National Conference on Engineering & Ecohydrology for Fish Passage

June 5-7, 2012

University of Massachusetts Amherst

Conference Program

Thanks to our sponsors..

Benefactors

USGS science for a changing world

National Program FISH PASSAGE Creating Aquatic Possibilities

University of Massachusetts Amherst 1863

U.S. Fish & Wildlife Service — Department of the Interior

National Oceanic and Atmospheric Administration — NOAA — U.S. Department of Commerce

Sponsors

Brookfield

Supporters

AIL Atlantic Industries Limited

HDR

SumCo Eco-Contracting

Gomez and Sullivan Engineers, P.C. — Engineers and Environmental Scientists

Normandeau environmental consultants

ALDEN

Kleinschmidt

Welcome to Fish Passage 2012

The National Conference on Engineering & Ecohydrology for Fish Passage

Fish passage 2012 is intended for researchers, educators, practitioners, funders, and regulators who have an interest in advancements in technical fishways, nature-like fishways, stream restoration and stabilization, dam removal, road ecology, and the myriad of funding, safety, climate change, and other social issues surrounding connectivity projects.

Advancing the science and practice of fish passage requires the integration of skills from three areas:

- Engineering and Water Resources
- Biology and Ecology
- Management and Social Factors

Fish Passage 2012 is intended to bring together professionals from these areas to share information and ideas across disciplines. To accomplish this, contributed presentations are presented in four tracks, each covering a myriad of topics that span the three areas. In addition, each morning session begins by keynote, featured, or plenary speakers addressing topics that range from climate change to broad policy issues.

Organizing Committee

Ted Castro-Santos,

USGS

Brett Towler,

USFWS

John Catena,

NOAA Restoration Center

David Ahlfeld,

UMass CEE

Kevin Moody,

FHWA, USDOT

Austin Polebitski,

UMass CEE

Susan Wells,

National Fish Passage Program

Conference Advisory Board

The Conference Advisory Board consists of experts from academia, government, non-governmental organizations and industry. Board members evaluate abstract submissions, recommend invited presenters, advise on session topics, and serve as conference ambassadors.

Margaret Lang,

Chair (Humboldt State University)

Colin Lawson,

Trout Unlimited

Bryan Arroyo,

USFWS

Stephanie Lindloff,

American Rivers

Alison Bowden,

The Nature Conservancy

Mike McGowan,

HDR

Scott Jackson,

UMass Amherst

Brian Stetson,

Brookfield Renewable Power

Paul Jacobson,

EPRI

Hans Tritico,

Youngstown State University

Paul Kemp,

University of Southampton, UK

Amy Unthank,

US Forest Service

Dan Kuzmeskus,

USFWS retired

Laura Wildman,

Princeton Hydro

Guide to Program

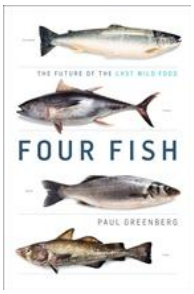
Keynote Speaker for the 2012 Conference:

Rebecca Wodder - Senior Advisor to The Secretary of the Interior

From 1995 to 2011, Ms. Wodder served as president of American Rivers, directing the strategic, programmatic and financial operations of this national nonprofit conservation organization. During her tenure at American Rivers, she led efforts to help dozens of communities restore the health of their rivers through innovative conservation measures such as the creation of river trails, the removal of obsolete and dangerous dams, and the implementation of green infrastructure solutions to safeguard clean water. In 2010, she was recognized as one of the Top 25 Outstanding Conservationists by Outdoor Life Magazine, and was named Woman of the Year by the American Sportfishing Association in 1998. Ms. Wodder is currently serving as senior advisor to The Secretary of the Interior working primarily on conservation issues and the "America's Great Outdoors" initiative.

Featured Speaker for the 2012 Conference:

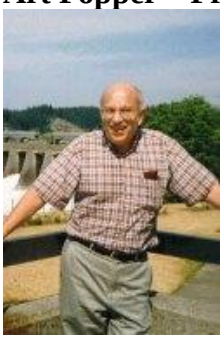
Paul Greenberg - Author of Four Fish



Paul Greenberg is the James Beard award-winning author of the New York Times bestseller and Notable Book Four Fish: The Future of the Last Wild Food. A regular contributor to the New York Times' Opinion Page, Magazine, Dining section, and Book Review, Greenberg lectures widely on seafood and ocean sustainability. His lecture venues include Google, the United States Senate, the United States Supreme Court, the Monterey Bay Aquarium, the New England Aquarium, The Culinary Institute of America, Brown University, Williams College, Yale University's Peabody Museum, Chefs Collaborative National Summit, SeaWeb's Seafood Summit, and Paine & Partners annual shareholders meeting.

Plenary Speaker(s) for the 2012 Conference:

Art Popper – Professor in the Department of Biology at the University of Maryland



Prof. Arthur N. Popper is co-Director of the Center for Comparative and Evolutionary Biology of Hearing and Professor in the Department of Biology at The University of Maryland. Dr. Popper's research includes understanding basic structure and function of the auditory system in fishes and other vertebrates. He has applied his research on fish bioacoustics to examine the behavioral and physiological effects of human-generated (anthropogenic) sound on fish. Over the past several years, his research group has investigated the effects on fish of seismic air-guns, sonar, increased background levels, and sounds associated with barging of fish. Most recently, his lab has been completing the first quantified studies of the effects on fishes of the very high intensity sounds produced during pile driving.

Panelists for Climate Change and Fish Passage Plenary:

Paul Anderson

Paul Anderson currently works for the USDA Forest Service as a Staff Engineer in the Washington Office. He has worked in Forest Service Roads and Planning related assignments for the last 35 years. Paul has been involved in Aquatic Passage issues for the last 15 years. He is involved in writing Aquatic Passage and watershed restoration policy and direction for the USDA Forest Service.
Paul has a Bachelor's Degree in Forest Management from the University of Massachusetts, Amherst and a Master's Degree in Forest Engineering from Oregon State University.
He has championed restoration of road related impacts on National Forest System Lands for the last 23 years. He worked to as the regional Transportation Planner and restoring wet meadow habitat in New Mexico and Arizona for 10 years. In the Pacific Northwest, he worked on Salmon Recovery and restoring aquatic habitat connectivity.

Paul Jacobson

Dr. Jacobson currently manages EPRI's Waterpower Program, which encompasses conventional hydropower as well as marine and hydrokinetic technologies. His professional work over the past 25 years has focused on environmental assessment in aquatic ecosystems. Prior to joining EPRI in September, 2009, he worked in the environmental consulting arena, most recently for 13 years as the founder and principal scientist of Langhei Ecology, LLC. Dr. Jacobson's specialty is design, analysis, and interpretation of monitoring and assessment programs to support environmental decision-making. For three years he served as the chairman of the Maryland Water Monitoring Council (a collaborative organization encompassing federal, state and local government agencies, NGOs, and for-profit organizations) and has served on the boards of local, environmental foundations. Since 1998, Dr. Jacobson has been a faculty member of the Johns Hopkins University, Krieger School of Arts and Sciences, where he teaches a graduate course on ecological assessment.

Keith Nislow

Dr. Nislow conducts research on the relationship between land use, aquatic habitat, and the distribution, abundance of fish and aquatic invertebrates. Specializing in establishing explicit, mechanistic links between environmental variation with the behavior, growth, and survival of stream salmonid fishes, Dr. Nislow is particularly interested in using basic science to assist restoration, conservation, and management. Dr. Nislow currently serves as a technical adviser to the Connecticut River Atlantic Salmon Commission, and the Green and White Mountain National Forests, and as an Associate Editor of the North American Journal of Fisheries Management.

Richard Palmer

Richard Palmer is the Department Head and Professor of Civil and Environmental Engineering at the University of Massachusetts Amherst. From 1979 to 2008, he was a professor at the University of Washington in Seattle, Washington. Dr. Palmer received his Ph.D. from the Johns Hopkins University in 1979, his Master's of Science in Environmental Engineering from Stanford University in 1973, and his undergraduate degrees from Lamar University. His primary areas of interest are in the impacts of climate change on water resources, drought planning, real-time water resource management, and the application of decision support to civil engineering management problems. He has received numerous awards from the American Society of Civil Engineers. He is the Principal Investigator of the new North East Climate Science Center, funded by the Department of Interior, which is a five year project to evaluate the impacts of climate change.

