitative timed-search mussel surveys in the Niagara River over an 18.5-acre area on the north shore of Grand Island, Erie County, New York. These surveys were to inform the in-water design and construction of habitat restoration projects for NYS Parks. Survey cells were established and mussels were collected, identified, sexed, measured, and released. Water depth, flow, substrate, and habitat were characterized. A total of 311 grid cells were searched visually and tactilely. Nine species of mussels and 294 individuals were found. Four species are Species of Greatest Conservation Need (SGCN) but none are state or federally listed. The community was dominated (91.1% of mussels) by three species (*Fusonaia flava*, *Pleurobema sintoxia*, *Lampsilis siliquoidea*). Two species (*Ptychobranchus fasciolaris*, *Villosa iris*) had not been recorded in the Niagara River in over 70 years. Two other species (*Strophitus undulatus*, *Lasmigona compressa*) were known to occur in the watershed but had not been recorded from the Niagara River. Zebra mussels were present in 39.9% of cells but attached to mussels in only 5.8% of cells. Substrates averaged 73.7% silt and clay, 10.8% sand, 6.8% cobble, 5.8% gravel, and 2.8% boulder. Most cells (95.5%) has submerged aquatic vegetation with average percent cover of 58.2%. Over half of the cells (56.6%) had large woody debris. The habitat characteristics of mussel concentrations were used to inform the engineering designs of in-water habitat restorations by

NYS Parks. The relative abundance and species richness of mussels found in the mainstem Niagara River was found to be comparable to known refugia in the Great Lakes.

59. AN UPDATE ON UTAH MOLLUSK CONSERVATION EFFORTS

Kate Holcomb[1] & Kevin Wheeler[2]
[1]Utah Department of Natural Resources, Division of Wildlife Resources, Salt Lake City, UT, [2]Utah Department of Natural Resources, Division of Wildlife Resources, Hurricane, UT

Utah is home to about 139 species of mollusks, but 45 of these species are listed as species of greatest conservation need in the Utah Wildlife Action Plan. Utah's goal for mollusk conservation is to ensure the long-term persistence of mollusks and their habitats and prevent the need for listing under the Endangered Species Act (ESA). There have been limited efforts to understand the status and distribution of mollusks in Utah in the past, but efforts to address this goal have increased in recent decades. Much of the recent conservation effort has involved field and eDNA surveys. Working groups have also formed in an attempt to share knowledge and coordinate mollusk conservation efforts throughout Utah and surrounding states. Some important outcomes of recent mollusk conservation efforts in Utah include: (1) improved understanding of snail taxonomy, (2) determination that Bifid Duct Pyrg (*Pyrgulopis peculiaris*) was not warranted for listing under the ESA, (3) development of eDNA assays for Utah freshwater mussels, and (4) an improved understanding of *Anodonta* population genetics in the Bonneville Basin in Utah. There are still several species needing taxonomic revision, and surveys are still needed to solidify species distributions. There is also a need to identify and reduce threats to mollusks and determine whether propagation is an appropriate conservation action for some of the most imperiled species.

60. QUANTITATIVE MUSSEL SAMPLING IN THE PAINT ROCK RIVER BASIN FOR LONG-TERM POPULATION MONITORING AND SURVIVORSHIP ESTIMATION OF STOCKED JUVENILES.

Michael Buntin[1], Todd Fobian[1], Jeff Garner[2], Jesse Holifield[1], Thomas Tarpley[1] & Paul Johnson[1]
[1]Alabama Department of Conservation and Natural Resources (ADCNR), Alabama Aquatic Biodiversity Center, Marion, Alabama; [2]ADCNR, Florence, Alabama

Freshwater mussel diversity of the Paint Rock River (PPR) basin has been well documented and recent survey efforts have determined 48 of 58 historical species are extant. Additionally, multi-state planning efforts identified the PRR as a high priority locality for mussel reintroductions, which have been ongoing since 2010. Hatchery reared *Epioblasma capsaeformis* and *Venustaconcha trabalis* have been reintroduced to the basin and *Lampsilis virescens* and *Toxolasma cylindrellus* have been extended past current ranges into unoccupied historical habitats using propagated juveniles from PRR brood stock. In addition to stocking, ADCNR has established fixed monitoring stations and completed a second quantitative sampling effort in 2018. Most populations remained unchanged from 2013, although total mussel density significantly increased at one upper basin locality. Five species (*Amblema plicata*, *Villosa taeniata*, *Villosa iris*, *Toxolasma lividum*, and *Obovaria subrotunda*) had significant increases at individual sampling stations, whereas *Fusconaia subrotunda* and *Pleurobema oviforme* had significant decreases at single sites. Most changes were likely caused by drought conditions in 2016, leading to increased mortality of adults for some species while