List of Exhibitors

Alden Research Laboratory, Inc., 30 Shrewsbury Street, Holden, MA

Atlantic Industries Limited, PO Box 1006, 3155 Route 935, Dorchester, New Brunswick, E4K 3V5 Canada

BioSonics, Inc., 4027 Leary Way NW, Seattle, WA 98107

Blue Leaf Environmental, Inc., 2301 W. Dolarway Rd, Suite 3, Ellensburg, WA 98926

Brookfield Renewable Energy Partners L.P., 200 Donald Lynch Blvd, Marlborough, MA 01752

UMass Civil & Environmental Engineering, 18 Marston, UMass Amherst, MA 01003

Fuss & O'Neill, Inc., 146 Hartford Road, Manchester, CT 06040

Geosyntec Consultants, Inc., 289 Great Road, Suite 105Acton, MA 01720

Gomez and Sullivan Engineers, P.C., 41 Liberty Hill Road, Building 1, P.O. Box 2179, Henniker, NH 03242

HDR, Inc., 8404 Indian Hills Drive, Omaha, NE 68114-4098

Kleinschmidt Associates, P.O. Box 650, 141 Main Street, Pittsfield, ME 04967

Lotek Wireless Inc., 115 Pony Drive Newmarket, Ontario Canada L3Y 7B5

Milone & MacBroom, Inc., 99 Realty Drive, Cheshire, CT 06410

The National Fish Passage Program, USFWS, 1849 C Street, NW, Washington, DC 20240

Normandeau Associates, 917 Route 12, #1, Westmoreland, NH 03467

Oregon RFID, 4246 SE Ogden St Portland, Oregon 97206-8452

Smith-Root, Inc., 14014 NE Salmon Creek Avenue, Vancouver, Washington 98686

S.O. Conte Anadromous Fish Research Center, One Migratory Way, P.O. Box 796, Turners Falls, MA 01376-0796

SumCo Eco-Contracting, LLC, 16 Front Street, Suite 206, Salem, MA 01970

Worthington Products, Inc., 3405 Kuemerle Avenue N.E., Canton, OH 44705

YSI, Inc., 13 Atlantis Dr., Marion, MA 02738

Detailed Program

Tuesday - June 5th (Morning Session)				
Time	**Track A (Room 165/169)**	**Track B (Room 101)**	**Track C (Room 163C)**	**Track D (Reading Room – Upstairs)**
8:30	**Welcome to Conference (Campus Center Auditorium)**			
8:35	**Keynote Speaker: Rebecca Wodder, Senior Advisor to the Secretary of the Interior**			
9:20	**Plenary Speaker: Prof. Arthur Popper, Department of Biology at the University of Maryland**			
10:05	**Break**			
	Session A1: Fish Passage Policy and Design Resources Moderator: Bill McDavitt	**Session B1: Emerging Species of Design Concern Moderator: John Catena**	**Session C1: Functional Framework for Stream Assessment and Restoration Moderator: Gian Dodici**	**Session D1: The Use of CFD to Improve Passage Moderator: Greg Allen**
10:30	A. Hoar; History of fish passage public policy (pg. 17)	B. Kynard; Behavior, impingement, and entrainment of shortnose sturgeon at a vertical bar rack: with and without a bypass orifice (pg. 34)	R. Starr; Stream Functions Pyramid Framework (pg. 50)	G. Lemay; Susquehanna River Two-Dimensional Hydraulic and Habitat Modeling (pg. 69)
10:50	P. Brownell; Diadromous Fish Passage: A Primer on Technology, Planning, and Design for the Atlantic and Gulf Coasts (pg. 17)	K. Long on behalf of R. Bleistine; Biological and Engineering Studies of American Eel Anguilla Rostrata at the Conowingo Project (pg. 35)	W. Harman; Applying the Stream Functions Pyramid to Geomorphic Assessments and Restoration Design (pg. 51)	M. Rashid; Application of CFD Models in Support of Fish Passage Facilities Design (pg. 69)
11:10	S. McClain; Examining State Fish Passage Laws: Applicability and Enforcement (pg. 18)	T. McCarthy; Management of migrating European eel (Anguilla anguilla) in Irish rivers used for hydropower generation. (pg. 36)	S. Stranko; Comparing the Fish and Benthic Macroinvertebrate (pg. 51)	G. Hecker; CFD Improves Upstream Fish Passage at Hadley Falls (pg. 70)
11:30	J. Turek; Status and Overview of Federal Interagency East Coast Fish Passage Manual (pg. 18)	A. Haro; Effect of Upstream Fish Passage Structure Entrance Design and Head Differential on Attraction and Entry of Adult American Shad (pg. 36)	B. Hutzell; Case Study - Project Application of the Stream Functions Pyramid Framework (pg. 52)	J. Richardson; The Efficacy of CFD Modeling at Brunswick Station (Maine) (pg. 70)
12:00	**Lunch – Campus Dining Common of Your Choice**			

Tuesday - June 5th (Afternoon Session)				
Time	**Track A (Room 165/169)**	**Track B (Room 101)**	**Track C (Room 163C)**	**Track D (Reading Room – Upstairs)**
	Session A2: Tackling Up and Downstream Fish Passage in Europe Moderator: Herman Wanningen	**Session B2: Prioritizing Barrier Removal for Connectivity Moderator: Scott Jackson**	**Session C2: Stream Simulation Methodologies Moderator: Bryan Sojkowski**	**Session D2: 3D Acoustic Telemetry in Fish Passage Research Moderator: Tim Hogan**
1:30	O. Calles; A historical perspective on downstream passage at hydroelectric plants in Swedish rivers (pg. 19)	S. Jackson; Critical Linkages: Assessing Connectivity Restoration Potential for Culvert Replacement and Dam Removal in Massachusetts (pg. 37)	S. Koenig; The art and science of assessing stream gradient and bankfull width (pg. 52)	T. Hogan; Use of 3D Acoustic Telemetry to Monitor Upstream Passage of American Shad on the Merrimack River in Massachusetts (pg. 71)
1:50	K. Dorst; Free access for riverine fish along the Dutch Rhine, hydraulics and construction of the Dutch Rhine fishways (pg. 19)	D. Kohtio; Identifying Opportunities for Barrier Removal and Fish Passage Improvements within the Hudson-Raritan Estuary (pg. 38)	W. Rice; Bed and Bank Design Considerations When Selecting Culvert Width (pg. 53)	D. Deng; A cabled acoustic telemetry system for detecting and tracking juvenile salmon (pg. 71)
2:10	I. De Vries; Following a river basin approach for optimal fish passage in the boundary crossing River Vecht (pg. 20)	R. Schiff; Assessing, Prioritizing, and Implementing Numerous Small Culvert AOP Projects in a Short Period of Time - A Case Study of a Time (pg. 38)	R. Gubernick; Stream Simulation: Analytical versus Standards based design methodology (pg. 53)	L. Sullivan; Juvenile Steelhead Survival and Predator-Prey Interactions Using JSATS through the Priest Rapids Reservoir in 2011 (pg. 72)
2:30	A. Maltby; Living North Sea project & community approaches to fish migration in Europe (pg. 20)	J. Conyngham; Assessing fish passage connectivity at the watershed scale: Truckee River case study (pg. 39)	J. Perry; Stream Simulation in the DOT World: The Challenges, the Constraints, and the Costs (pg. 53)	
3:00	**Break**			

Tuesday - June 5th (Afternoon Session)				
Time	**Track A (Room 165/169)**	**Track B (Room 101)**	**Track C (Room 163C)**	**Track D (Reading Room – Upstairs)**
	Session A3: Fish Guidance Systems Moderator: Ralph Nelson	**Session B3: Assessing Impact of Road Crossings on Connectivity Moderator: Hans Tritico**	**Session C3: Nature-Like Passage and Stream Restoration Moderator: Margaret Lang**	**Session D3: Monitoring and Evaluation Moderator: Brett Towler**
3:25	C. Burger; Graduated-Field, Pulsed-DC Fish Guidance Technology: Successes, Challenges and New Concepts (pg. 21)	H. Tritico; Assessing Fish Passage through Culverts in Midwest Streams: Identifying Design Parameters that Correlate with Passage Success (pg. 40)	J. Louisos; Fish Passage Restoration at the Briggsville Dam: Using Sediment Transport Analysis for Natural Channel Design (pg. 54)	B. Towler; Fish Passage Monitoring, What's really going on out there? (pg. 73)
3:45	S. Scott; Fish passage survival improvements measured at Positive Barrier Guidance Systems (pg. 21)	M. Diebel; Road crossings limit nothern pike access to seasonal spawning habitat (pg. 40)	S. Mahlum; Understanding Stream Connectivity: Linking Structure with Fish Community (pg. 55)	A. Ficke; Evaluation of two rock ramp fishways in a Colorado transition-zone stream (pg. 73)
4:05	P. Parasiewicz; Neptun: the electronic guidance system that effectively manages fish movement in a down and upstream waterway. (pg. 22)	M. Schrecengost; Road crossings as barriers to pearly mussel distribution in the southwestern Lake Ontario basin (pg. 41)	D. Baumert; Pullen Mill natural Constructed Pool and Weir Fish Passage Project (pg. 55)	E. Douglas; Physical and Biological Assessment of the Eel River Headwaters Restoration Sites in Plymouth, Massachusetts (pg. 74)
4:25	Withdrawn	S. Moore; Understanding and responding to the impacts of road-stream crossings in Maine (pg. 42)	R. Davis; Geddes Brook and Ninemile Creek Channel and Floodplain Restoration at Onondaga Lake (pg. 56)	A. Peter; Lessons from a comprehensive survey of a fish pass by a digital video system in the Reuss River (pg. 74)
5:00	**Poster Session/Social Hour in Campus Center Auditorium Dinner on your own**			

Wednesday – June 6th (Morning Session)				
Time	**Track A (Room 165/169)**	**Track B (Room 101)**	**Track C (Room 163C)**	**Track D (Reading Room – Upstairs)**
8:30	**Paul Greenberg – Featured Speaker (Campus Center Auditorium)**			
10:05	**Break**			
	Session A4: Policy and Prioritization Moderator: David Ahlfeld	**Session B4: Issues Affecting Riverine Species Moderator: Allison Roy**	**Session C4: Dam Removal Case Studies Moderator: Laura Wildman**	**Session D4: Environmentally-enhanced Turbines and Turbine Passage Survival Moderator: Norman Perkins**
10:30	L. Hollingsworth-Segedy; Effective Public Engagement for Successful River Restoration Projects (pg. 23)	E. Rodgers; Differences in frequency and range of trout movement through culverts in headwater streams (pg. 42)	S. Landry; "If You Remove It, They Will Come..." The Maxwell Pond Dam Removal / Black Brook Restoration Success Story (pg. 56)	D. Dixon; EPRI's Program to Develop, Install and Test the Alden Fish-Friendly Hydropower Turbine (pg. 75)
10:50	B. Naumann; Using a focus area approach to restore watershed-scale stream connectivity (pg. 24)	M. Goettel; An Exploratory Evaluation of the Swim Path Selection of Western Blacknose Dace in a Modified Flow Field (pg. 43)	M. Wamser; Removal of the Merrimack Village Dam (pg. 57)	N. Perkins; The Science Behind a Fish-Friendly Turbine (pg. 76)
11:10	K. Farmer; Lessons learned from recent USDA-NRCS assisted fish passage projects in Rhode Island (pg. 24)	J. Wechsler; Estimating entrainment of juvenile bull trout in Lake Creek (Montana), a desk-top vs. field study approach (pg. 43)	A. Lipsky; Pawtuxet Falls Restoration: Lessons from Narragansett Bay's Largest Dam Removal (pg. 58)	T. Carlson; Assessment of the conditions for fish passage through hydroturbines and the response of fish to passage (pg. 76)
11:30		N. Beckman; Log Jam Distribution and Carbon Storage in Headwater Streams in Colorado's Front Range (pg. 44)	J. Jengo; Calco Dam Removal - Commencing the Restoration of the Raritan River Watershed, New Jersey (pg. 58)	G. Cada; Using Fish Morphological Characteristics to Re-design Hydroelectric Turbines (pg. 77)
12:00	**Lunch – Campus Dining Common of Your Choice**			

Wednesday – June 6th (Afternoon Session)				
Time	**Track A (Room 165/169)**	**Track B (Room 101)**	**Track C (Room 163C)**	**Track D (Reading Room – Upstairs)**
	Session A5: The State of Knowledge on Passage of River Herring: I Moderator: Michael Chelminski	**Session B5: Biomechanics and Locomotion Moderator: Ted Castro-Santos**	**Session C5: Dam Removal Project Initiation & Regulatory Hurdles Moderator: Laura Wildman**	**Session D5: Turbine Passage Survival Moderator: Lee Emery**
1:30	J. Catena; NOAA's Efforts to Restore River Herring in the Northeast U.S. (pg. 25)	T. Castro-Santos; Breaking the speed limit--comparative sprinting performance of brook trout and brown trout (pg. 44)	L. Batt; Initiating Dam Removal Projects (pg. 59)	P. Heisey; Estimation of Turbine passage survival of juvenile American shad, Alosa sapidissima, by different methods for practical application (pg. 77)
1:50	K. Plymesser; History of Design for the Passage of River Herring in the Northeast (pg. 26)	E. Goerig; Modelling brook trout (Salvelinus fontinalis) passage success through road culverts: from theory to reality (pg. 45)	V. Humenay; Regulatory Hurdles and Inconsistencies of Dam Removal (pg. 59)	R. Brown; Barotrauma in Juvenile Salmonids Exposed to Simulated Hydroturbine Passage: pathways, management implications and applications (pg. 78)
2:10	C. Patterson; Operations and Maintenance of Fishways for River Herring in New Hampshire Coastal Rivers (pg. 26)	C. Tudorache; The effect of temperature and ammonia exposure on swimming performance of brook charr (Salvelinus fontinalis) (pg. 45)	B. Lambert; Regulatory Reform in Massachusetts: Instituting a General Permit for Dam Removal Projects (pg. 60)	B. Apell; Downstream Passage Survival of American Eel at the School Street Hydroelectric Project Cohoes, NY (pg. 79)
2:30	A. Haro; Methodologies for River Herring Passage Evaluations, Monitoring, and Assessment of Population Restoration Success (pg. 27)	S. Monk; Culvert Roughness Elements for Native Utah Fish Passage (pg. 46)	B. Beran; Top Ten Dam-Bustin' Lessons (pg. 60)	C. Kriewitz; Downstream Fish Migration Systems and Intake Structure Optimization & Possible Synergies (pg. 80)
3:00	**Break**			

Wednesday – June 6th (Afternoon Session)				
Time	**Track A (Room 165/169)**	**Track B (Room 101)**	**Track C (Room 163C)**	**Track D (Reading Room – Upstairs)**
	Session A6: The State of Knowledge on Passage of River Herring: II Moderator: Abigail Franklin	**Session B6:Ask the Hydropower Experts Moderator: Tim Brush**	**Session C6: Dam Removal Scientific and Engineering Issues Moderator: Vince Humenay**	**Session D6: Practice and Application Moderator: Curt Orvis**
3:25	T. Willis; Fish Passage at Natural "Barriers" (pg. 27)	A Panel of Hydropower Owners and Operators J. Ragonese, *TransCananda;* K. Bernier, *Brookfield Renewable Energy*; K. Long, *Exelon;* S. Moran, *Avista* (pg. 46)	L. Wildman; Replacing Dam Functions when Removing a Dam (pg. 61)	G. Giannico; Tide Gates And Their Impacts On Juvenile Coho Salmon In Southern Oregon (pg. 80)
3:45	M. Bernier; Designing Sustainable Fish Passage (pg. 28)		N. Nelson; Is dam removal enough? Finding the balance between economics and channel/habitat restoration. (pg. 61)	T. Brush; Susquehanna American Shad Model (SASM) - A tool for evaluating various restoration measures (pg. 81)
4:05	K. Hoverman; A 10 Year Retrospective Look at the Current Condition and Success of Nature-Like Fishways Installed on Three Maryland Rivers (pg. 28)		B. Chernoff; The Effects of Dam Removal on the East Branch of the Eightmile River, Connecticut (pg. 62)	L. Stiles; Menominee Hydroelectric Facility Phase II - Fish Lift System (pg. 81)
4:25	A. Bowden; Fish Passage, Ecohydrology, and More: A Comprehensive Approach to Protect River Herring in the Wild and Scenic Taunton River Wa (pg. 29)		L. Wildman; Guidelines For Assessing Sediment-Related Effects of Dam Removal (pg. 62)	C. Bunt; Automated Fishway Monitoring Systems (pg. 82)
5:00	**Social Hour – Campus Center Auditorium**			
6:00	**Banquet – Campus Center Auditorium**			