increasing host fish densities and recruitment success of others. All four stocked species were recaptured alive during survey efforts, with only *V. trabalis* not present in the quantitative samples. Survivorship estimates of stocked mussels varied across species and sites, ranging from 0% for cohorts that weren't detected to 70% for *L. virescens* at a single locality. A newly recruited juvenile from propagated *T. cylindrellus* was also detected in the sampling, demonstrating the potential viability of the stocked mussel populations in the PRR.

61. UNIONID MUSSEL DISTRIBUTION IN THE GREATER AUSTIN AREA: AN ASSESSMENT OF MUSSEL COMMUNITIES IN STREAM TRIBUTARIES OF THE COLORADO RIVER DOWNSTREAM OF LONGHORN DAM

Liz A Johnston & Ashley Seagroves
City of Austin Watershed Protection Department, City of Austin, TX

Drastic declines of freshwater mussel populations in recent decades have sparked immense research efforts among universities, state and federal agencies, and now municipalities that are attempting to balance the needs of increasing human populations and subsequent development pressures on suburban creeks. As development pressure extends outwards from the urban cores, the protection of existing mussel communities should be considered by municipal policy makers. The first step for municipalities is to determine the status of freshwater mussels within jurisdictional areas and their contributing drainages. Previous studies from City of Austin Watershed Protection Department found many mussels in Austin reservoirs, but few have been reported in tributaries which flow into the Colorado River directly downstream of the Longhorn Dam, the last major dam in the city of Austin before the Colorado River runs into the Gulf of Mexico. The objectives of this study were to investigate the distribution, species richness, abundance, and size distributions of freshwater mussels in Austin tributaries hydrologically connected to the Colorado River downstream of Longhorn Dam. This study also aimed to detect any variation in findings with increasing drainage area. Eighty-nine randomly-selected sites were visited. Sites with sufficient water were surveyed using timed visual and tactile searches of various mesohabitats, and dry sites were searched for mussel shells. Detected mussels were identified to species and measured. Nine species and 259 live or very recently dead mussels (containing mantle tissue) were detected in this study and were found among 13 of the 19 creeks surveyed. Species richness was greater in larger watersheds, and many detected populations showed signs of recruitment. However, mussels were generally low in abundance and were less common in upper stream reaches, which had smaller drainage areas and may be more prone to desiccation. Stream reaches with larger drainage areas and more permanent water may act as refugia for remaining mussel populations. Further knowledge of the mussel communities in Austin tributaries, along with the Colorado River downstream of Longhorn Dam will assist in stream management decisions and conservation of these valuable aquatic resources.

62. DISTRIBUTION AND STATUS OF THE EASTERN PEARLSHELL (*MARGARITIFERA MARGARITIFERA*) IN NORWAY

Jon H. Magerøy[1] & Bjørn Mejdell Larsen[2].
[1]Norwegian Institute for Nature Research, Gaustadalléen 21, 0349 Oslo, Norway; [2]Norwegian Institute for Nature Research, P.O. Box 5685 Torgarden, 7485 Trondheim, Norway

Norway is one of the last strongholds of the eastern pearlshell (Margaritifera margaritifera), with about two thirds of the remaining European populations. The pearlshell is found in all 18 regions of Norway. Within these regions, the mussel is commonly found in rivers/streams close to