Thursday – June 7th (Morning Session)				
Time	**Track A (Room 165/169)**	**Track B (Room 101)**	**Track C (Room 163C)**	
8:30	**Panel Discussion: Climate Change and Fish Passage Panelists: P. Anderson, P. Jacobson, K. Nislow, and R. Palmer Moderator: E. Douglas (Campus Center Auditorium)**			**Session D7 Morning Field Trip – Holyoke Dam**
10:15	**Break**			
	Session A7: Gulf of Maine District Population Segment of Endangered Atlantic Salmon Moderator: Donald Dow	**Session B7: Upstream Passage of American Shad-The Fussy Fish Moderator: Steve Arnold**	**Session C7: Managing Extreme Flows to Maintain Stream Passage Moderator: Jim MacBroom**	
10:30	D. Kircheis; A Systematic Approach to Improve Passage at Dams Necessary for Recovery of Endangered Atlantic Salmon in Maine (pg. 29)	J. Tryninewski; The Lower Susquehanna River: 3 Fish Lifts & 3 Fish Passage Results (pg. 46)	J. MacBroom; Channel Damage, Repair, and Recovery after Extreme Floods (pg. 63)	
10:50	C. Fay; Estimation of Turbine Passage Survival for Atlantic Salmon Entrained at Penobscot River Hydroelectric Projects (pg. 30)	S. Leach; Santee-Cooper: A Lock on Fish Passage Success (pg. 47)	D. Ruttenberg; Installation of large wood in a homogenous reach of a coastal stream to restore California Central Coast Coho habitat (pg. 64)	
11:10	S. Amaral; Estimation of Total Project Survival for Atlantic Salmon Passing Downstream at Penobscot River Hydro Projects (pg. 31)	T. Castro-Santos; Putting together the pieces: Multi-Dam passage of American shad on the Connecticut and Columbia Rivers (pg. 47)	M. Trumbauer; Regenerative design applications to sustain baseflow to enhance fish passage in urban channels (pg. 65)	
11:30	J. Nieland; Dam impact analysis on Atlantic salmon recovery in the Penobscot River, Maine (pg. 31)	S. Arnold; York Haven Shad Migration: Which Way Did They Go? (pg. 48)	D. McKinley; Roads, aquatic organism passage and extreme events: lessons from Hurricane Irene (pg. 65)	
12:00	**Lunch – Campus Dining Common of Your Choice**			

Thursday – June 7th (Afternoon Session)				
Time	**Track A (Room 165/169)**	**Track B (Room 101)**	**Track C (Room 163C)**	
	Session A8: Stakeholder and Community Involvement Moderator: Jesus Morales	**Session B8: Potpourri Moderator: Austin Polebitski**	**Session C8: Fish Passage Case Studies Moderator: Katey Plymesser**	**Session D8 Afternoon Field Trip – Conte Lab/Cabot Station - Turners Falls**
1:30	C. Bowser; The Hudson River American Eel Project: low-cost fish passage through citizen science (pg. 32)	A. Hoar; Biological Purposes for Fish Passage (pg. 48)	B. Ripp; Sand Creek Meanders Inside Culvert (pg. 66)	
1:50	H. Wanningen; Fish Migration Day (pg. 32)	K. Healey; Modelling fish passage response to instream flows on run-of-river hydroelectric projects (pg. 49)	K. Dorst; Restoration of fish migration at the Afsluitdijk, The Netherlands, a unique challenge (pg. 66)	
2:10	M. Stottler; Beaver Island Wetland Restoration Project (pg. 33)	A. Soli; Ecological Monitoring to Evaluate the Benefits of Dam Removal and Passage Efficiency of Fish Ladders (pg. 49)	T. Sullivan; Shad and Eel Passage at the Conowingo Project (pg. 67)	
2:30	A. Ania; Emerging Concerns of Fish Passage and Aquatic Habitat Restoration Projects in the Great Lakes: The potential short and long term (pg. 34)	C. Caudill; Spawning migrations of American shad in the Columbia River (pg. 50)	S. Moran; Fish Passage Development on the lower Clark Fork River (pg. 68)	
3:00	**Conference Ends**			

Poster Presentations

#	Author(s)	Poster Title
1	Austin Polebitski, Scott Steinschneider, Casey Brown, University of Massachusetts Civil and Environmental Engineering; Ben Letcher, USGS Conte Anadromous Fish Laboratory	Assessing the Impacts of Climate Change at Ungaged Sites for Design Purposes
2	Bradford C. Chase, Mass. Division of Marine Fisheries; Timothy Dexter, Mass. Department of Transportation, Highway Division; N. Tay Evans, Mass. Division of Marine Fisheries; Jim Herberich, AECOM	A Geographic Information System data layer to assist transportation and diadromous fish restoration planning in Massachusetts
3	Brian Fox, Colorado State University, Department of Civil and Environmental Engineering; Brian Bledsoe, Colorado State University, Department of Civil and Environmental Engineering; Christopher Myrick, Colorado State University, Department of Fish,Wildlife, and Conservation Biology; Matthew Kondratieff, Colorado Division of Parks and Wildlife	Assessment of Fish Passage Barriers in Whitewater Parks
4	Chris Alford, American Rivers	The High Impact of Temporary Low Flow Dams: Summer Water Diversions and Salmon
5	David Ahlfeld, University of Massachusetts; Brett Towler, US Fish and Wildlife Service	Education in Engineering and Ecohydrology for Fish Passage
6	Denis Ruttenberg, Stream Engineer, USDA NRCS and USFWS Partnerships	Retrofitting a rural concrete stream crossing to a vented ford to facilitate upstream passage of Southern California Steelhead
7	Eric W. Hutchins, NOAA Restoration Center; Darrel DeTour, Great Works Regional Land Trust; Dave Huntress, Stantec, Inc.	Small Watershed Fish Passage Case Study: Shorey's Brook, South Berwick, Maine
8	Ismail Albayrak ETH Zurich, Laboratory of Hydraulics, Hydrology and Glaciology (VAW); Vladimir Nikora, School of Engineering, University of Aberdeen, UK; Oliver Miler, Leibniz-Institut für Gewässerökologie und Binnenfischerei, Berlin, Germany; Matthew O'Hare, Centre for Ecology & Hydrology Edinburgh, UK	Effects of plant biomechanical and morphological properties on plant-flow interactions in aquatic ecosystems
9	Caitlin Jenkins, Jessica Pica, Carla Stauber, Lauren Stocker - University of Massachusetts Amherst; John Noreika - S.O. Conte Anadromous Fish Research Center, USGS	Alternative Downstream Passage Designs for the Main Street Fishway
10	Joelene Diehl, Jenny Baker - The Nature Conservancy	Fisher Slough Restoration Project: Evaluating the Benefits to Fish and Farmers

#	Author(s)	Poster Title
11	Karen A. Wilson, Department of Environmental Science, University of Southern Maine	Diadromous Species Restoration Research Network (DSRRN)
12	Kevin Mulligan, Gil Loud - University of Massachusetts Amherst	Using River2D to Model Fishway Entrances
13	Leah Sullivan, Timothy J. Sullivan, Paul E. DeVries, and Judith A. Simon - R2 Resource Consultants	Fish Passage during Removal of a Small Dam on the Hood River, Oregon
14	Mark G. Cantwell, USEPA Atlantic Ecology Division; Monique M. Perron, Brown University; Julia Sullivan, USEPA Atlantic Ecology Division; David R. Katz, USEPA Atlantic Ecology Division; Robert M. Burgess, USEPA Atlantic Ecology Division	Assessing Changes to Organic Contaminant Fluxes from Contaminated Sediments Following Dam Removal in an Urbanized River
15	Martin Boote, Lisa Huntington, Alice Bailey, Lauren Hoffman - ECT, Inc.	Watervliet Dams: Restoration Success Through Dam Removal
16	Michael Kampnich, Rob Bosworth - The Nature Conservancy	Klawock River, Alaska Causeway Fish Passage Project
17	Elsa Loehmann MSCE, EIT, Milone & MacBroom, Inc.; Nick Wildman, MA DER	Dam removal case study: Wapping Road Dam- Kingston, MA
18	Timothy J. Sullivan, Paul E. DeVries, and Judith A. Simon - R2 Resource Consultants	Fish Passage during Removal of a Small Dam on the Hood River, Oregon
19	Thomas J. Maier, US Army Corps of Engineers (USACE), Pittsburgh, PA; David L. Smith, USACE - Engineer Research & Development Center, Vicksburg, MS; Conrad Weiser, USACE, Pittsburgh, PA; John Stark, The Nature Conservancy, Dublin, OH.	Fish Passage via Navigation Locks: Potential for Improvement on Large Urban Rivers?
20	Denis Ruttenberg, Stream Engineer, USDA NRCS and USFWS Partnerships	Development of hydraulic models and synthesis of fish movement to evaluate effectiveness of upstream fish passage at boulder weirs

A1

History of fish passage public policy
Alex Hoar, *U.S. Fish and Wildlife Service*

Protecting the integrity of the aquatic pathways used by fish to migrate upstream and downstream has been a critical social issue since ancient times. There is a long history in Europe of fisheries being held in the public domain and protected by the sovereign under the common law for the benefit of its subjects. Conflicts between the fishery and other uses in the public interest arose and many were resolved, but tension remained. The fishery provided a critical food source and an important source for commerce and there was a common belief that the fisheries resources were held in the public domain. This was established as common law in England and transferred to colonial America. In accord with English laws and practices of the day, landowners were required to mitigate an obstruction to fish passage at their own expense or compensate their upstream abutters. At independence, the states became the sovereign and assumed responsibility to hold fisheries in the public domain, to protect them in the public interest, and adopted fishway laws. Later, in eighteenth and nineteen-century U.S., several important court decisions in coastal and inland states and the U.S. Supreme court not only reaffirmed fisheries as a publicly held interest, but required dam owners to protect the resource by providing fishways at their own expense. Increasing legal requirements to pass fish helped fuel the science of fishway engineering. Vast numbers of barriers to fish migration remain. In the U.S. alone, there are over 85,000 dams and 2 million culverts; the majority are an impediment to riverine and diadromous fish movement. Fish passage is now an important element at the interface of engineering design, ecohydrology, and higher education. Sustainable solutions are being advanced to support connectivity and quality of aquatic habitat, transportation systems, and renewable energy generation with hydropower. To enhance the ecological literacy of water resource engineers and foster collaborative research in the fields of fish passage, stream restoration, road ecology, and dam removal, a relevant graduate level program in Fish Passage Engineering and Ecohydrology has recently been created at the University of Massachusetts, Amherst.
This presentation identifies the biological purposes supported by effective fish passage. It raises awareness that interest in fish passage is not new, has long been an important public purpose, and the need for research and education in the field. Historical and current perspectives are presented that foster understanding of how the history of fish passage has influenced public policy, modern statutes, and creation of the graduate program .

Diadromous Fish Passage: A Primer on Technology, Planning, and Design for the Atlantic and Gulf Coasts
Prescott Brownell, *NOAA National Marine Fisheries Service Southeast Region, Habitat Conservation Division*, Sean McDermott, *NOAA Fisheries Northeast Region*, Alex Haro, *USGS Silvio O. Conte Anadromous Fish Research Laboratory*, Fritz Rohde, *NOAA Fisheries Southeast Region,* John Johnson, *NOAA Fisheries Northwest Region (Retired),* Alan Blott, *NOAA Fisheries Northeast Region (Retired),* Ben Rizzo, *USFWS Northeast Region (Retired)*

Recognition of ecological benefits of ocean-river migratory fishes and restoration of historical spawning habitats is an important focus for marine, estuarine, and river ecosystems and fisheries of the Atlantic and Gulf Coast rivers of North America. We review a brief history of the ocean-river fisheries, historical fishways, and the decline of fish populations and river fisheries in the 20th Century. In an effort to build broad knowledge of fish passage and restoration programs, NOAA Fisheries developed Atlantic and Gulf Fish Passage Design Primer document to support public awareness of the importance of restoration for ocean-river migratory fish and future directions. The document is available on NOAA Northeast and Southeast Region websites, and was developed in collaboration with U.S. Geological Survey Conte Anadromous Fishery Research Laboratory, and the U.S. Fish and Wildlife Service Fish Passage Team.

Prescott Brownell, Prescott Brownell is currently the NMFS Southeast Region Coordinator for hydropower licensing and fish passage restoration, based in Charleston, South Carolina. He received his

education in Zoology, Limnology, and Marine Biology at N.C. State University in the 1965-70, and during his career has worked since 1971 with South Carolina Wildlife and Marine Resources Department, U.S. Fish and Wildlife Service as Chief of the Division of Ecological Services, Atlanta, and the National Marine Fisheries Service.

Examining State Fish Passage Laws: Applicability and Enforcement
Serena McClain, *American Rivers River Restoration*

The presence of strong fish passage laws, particularly with enforcement mechanisms in place, can provide greater opportunity for restoration success. However, these laws, when present, vary significantly from state to state in how they are applied and enforced. This presentation will offer an overview of state fish passage laws around the country and examine where these regulations are most effective in terms of how they are applied and whether they are enforced. We will look at specific recommendations for states without fish passage laws or those whose laws have no teeth. Finally, we will briefly survey case law on what impact, if any, it has had on existing laws.

Serena McClain, Serena McClain has worked in the river restoration field for nearly eleven years, focusing largely on dam removal planning. Serena works with local and national stakeholders to demonstrate how to enhance safety, quality of life and economic development by restoring the natural function of rivers. In addition to helping formulate policy and messaging work on river restoration, she manages American Rivers-NOAA partnership funding and manages restoration projects throughout Maryland and Virginia.

Status and Overview of Federal Interagency East Coast Fish Passage Manual
James Turek, *NOAA Fisheries Restoration Center*, Alex Haro, *USGS*, Matt Bernier, *NOAA Restoration Center*, Melissa Belcher, *USGS-UMass*, Bill McDavitt, *NOAA Fisheries*, Steve Gephard, *CT DEEP*

The National Marine Fisheries Service (NMFS) established a Memorandum of Agreement with the U.S. Geological Survey (USGS) in 2009 (and later joined by the U.S. Fish and Wildlife Service (USFWS) in 2010) to collaboratively prepare a guidance manual with passage design criteria for 15 East Coast diadromous fish species. A primary focus of the document is to provide non-prescriptive passage criteria based on the biology of each species (such as timing of East Coast runs and general species habitat requirements), and the swimming performance, leaping capability, and behavioral challenges of each species, based on: field (telemetry) and laboratory (flume and/or respirometer experiments) studies, documentation in published literature, and/or experienced regional fish passage expert best professional judgment. The passage criteria are intended to be applied in the design of a variety of fish passage types. The document describes the fish passage types with a greater emphasis on dam removals and nature-like fishways, and to a lesser extent, structural fishways, culverts and tide gates. Information is also included on engineering considerations (e.g., weir and notch design) relative to fish passage and in particular, to dam removals and nature-like fishway design. Manual chapters also address topics of hydrology, and specifically calculating flows for the target species run period, and hydraulics such as streaming versus plunging flows, head-velocity relationships, and energy dissipation. A manual chapter is dedicated to passage evaluation and monitoring with a primary focus on biological monitoring, although we also present a step-by-step, physical assessment survey protocol that can be used by fish passage practitioners as a diagnostic tool to evaluate physical conditions at nature-like fishway sites, certain dam removal sites, and possibly other passageways. Case study site examples from the Northeast, with site descriptions and results of diagnostic physical evaluations, are included as an appendix in the document along with other appendices with species profile summaries and a glossary of terms. The manual is expected to be available to the public as a web-based document that can be periodically updated by the agencies as new information is gained from science-based studies and advances in engineering and technology.

James Turek, James Turek is is Assistant Northeast Team Leader and restoration ecologist with the NOAA Fisheries Restoration Center (13 years). He

is responsible for managing or providing technical assistance on restoration projects targeting Narragansett Bay, Long Island Sound, Buzzards Bay and their watersheds. He has nearly 28 years of government and private sector experience in fishery biology and wetlands ecology and his experience includes the planning, design, construction and monitoring of fish passage and wetland restoration and creation sites. He holds a Bachelor's Degree in Zoology and minor in Geological Sciences from the University of Maine at Orono, and a Master's Degree in Marine Affairs from the University of Rhode Island.