the coast and at lower elevations inland. However, the species is in decline in Norway too. Originally, the pearlshell was present at over 600 sites. Currently it is only present at ca. 420 sites and juvenile recruitment is insufficient to maintain the populations at ca. half of these sites. The greatest decline has occurred along the southern coast (Sørlandet), where ca. 90 % of the populations have gone extinct. Declines have also been substantial in the southeastern part (Østlandet), along the southwestern coast (Sørvestlandet) and in the northernmost region (Finnmark), where ca. 20-50 % of the populations have gone extinct. The situation is better in the central and in most of the northern part of the country, where less than 20 % of the populations have gone extinct. The greater extinction rates in the southern part of the country is probably caused by three main factors: 1. Eutrophication due to intense farming and high population levels. 2. High levels of acidic precipitation during the latter half of the 20th century. 3. Chemical pollution due to many industrial centers. The decline in the northernmost region is more difficult to explain, but may be due to pollution from Russian industrial centers. Fortunately, eutrophication, acidification and chemical pollution has declined over the last decades in Norway. Thus, we see a mixed trend, with many populations continuing to decline while some recover. Further reduction in pollution, along with mitigation of threats like hydro power regulation, is needed for the recovery of threatened pearlshell populations in Norway.

63. INTO THE DEEP: FRESHWATER MUSSEL DISTRIBUTION BY DEPTH IN TEXAS RIVERS

Jeremy D Maikoetter, Jacob D Owen, David McBee & Krista McDermid
Zara Environmental, Manchaca, TX

Zara Environmental, LLC. (Zara) has been conducting freshwater mussel surveys for private sector and government agencies since 2010. Texas hosts 15 state-listed freshwater mussel species, one of which is federally listed as endangered and five of which are currently candidates for federal listing. Key to survey protocol development is an understanding of the habitat in which the surveys are to take place. Much of the published literature relating to Texas freshwater mussel habitat focuses on depth only as a subset of velocity. Only a few examples of species distribution by depth exist in the literature, and most indicate that unionids are more commonly found in shallow water, many in two meters or less; however, this may reflect a bias in sampling efforts of shallow waters rather than a true ecological tendency. While the sampling frames represented by our work were not random (due to client needs being primarily fully exhaustive), numerous basins and mesohabitats have been sampled by Zara. Utilizing a large data set of 4,371 live mussels encountered across five river basins, we have found that several Texas species occur at depths exceeding three meters. Specifically, on two sampling sites within the Trinity River, we also determined that surveying randomized quadrats totaling 625 m^2 is adequate for detecting presence of all but rare species. This suggests that freshwater mussel surveys in Texas should include a variety of depths and mesohabitats in order to determine species composition and abundance and that the use of SCUBA is an effective method of surveying mussel habitat in deep water.

64. *GONIDEA ANGULATA* (WESTERN RIDGED MUSSEL) LIFE HISTORY AND STATUS ON CTUIR CEDED TERRITORY, OREGON.

Alexa Maine[1], Christine O'Brien[2] & Donna Nez[3]
[1]Confederated Tribes of the Umatilla Indian Reservation, Walla Walla, WA; [2]Browns River Consultants LLC, Waynesville, NC; [3]CTUIR Pendleton, OR

The Confederated Tribes of the Umatilla Indian Reservation's (CTUIR) Freshwater Mussel Project monitors mussel populations throughout Southeastern Washington and Northeastern Oregon, USA. Historically, *Gonidea angulata*, Western Ridged Mussel, has been found from southern British Columbia to southern California, eastward to Nevada and Idaho. Status surveys located *G. angulata* in the following river drainages on CTUIR ceded territory: Grande Ronde, Middle Fork John Day, North Fork John Day, Owyhee, and Umatilla. This long lived (60+ years) monotypic species can be found in a variety of stable habitats ranging from consolidated sand to boulder dominated habitat in mid to lower reaches of riverine systems. Host fish have been confirmed as Cottus sp. (sculpin) using laboratory and field studies. The hookless glochidial shell is subtriangular with a slight nipple-like extension on the ventral valve. The shell measures 169.8 ± 17 µm in height and 172.2 ± 10 µm in length. Since initial surveys conducted in 2005, die-offs and population declines at monitoring sites have been reported in the lower Grande Ronde, lower Middle Fork John Day, and Owyhee rivers. For example, one of the most densely populated sites identified during 2005 surveys showed abundance of *G. angulata* of up to 500 mussels/m^2, and when resurveyed in 2010 abundance had dropped to 0 mussels/m^2. Additional follow up surveys conducted in 2013 reported a 13% percent decline of *G. angulata* in Middle Fork John Day sites. The reason(s) for the die-offs may be a result of environmental changes, including but not limited to climate change, agricultural impacts, algal blooms, and invasive species, however further research is needed to determine site-specific causes.