A2

A historical perspective on downstream passage at hydroelectric plants in Swedish rivers

Olle Calles, *Karlstad University Department of biology*, Peter Rivinoja, *Swedish University of Agricultural Sciences*, Larry Greenberg, *Karlstad University*

Downstream passage problems have been studied mainly in Europe and North America, but not so much in the rest of the world, and have focused on anadromous species, particularly salmonids. Relatively few studies have been conducted on other migratory species. Moreover, in many cases bypass facilities for downstream migrants have been implemented without evaluating their effectiveness or if effectiveness has been evaluated, it has often been shown to be low. We will provide a brief historical review of downstream bypass problems in Sweden. This is followed by a description of the Swedish situation today, with focus on several case studies that have evaluated downstream bypass efficiency in rivers of different sizes and for several different species.

We have divided Swedish rehabilitation history into four periods: Fish migration and natural reproduction (pre 1900s), Fish ladders and racks with unknown function (1900-1935), The compensatory stocking and turbine passage era (1935-2000), and the modern approach of rehabilitating regulated rivers to allow natural reproduction. We will give examples of recent rehabilitation on Swedish rivers including measures such as inclined racks and bypasses/traps and guiding/skimming walls and we will present the results from their evaluation.

Olle Calles, Olle received a M.Sc. in Biology at Uppsala University in 2000, which included a one year stint as an exchange student at James Cook University, Townsville, Australia. After my studies in Uppsala I worked with various projects at the County Board in Gävleborg, before starting a PhD-position at Karlstad University in 2001. I finished my PhD in early 2006 and spent some 1½ years doing research and lecturing before being accepted for a postdoctoral fellowship at Politecnico di Torino, Italy, in 2008. After my return to Sweden and Karlstad University in 2009, I have held a position as assistant professor, which was co-funded by The Knowledge Foundation (Swedish: KK-stiftelsen), E.ON Hydropower and Karlstad University.

Free access for riverine fish along the Dutch Rhine, hydraulics and construction of the Dutch Rhine fishways

Kees Dorst, *Ministry of Infrastructure and the Environment Centre for Infrastructure, Department of Hydraulic Engineering and Environment*, Frank Kok, *Ministry of Infrastructure and the Environment*

Until 1985 migration of riverine fish for instance salmon and sea trout through the river Rhine system has dramatically declined due to the tremendous decrease of water quality and the construction of river regulation works such as weirs and dams and hydropower stations. During the last decades the water quality in the Rhine and therefore the environmental circumstances for migratory fish has improved significantly. At the same time on international level a discussion was started on the feasibility of restoring fish migration. In 1987 all countries along the river Rhine adopted the Rhine Action Programme. One of the aims of this plan is to restore the main stream as the backbone of the complex Rhine ecosystem and its main tributaries as habitats for migratory fish.

The construction of fishways at the three weirs in the river Neder-Rhine was the major Dutch activity in restoring the migration route in the Rhine. Accurate investigations of the behaviour of different fish species and the required migration circumstances, resulted in a design of spacious pool- and weir

fishways as bypass channels in the floodplain. To enable migration of different migratory fish species during the various discharge situations of the river the channels have V-shaped weirs with vertical slots. The design and construction of a fishway is not easy. Knowledge of the behaviour of migratory fish, the required hydraulic circumstances, water management, engineering and construction are very necessary and important. Only an multidisciplinary team can succeed. All these aspects will be discussed in the paper.

Kees Dorst, Kees works as a senior specialist in hydraulic engineering at the The Dutch Ministry of Infrastructure and the Environment. He also works in different national and international advisory and working groups editing frameworks and guidelines. He received his Master Sc. degree in Hydraulic Engineering in 1995 at the University of Technology. He also is a lecturer at IHE Delft.

Following a river basin approach for optimal fish passage in the boundary crossing River Vecht
Iwan De Vries, *Dutch Waterboard*

The river Vecht is a 180 km long river flowing from Germany into the Netherlands and into a lake that is connected to the sea. The river crosses boundaries of countries, provinces, communities and land owners The presentation is about the difficulties we encounter and howwe handle them in making the river a more natural river and also providing fish passage possibilities.
What are the success and fail factors, what happens in the field and what can we learn from the process we are in now for multiple years.

Iwan De Vries, The presenter is an ecologist at the dutch waterboard. The last 5 years he has specialed himself in designing fish passage solutions. He is now a teacher in the construction of fish passages. He is also an advisor for the waterboard where it considers the constructions of fish passages.

Living North Sea project & community approaches to fish migration in Europe
Alistair Maltby, *North of England Rivers Trust*
How do fish biologists and river managers get fish migration on the agenda where flood risk management and other pressures dominate the politics of watershed management? This is the aim of the Living North Sea project, a 6.4 million euro project to address fish migration issues in the North Sea region of Europe, which incorporates 15 partners in seven countries.
There is strong solidarity between those working on fish migration issues throughout the world, but individually, the sector struggles to gain influence where the public and thus politics are concerned about other pressing environmental issues, such as the risk of climate change on flood frequency and magnitude. Over several generations, this has fragmented rivers and migratory pathways in North Sea countries on a scale seen perhaps nowhere else in the world.
LNS addresses this issue in two key work packages. The first uses sea trout (salmo trutta L.) as an example of a bioregional diadromous fish for the North Sea region. Fishery managers have been co-operating across political boundaries, incorporating the principles of Integrated Coastal Zone Management, to demonstrate the connection and consequences of management policies for this species in different European member states. The second identifies the key fish migration problems for all species in the region, quantifies the scale of the problem on a regional basis to provide political weight to the issue, identifies potential solutions, and works outside of the fisheries sector to see these solutions adopted by the public and decision makers. The project is led by The Rivers Trust, an organisation of community-led non-government watershed managers which is unique to the British Isles, but has some similarities with watershed councils and other community-led river restoration initiatives in North America, but which are currently rare in mainland Europe. The capability and solutions of community-led organisations are also presented in the context of this important role in reducing watershed fragmentation and increasing affordability of fish migration projects.

Alistair Maltby MSc CEnv FIFM is Director for the North of England of The Rivers Trust, the umbrella body for community-led river restoration in England, Wales and Northern Ireland and project manager of the Living North Sea project. He has been involved in grass root watershed restoration since 1997. A fish

biologist with special interest in brown trout, he was awarded a Winston Churchill Travelling Fellowship to the Pacific North West in 2007 to investigate fisheries restoration in the context of climate change.

A3

Graduated-Field, Pulsed-DC Fish Guidance Technology: Successes, Challenges and New Concepts

Carl Burger, *Smith-Root, Inc.*, John Parkin, *Parkin Engineering*, Martin O'Farrell, *Smith-Root, Inc.*, Aaron Murphy, *Smith-Root, Inc.*

Various technologies have been developed for fish guidance at hydropower and water diversion projects. Historic attempts to guide fish with electricity used alternating current (AC) for deterrence (often with injurious consequences). This paper highlights an approach to fish guidance that combines new developments in the use of DC electric fields to direct or block fish movements. These include the ability to: (1) vary and control pulsed DC waveforms; (2) remotely monitor and adjust output levels; (3) implement safeguards to minimize potential human or animal interactions with deterrence fields; and (4) create Graduated Field Fish Barriers (GFFBs) for fish conservation (as well as non-graduated, abrupt deterrence fields where conditions warrant). We review the efficiencies of GFFBs and other bottom-mounted electric guidance arrays (which can be up to 100% effective) from results in peer-reviewed literature. Published accounts primarily address deployments to block movements of invasive species (e.g. Asian carp; Chicago Ship Canal). Hydropower facilities using GFFBs have included a tailrace barrier for a power plant in Vessy, Switzerland and a tailrace barrier at the Beeston hydropower facility in the U.K. There are 47 GFFB arrays in use around the world for fish guidance and deterrence. This paper outlines "the lessons learned" in applying electric barrier technology " addressing its successes, challenges, limitations and design modifications to enhance effectiveness. Whereas guidance and deterrence barriers have been largely successful for upstream-moving species, only limited success has been achieved with downstream-moving fish. Accordingly, we discuss some new but untested concepts for guiding downstream-moving fish. These innovative ideas include bottom-mounted, angled-array systems and surface-suspended systems having vertical electrodes (either of which could be used in combination with other deterrence technologies) to induce movement away from intake structures and avoiding incapacitation by the electric field.