65. A PRELIMINARY EXPLORATION INTO THE STATUS OF FRESHWATER MUSSELS IN THE PIPESTEM RIVER, ND

Kyle I McLean & David M Mushet
U.S. Geological Survey, Northern Prairie Wildlife Research Center, Jamestown, ND

Widespread declines of unionid mussel populations across North America have been documented during recent decades. These declines have been associated with reductions in the crucial ecosystem functions performed by mussels. However, the status of mussel populations in the northern Great Plains of the United States is relatively unknown due to a lack of research and monitoring in this region. In an effort to expand our knowledge on the relationship between freshwater mussels and stream hydrology, water quality, and morphology in the northern Great Plains, we conducted a survey of mussels along twelve, 100-m, stream-reaches of the Pipestem River in central North Dakota. We then compared mussel diversity, frequency, and density to characteristics of the stream-reaches we sampled. The 12 stream-reaches were distributed between the river's headwaters and its downstream entry into the Pipestem Reservoir. We used a combination of timed snorkel-searches and 1-m^2 quadrat surveys in each reach to identify mussel presence, distribution, and density by species. We found only two mussel species, giant floater (*Pyganodon grandis*) and white heelsplitter (*Lasmigona complanata*), in our surveys. Four of the 12 reaches sampled were void of mussels. The giant floater was by far the most abundant of the two species with up to 53 individuals in a single 1-m^2 quadrat. In the Pipestem, water depth and stream permanency were significant predictors of mussel occurrence and density. Mussels were not found in the three, upper reaches of the Pipestem, which were characterized by narrow channels and intermittent hydroperiods. Density and

distribution increased towards the middle portions of the river and declined again as we approached the downstream reservoir. While we did see changes in water clarity and bank degradation, these impacts were likely outweighed by the influence of intermittent inundation in the headwaters and periodic flooding of the reach nearest the reservoir.

66. CONSERVATION STATUS OF *CYCLONAIAS TUBERCULATA* (PURPLE WARTYBACK) IN CANADA

Kelly A. McNichols-O'Rourke, Margaret N. Sheldon & Todd J. Morris
Fisheries and Oceans Canada, Burlington, ON

Cyclonaias tuberculata is a candidate species for assessment by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). Currently the species is limited to three subpopulations in Canada, the Ausable, Sydenham and Thames rivers in southwestern Ontario – the northern limit of their range. The distribution of this species has decreased by approximately 60% since 1997, as it was historically also found in Lake Erie and the Detroit River. Very little is known about this species in Canada, and studies were initiated at Fisheries and Oceans Canada (DFO) in 2018 to provide insight into the age and reproductive timing windows of the species. Although the species is dioecious, the shell does not exhibit sexual dimorphism, therefore, gonad fluid was taken from a minimum of five individuals at nine different sampling events from early June until mid-October. Sperm were observed at all but one sampling event (Aug. 8, 2018), however the highest amounts were in October. Eggs were observed at five of the sampling events with the highest number in October. Host fish(es) for *C. tuberculata* have not been confirmed in Canada, however the assumption is that they are similar to those confirmed in the USA – Channel Catfish, Black and Yellow bullheads. These fishes are wide spread throughout southwestern Ontario and do not appear to be limiting the mussel population. Fifty-three shells were collected for ageing purposes ranging from 12.58 mm to 138.04 mm and preliminary data suggest an age of up to 46 years. The main threats affecting *C. tuberculata* include pollution from agriculture and urban runoff and climate change. These are chronic threats that most likely interact with each other, however specific studies that address either the short or long-term effects on *C. tuberculata* have not been completed.

67. REFINEMENT OF eDNA AS AN EARLY MONITORING TOOL AT THE LANDSCAPE-LEVEL: STUDY DESIGN CONSIDERATIONS

Emy Monroe[1], Katherine Bockrath[1], Richard Erickson[2], Christoper Merkes, Nicholas Berndt[1], Jeena Credico[1], Katherine Bockrath[1], Nikolas Grueneis[1], Jenna Merry[1], Kyle Mosel[1], Maren Tuttle-Lau[1], Kyle Von Ruden[1], Zebadiah Woiak[1], Kelly Baerwaldt[1], Sam Finney[1] & Jon Amberg[2]
[1]U.S. Fish & Wildlife Service (USFWS), Onalaska, WI; [2]U.S. Geological Survey (USGS), La Crosse, WI

Natural resource managers use data from survey or monitoring efforts that use a wide variety of tools. Environmental DNA (eDNA) is a genetic surveillance tool for detecting species and holds potential as a tool for large-scale monitoring programs. Two challenges of eDNA-based studies are imperfect capture of eDNA in collection samples (e.g., water field samples) and imperfect detection of eDNA using molecular methods (e.g., quantitative PCR), which create uncertainty about sample designs for eDNA-based monitoring. We used an occurrence model to address these challenges and determine how many samples were required to detect species using eDNA and to examine when and where to take samples. Water samples were collected from three different habitat types in the Upper Mississippi River when both Bighead Carp and Silver Carp were known to be present based on telemetry detections. Each habitat type was sampled during April, May and November.

Detections of eDNA for both species varied across sites and months, but were generally low, 0 - 19.3% of samples were positive for eDNA. Additionally, we found statistical artifacts where sample eDNA capture probabilities would artificially inflate estimates of molecular detection probabilities. Overall, we found that eDNA-based sampling holds promise to be a powerful monitoring tool for resource managers, however, limitations of eDNA-based sampling include different biological and ecological characteristics of target species as well as aspects of different physical environments that impact the implementation of these methods.

68. FIRST RECORD OF *PYGANODON LACUSTRIS* IN ONTARIO, CANADA?

Todd J Morris[1], Fraser Gibson[1], Kelly A McNichols-O'Rourke[1], Magaret N Sheldon[1] & Dave T Zanatta[2]
[1]Fisheries and Oceans Canada, Burlington, ON; [2]Central Michigan University, Mount Pleasant, MI

In July 2018, several individuals of the genus *Pyganodon* were collected by an amateur malacologist in Little Sheguiandah Lake within the boundary of Killarney Provincial Park in the Lake Huron drainage of south-central Ontario, Canada. Photos of the specimen were sent to Fisheries and Oceans Canada in Burlington, Ontario for identification and it was confirmed that the specimens were not *Pyganodon grandis*, the only *Pyganodon* known to occur in the area. The images were shared with regional experts and it was determined that the shells most closely resembled *Pyganodon lacustris*, a species not previously recorded from Ontario but known to occur nearby in Michigan. In September 2018, Fisheries and Oceans Canada visited the site of the original collection in Little Sheguiandah Lake and two nearby sites in George Lake. Surveys were conducted at the three sites by snorkelling the nearshore habitat less than 2 m deep for either 7.5 person-hours (Little Sheguiandah Lake) or 2.5 person-hours (George Lake). At the site of the original collection in Little Sheguiandah Lake 42 *Elliptio complanata* were collected along with 24 specimens of the unknown *Pyganodon*. No live animals of any species were collected within George Lake. *Pyganodon* specimens were measured in the field, photographed (right valve, left valve and dorsal view) and preserved in 95% ethanol after relaxation. Morphometric and DNA barcoding analyses were completed on each specimen to confirm identifications.

69. ASSESSING THE RECOVERY OF FRESHWATER MUSSEL POPULATIONS FOLLOWING DAM REMOVALS

Vincent P Santini & Michael M Gangloff
Appalachian State University, Boone, NC

Presently we are experiencing the planet's sixth mass extinction event and currently >70% of all North American mussels are considered imperiled. This is largely attributable to widespread anthropogenic modification of stream habitats. Recently, there has been a substantial societal push for removal of dams in order to increase habitat connectivity and ecosystem function. However, although dam removals may also impact tailwater habitats and communities, few studies have examined long-term impacts to downstream reaches. Additionally, relatively few dam removal projects quantify downstream mussel populations, habitat conditions and watershed LULC conditions. Our goal is to address this gap by examining the long-term impacts of dam removal on freshwater mussel populations. We hope to examine streams east of the Mississippi River where dams have been removed during the last two decades. Mussel surveys will be conducted in both the former dam tailwater as well as at reference sites up- and downstream of the former impoundment. We will prioritize sites where pre-impoundment survey data were collected but the study design does not necessitate that pre-removal data are available. We are seeking information on

previously removed dams in streams with freshwater mussel populations as well as collaborations with state and federal agencies and non-governmental agencies involved in dam removals. Data from this study will provide important context for understanding the recovery of mussel populations following dam removals as well as provide context for future dam-removal projects.