Carl Burger, Carl Burger heads the Science Department at Smith-Root, Inc. in Vancouver, WA where he and his team focus on the development and testing of innovative technology for fish behavioral guidance, invasive species control, and marine mammal deterrence. Prior to joining Smith-Root in late 2006, Mr. Burger spent 31 previous years with the U.S. Fish & Wildlife Service as a Pacific salmon research scientist (Alaska), a science center director (Washington), and a field administrator for the recovery of listed Atlantic salmon in Maine. He was President of the American Fisheries Society in 2001.

Fish passage survival improvements measured at Positive Barrier Guidance Systems

Shane Scott, *S. Scott & Associates LLC*

Many anadromous fish species, such as Pacific and Atlantic salmon (Onchorhynchus spp., Salmo salar), the shads and river herring (Alosa spp.), and catadromous species including the American eel (Anguilla rostrata), are in danger of extinction throughout some or all of their range. Impacts to these populations include entrainment at hydroelectric dams and other water conveyance facilities. State and federal laws now mandate protection of these and other fish populations. Facility operators must often implement physical or operational modifications to reduce fish entrainment. This presentation will document the improved juvenile fish passage survival results at several Fish Guidance System (FGS) installations in North America. The FGS has been demonstrated to successfully guide downstream migrating fish to safer bypass routes, thereby reducing entrainment and improving survival. Most fish species migrate downstream in the thalweg, taking advantage of higher water velocities. The FGS is designed to exploit this migratory behavior and guide fish to a safer point of egress. The FGS is composed of a

series of floating panels anchored across the river channel. The design and configuration of the FGS varies at each site according to hydraulic conditions and species present. Acoustic telemetry and hydroacoustic studies conducted on various FGS installations indicate that from 53% to upwards of 92% of downstream migrating juvenile Pacific and Atlantic salmon were successfully guided to a safer bypass route in a variety of facility configurations and flow conditions. Further research is needed, but the FGS should also provide significant survival benefits to other downstream migrating fish species that demonstrate similar migration behavior, including juvenile shad and herring (Alosa spp.), adult eels (A. rostrata) and kelts (O. mykiss, S. salar).

Shane Scott, Shane Scott is a fisheries biologist and owner of S. Scott & Associates LLC in Vancouver, WA. He currently works with utilities and other river oriented industries to develop facility operations and projects to improve fish passage survival through hydroelectric dams and related facilities. Previously he worked with the Washington Department of Fish and Wildlife and Tacoma Power where he developed fish protection and mitigation policies and projects.

Neptun: the electronic guidance system that effectively manages fish movement in a down and upstream waterway.

Piotr Parasiewicz, *Fishways Global, LLC*, Rick Harding, *Fishways Global, LLC*, Jason McHugh, *Fishways Global, LLC*, Mariusz Malinowski, *Procom Systems SA*, Sabina ZioÅ, *Procom Systems SA*

The protection of fish communities at man-made facilities and barriers has a long history of significant expenditure of scientific and monetary resources. Beyond creating fishways, considerable investment is made to protect fish by blocking their access to turbines, water intakes, and directing them to less risky areas. Nevertheless, guiding fish to the fish passages, especially in downstream direction still present a big problem. The anticipated success of electrical fish barriers and guidance structures has been limited due to current design limitations. However, a device with a fundamentally new design feature has been successfully deployed in Poland. The device is called "NEPTUN". NEPTUN is an electric-electronic 3-phase barrier, producing a smooth non-uniform pulsed electric field of low voltage. It uses arrays of positive and negative electrodes and gradually increases the intensity of the electric field between the electrodes from positive to negative. Unlike other devices NEPTUN does not stun fish, but affects their neuromuscular system at the informational level, allowing them to escape from the area of the electric field. The basic field installation consists of steel electrodes attached to the river bottom so that they can move from the vertical to an angle of + / - 90 degrees. A buoy attached at the end of the electrode keeps it in an upright position. Groups of electrodes are powered by remotely controlled generators. Specialized software controls the parameters of the electric field, creates statistically-mastered changes, and controls the switching of each group of electrodes. The system supports sensors for monitoring temperature and conductivity of the water which can be used to automatically adjust the properties of the electric field. With an average power input of 0.43 to 0.45 kWh and electricity consumption of 0.0018 kW/m2, "NEPTUN" has a low operating cost. Additionally, the system maintenance is minimal.

Piotr Parasiewicz, Dr. Piotr Parasiewicz is a civil and environmental engineer educated on the University of Agricultural Sciences in Vienna. He is an expert in instream flow models, habitat restoration and nature-like fishways. Piotr is a developer of MesoHABSIM (www.MesoHABSIM.org), a multiscale approach for instream habitat modelling. It is currently used in instream flow management and river restoration and planning across US and in Europe. Among others, the model has been applied for determination of Protected Instream Flow Standards in the State of New Hampshire where it has been adopted as a part of State's legal framework.

Since 1999 in USA, he worked at Cornell University and University of Massachusetts, Amherst. He is currently a director of the Rushing Rivers Institute, a river research non-profit (www.RushingRivers.org) and an Adjunct Professor at the University of Nebraska Lincoln.

Dr. Parasiewicz frequently offers technical advise to the government, non-profits and the industry. Most notably he was appointed by the Government of Austria as a member of Austrian Network for

Environmental Research, an expert commission actively participating in development of EU environmental and research policy. In 2006 and 2007 he was appointed as an expert to the Science and Technical Workgroup on Water Flow Regulations for the State of Connecticut. Currently he serves as a technical advisor at the Sustainable Water Initiative of the State of Massachusetts

Design of Small Scale Floating Surface Fish Collectors
Mike McGowan, *HDR Engineering, Inc*

There is increasing attention being given to the safe downstream passage of migratory fish past dams or other instream obstacles. This is due to the potential for increased exposure of these fish to predation, high mortality or injury created by passage through turbines, spillways or outlet works. For downstream migratory species prone to moving near the surface, the use of floating surface collectors has been proven to be effective, though these have typically been very expensive and fixed in one location. This paper will present information on two small scale, relatively inexpensive, floating surface collectors currently under design and scheduled for construction and deployment in the fall of 2012. One will be installed in a reservoir with a modest amount of water level fluctuation and will be located at a fixed horizontal position. This installation will be operated with gravity water flow through the collector. The other collector, to be installed in a reservoir with up to 185 ft of water level fluctuation, is designed to be both transportable between different water bodies as well as movable between different collection locations within a reservoir. This second, more portable design, utilizes off the shelf components and is operated with pumped fish attraction and transport flow. Information to be presented will include design criteria considerations, a description of operations, and the monitoring plans designed to measure the effectiveness of each collector installation.

Mike McGowan, Mike McGowan, P.E. received a BS and MS in Civil Engineering from Colorado State University and has worked in private practice for over 32 years. 20 of these years have focused on projects related to different aspects of fisheries including passage, screening and fish production throughout the western states. A Senior Project Manager with HDR Engineering, Inc, he is currently involved with the design of two unique floating surface collectors being designed to facilitate downstream passage of salmonids past two existing dams. He is currently coming off a 4 year assignment in Anchorage Alaska where he was the design project manager and on-site technical representative during construction for a new, 78 million dollar facility, that incorporated intensive recirculation rearing systems within a 3 acre building.

A4

Effective Public Engagement for Successful River Restoration Projects
Lisa Hollingsworth-Segedy, *American Rivers River Restoration*

Public engagement -- two words that often strike terror in the hearts of engineers and river restoration scientists. An effective public process can build project support, enlist partners, and resolve sticking points that would otherwise derail a project. A process that overlooks the needs of the public can be disastrous. This presentation will examine the types of decisions to be made when planning a public process, including defining the public, evaluating the anticipated outcomes of a public process, determining what kind of process is appropriate, how to talk about change, how to build connections with project opponents, and how to survive meetings that don't go as planned.

Lisa Hollingsworth-Segedy, Lisa Hollingsworth-Segedy, AICP is Associate Director for River Restoration in American Rivers' Western Pennsylvania Field Office. Since 2008, she provides technical assistance and project management for dam removals and other river restoration projects. Lisa has more than three decades of experience with water resources planning, including extensive experience with public engagement processes.