70. CLAM COUNTER: A CANADIAN APP FOR CITIZEN SCIENTISTS

Margaret Sheldon[1], Kelly McNichols-O'Rourke[1], Todd Morris[1] & Mary-Kate Whibbs[2]
[1]Fisheries and Oceans Canada, Burlington, ON; [2]Toronto Zoo, Scarborough, ON

In spring 2017, Fisheries and Oceans Canada (DFO) and the Toronto Zoo launched Clam Counter. The Clam Counter app is available for both Android and IOS devices and is also available in a standalone web version. It represents the second generation of Canadian freshwater mussel apps following DFO's release of the first generation Canadian Freshwater Mussel Guide in 2012. Clam Counter allows amateur and professional malacologists to identify and report collections of Canada's 55 freshwater mussel species. The app functions as a field guide with detailed information for each Canadian species including a physical description, specimen images, and Canadian range maps. To assist with species identification, the app includes an interactive key which filters the potential species list based on the physical characteristics present/absent. With the built in GPS capabilities of their device, users are able to restrict the list of potential species by tertiary watershed. Identifications can be reported through the app along with the geographic location, general habitat information, and photo vouchers. To date, Clam Counter has been installed 652 times with approximately 155 regularly active users throughout Canada from coast to coast. Forty species reports have been submitted over the two field seasons the app has been running. Once verified, DFO and the Toronto Zoo are able to incorporate the records into a national database maintained by DFO. The reported submissions provide a broader scope of unionid collections beyond what would be capable through professional organizations alone. These data will assist in refining species distributions throughout the country and providing more accurate information to future app users. Fisheries and Oceans Canada and the Toronto Zoo are continuing refinements and content updates of Clam Counter.

71. MONITORING CHANGES TO INTERSTITIAL SEDIMENTS IN THE SOUTH TOE RIVER USING FREEZE CORES

Michael J Thompson[1], Chantelle Rondel[1], Jason Mays[2] & Michael Gangloff[1]
[1]Appalachian State University, Boone, NC; [2]United State Fish and Wildlife Service, Asheville, NC

Fine sediments are widely believed to impact freshwater biodiversity, however, quantifying fine sediment composition at a scale that is meaningful to interstitial invertebrates can be challenging. The South Toe River is a headwater of the Tennessee River in western North Carolina and supports a population of endangered Appalachian elktoe (*Alasmidonta raveneliana*) mussels. As part of a larger project to assess impacts of a highway expansion project on this stream we are monitoring surface and interstitial sediment composition using freeze-core sampling. Mussel populations, instream habitat (including surface substrate composition) and interstitial sediments were quantified at 6 long-term monitoring sites in the South Toe River beginning in spring 2017. Freeze cores were collected by pounding galvanized iron tubes into the streambed and filling them with crushed dry ice. Tubes were left in place for 20 minutes before being extracted from the substrate. Sediments remaining on each tube were removed, dried, sieved and weighed. We computed the proportion of each sediment size fraction retained on

sieves. Surface substrate composition was highly variable both among sites and seasons but did not exhibit any meaningful longitudinal trends. In contrast, the concentration of interstitial fines was highest downstream of Little Crabtree Creek, a heavily-impacted stream flowing through the highway road cut. Downstream of Little Crabtree Creek the concentration of interstitial fines measured at 7.78%, compared to 2.50% at all remaining sites. These data suggest that highway construction projects have impacts on freshwater mussel habitats that may be undetectable using conventional methods of habitat measurement (i.e., Wolman pebble counts). Additionally they suggest that freeze cores are a viable method for sampling interstitial substrates in montane streams and provide insights into habitat changes that may not be evident from measurements of surface substrate conditions.

72. TESTING FORMULAS OF THE CONDITION INDEX ON *SINANODONTA WOODIANA*

Maria Urbańska[1], Nicoletta Riccardi[2], Wojciech Andrzejewski[1], Henryk Gierszal[3], Małgorzata Ożgo[4] & Patryk Gapski[1]
[1]Institute of Zoology, Poznań University of Life Sciences, Poznań, Poland; [2]CNR IRSA - Water Research Institute, Verbania-Pallnza, Italy; [3]Department of Applied Computer Science, Adam Mickiewicz University, Poznań, Poland; [4]Department of Evolutionary Biology, Kazimierz Wielki University, Bydgoszcz, Poland

The condition index has previously been shown to be a useful measure of the well-being of bivalves. It can vary relative to size of the shell, period of the year, environmental factors and above all to the food availability and reproductive stage. Seasonal changes of environmental factors lead to complex interactions between temperature and food which influence somatic growth and reproduction and indirectly, the condition index, too. A variety of condition indices (CIs) have been used to express the well-being of bivalves. Most of the formulas are based on dissected tissue hence cannot be used for highly rare and protected species of mussels. We will present preliminary results of CIs comparison related to alien and invasive *Sinanodonta woodiana* which specimens were taken from habitats of different characteristics. We have compared a few CI formulas to check if such different expressions can give reasonable and comparable results also for nonnative species and if the method based on alive mussels measurements (e.g.: CI = TWM / L x H x W, where TWM - total wet mass, L - shell length, H - shell height, W – shell width) can be used for evaluation of the mussels well-being to provide acceptable results about the mollusk conditions.

73. HABITAT UTILIZATION AND IMPACT OF FLOODING ON JAMES SPINYMUSSEL (*PARVASPINA COLLINA*) POPULATIONS IN VIRGINIA STREAMS

Christine A Verdream & Christine May
James Madison University, Harrisonburg, VA

Considering the ecosystem services that mussels provide and their high percentage of threatened species, specifically over half the freshwater mussels in Virginia, one avenue for future research could prioritize upstream mussels in downstream conservation plans. This project will provide information that could be applied to recovery plans for mussels in the James River watershed. In addition, the results will help bridge the gap between studies in freshwater and coastal systems through informing the release of propagated mussels to high survival habitats. Thus, increasing nutrient retention before reaching coastal systems. The objectives of the proposed research are: determine the relationship between flood disturbance and mussel population dynamics (abundance and variation through time), compare a stream with flood

disturbance to a dammed stream without flooding to determine if flooding drives a source-sink dynamic, and identify habitat preferences for *Parvaspina collina*. Analysis will use a four-year mark-recapture data set for sites in the James River watershed. Including a comparison of immigration and emigration between flooding events. A population viability analysis will be conducted to quantify extinction to determine if transiency is resulting in a source-sink dynamic. Furthermore, habitat preferences will be determined between two streams through a comparison and analysis of substrate, base-flow, water depth and velocity, and distance to the stream bank in areas where mussels have persisted. Our observations suggest that many mussels are temporarily occupying unstable habitats, understanding where mussels are most likely to survive and reproduce is crucial to identifying potential habitat and determining where propagated mussels should be released. Understanding the effect flooding has on *P. collina* populations can be vital in restoring the diminishing population and other endangered mussels in flood prone streams. Restoring populations will have positive ramifications for the filtration capacity of the populations of mussels in upland waters, benefiting nutrient retention downstream.

74. FRESHWATER GASTROPOD DISTRIBUTION IN NORTHEASTERN ILLINOIS, A CENTURY OF UNPRECEDENTED CHANGE

Rachel Vinsel
Illinois Natural History Survey, Champaign, IL

Northeastern Illinois, also referred to as “Chicagoland”, is home to five river basins and unique, formerly diverse, aquatic habitats. Chicagoland now houses over half of Illinois’ human population and thousands of miles of roads and railways, which often traverse aquatic habitats. Freshwater gastropods are the most imperiled group of mollusks in North America (Johnson 2013) yet the focus of most conservation efforts has been on freshwater mussels. Nearly 75% of North American gastropods (523 of 706 species) are believed to be extinct, endangered, or vulnerable, nevertheless protective status has been established for less than 10% of these species. A similar pattern persists in Illinois, as only 6 of 74 taxa are state or federally protected or established as in need of conservation. However, in 2015 the Illinois Department of Natural Resources placed nearly all native gastropods on a “watch list” to promote research on current status and distributions. While much of Illinois lacks current sampling data, gastropods have been collected in concert with bivalves at many sites in Chicagoland during Illinois Department of Transportation or Illinois Tollway surveys. We present the modern snapshot these roadway surveys provide and compare to historical knowledge on the distributions of native freshwater gastropods. Additionally, we examine range expansions of invasive gastropods and identify knowledge gaps.

NOTES

From the 2019 Biennial Symposium Planning Committee:

THANK YOU for making the 2019 Symposium a success!!!
We look forward to the 2021 meeting!