Using a focus area approach to restore watershed-scale stream connectivity

Ben Naumann, *USDA-Natural Resources Conservation Service*, Jeffrey Normant, *USDA-Natural Resources Conservation Service*, Norm Dube, *Maine Department of Marine Resources*, Merry Gallagher, *Maine Department of Inland Fisheries and Wildlife*, Jed Wright, *U.S. Fish and Wildlife Service*

The Natural Resources Conservation Service (NRCS), the Maine Department of Marine Resources (MDMR), the Maine Department of Inland Fisheries and Wildlife (MDIFW), the U.S. Fish and Wildlife Service (USFWS), and Keeping Maine Forests initiated a cooperative aquatic stream restoration and enhancement effort in 2011. The effort has focused on implementing on-the-ground stream restoration projects in the Penobscot River Basin. The primary goals of this initiative are to: 1) restore geomorphic characteristics and function of Maine's lotic systems and, 2) enhance in-stream habitat complexity and connectivity to benefit diadromous fishes, including Atlantic salmon, and resident species, including brook trout, at a watershed scale. With thousands of problem culverts in the Penobscot River Basin, NRCS and partners are using the Pleasant River sub-watershed as a "focus area" for this restoration initiative. The presentation will provide a summary of the focus area approach, progress of the cooperative effort, restoration challenges, and the creative avenues taken to get projects moving forward.

Ben Naumann, Ben Naumann is a fisheries biologist with the USDA Natural Resources Conservation Service's Bangor, Maine field office. Ben is currently the lead on the Pleasant River focus area initiative. Before his current position he worked for a NGO on stream connectivity and habitat enhancement projects in Maine. He obtained his Bachelor of Science degree in Environmental Science with an emphasis in Fisheries Biology from Unity College, Unity, Maine in 2002, and a Master of Science in Fisheries from the University of Guelph in Ontario, Canada in 2008.

Lessons learned from recent USDA-NRCS assisted fish passage projects in Rhode Island

Kevin Farmer, *Federal Government USDA-Natural Resources Conservation Service*

Over the past three (3) years, the USDA-Natural Resources Conservation Service has work with local partners to successfully design and/or implement fish passage projects throughout Rhode Island.
The projects have ranged from denil ladders, nature like fish ways, partial dam removals, and full dam removals. Many of these projects were accomplished by working with our conservation partners, state and local governments, and other federal agencies.
These projects have presented various challenges and provided several learning opportunities for us here at the USDA-NRCS.
Many of the projects that the USDA-NRCS worked on were funded under the NRCS Wildlife Habitat Incentives Program (WHIP). The purpose of the WHIP is to enable eligible participants to develop habitat for upland wildlife, wetland wildlife, threatened and endangered species, fish, and other types of wildlife. Prior to the 2008 farm bill, there were fewer constraints for NRCS to consider when providing assistance to eligible participants. Two major constraints of this program since the 2008 farm bill include mandatory funding levels and program eligibility requirements.
As for funding, NRCS is limited to providing no more than $50,000 per year in individual payments made to a program participant for conservation practices implemented under the WHIP program. Previously, this annual payment limitation did not exist.
Prior to the 2008 farm bill, WHIP did not require that eligible land be in agricultural production. However, now WHIP is purposed for developing wildlife habitat on private agricultural and forest lands. As well, NRCS could work with local municipalities and units of government prior to the 2008 farm bill.
These changes have prevented our past practice of working with state and local governments to design and implement fish passage on non-agricultural lands.
With these new constraints, NRCS will have to change the focus of our fish passage efforts and consider more cost effective means of achieving fish passage. No doubt it will be near impossible to

design and install a large denil fish ladder with these recent WHIP funding constraints.
However, there are several opportunities for NRCS to continue working with eligible landowners to install smaller fish passage measures such as, fish screens, culverts, nature like fish ways and partial dam removals. We have also being to utilize the Environmental Quality Incentives Program (EQIP) to install some of these measures.
Many of the projects that we have designed and implemented have been done through partnership efforts with local conservation organizations. Most of the local conservation organizations that we have worked with are limited in staff and simply do not have any engineering professionals on staff. This could appear to present a problem, but I believe that we have found ways to make up for the lack of engineering expertise while leveraging the strengths of these local organizations. For instance, many of these organizations have a passion to see the restoration of fish habitat for anadromous fish. They are very instrumental in organizing necessary entities to ensure that the projects are accomplished successfully. Many of these partners are vital to getting the community support and participation necessary to achieve fish passage. These partners are exceptional in helping to secure funding for shortfalls within the budget. They are able to meet the publicity needs to ensure that the community is well aware and receptive to the work that is going to occur. These local conservation partners are able to provide personnel who can assist with project coordination. As well, they have successfully managed agreements with NRCS to secure the technical expertise necessary to design and implement projects.
We have learned that in order to meet the engineering needs for these projects, we have to work closely with our local conservation partners and our federal agencies. To meet the engineering needs, NRCS has done some design work in-house. For more complex designs, we have entered into contribution agreements where we provide Technical Assistance funding to aid the local organizations in securing A&E design services. As well, we have relied heavily on the technical expertise of engineers from the U.S. Fish & Wildlife Service (USFWS) to provide guidance and technical assistance. Since these local conservation organizations do not have any engineering expertise on staff, NRCS still has to work closely with them throughout the project in order to provide oversight in the engineering services solicitation, design and construction administration of the projects. At times, it has been a challenge for NRCS to bring to preeminence the technical standards and specifications required by our agency. When a long anticipated project begins to come to fruition, excitement begins to overshadow protocol and many of the technical requirements tend to get suppressed by our non-engineering partners. As such, we often have to work harder and provide unanticipated technical guidance and oversight to ensure the adherence to technical standards, specifications and contract requirements. Nonetheless, we have learned that we can work successfully with non-engineering partners to achieve fish passage in Rhode Island. The USDA-NRCS is excited to engage in more opportunities to work with our local conservation partners in the design and implementation of fish passage in more Rhode Island watercourses

Kevin Farmer, As State Conservation Engineer, Kevin Farmer provides leadership in all phases of engineering programs for NRCS in the state of Rhode Island. He serves as advisor to the State Conservationist on all engineering phases of NRCS programs. He is responsible for establishing technical standards and procedures, and methods of operation for engineering work in the state of Rhode Island. Kevin began working with NRCS in 1995 working in the Marianna, AR field office. He has held numerous engineering positions with the USDA-NRCS in Alabama, Minnesota, California, Georgia, and Rhode Island. Prior to his current position, he served as the State Construction Engineer in Georgia. He is a graduate of Florida A&M University with a degree in Biological & Agricultural Systems Engineering.

A5

NOAA's Efforts to Restore River Herring in the Northeast U.S.

John Catena, *NOAA Restoration Center NOAA*

Owing to their trans-boundary, migratory life-history, their commercial and recreational importance, and

their ecological value to other commercially and recreationally important species, the restoration and protection of diadromous fish populations is a high priority for the National Oceanic and Atmospheric Administration (NOAA). The implementation of dam removal and other fish passage techniques is a primary tool that NOAA uses to address this priority. NOAA exercises this responsibility through a number of different programs and authorities including the Federal Power Act, Endangered Species Act, and through its pro-active restoration programs including the Community-based Restoration Program. Among the 14 diadromous species present in the Northeast United States, alewife and blueback herring are priority species for restoration. This presentation will summarize NOAA's efforts to restore these populations across the region and discuss recent and future opportunities and constraints. In particular the presentation will focus on river herring restoration accomplishments, efforts to develop a watershed-based geographic prioritization for fish passage in the Northeast, integrated monitoring, and the recent petition to list river herring under the Endangered Species Act.

John Catena, John Catena is the Northeast Regional Supervisor for the National Oceanic and Atmospheric Administration's (NOAA) Restoration Center based in Gloucester, MA. He is responsible for managing NOAA's habitat restoration programs throughout the Northeastern U.S. from Maine to Virginia and a staff of 15 professional, technical staff. John has been involved in managing, planning, and overseeing habitat restoration projects for over 15 years. He specifically has experience in the conceptual design, planning, and monitoring of tidal wetland, shellfish, riverine, and anadromous fish restoration projects including fish passage and dam removal projects. John received his B.S. in Marine Science from the University of South Carolina in 1984 and an M.A. in Marine Affairs from the University of Rhode Island in 1987.

History of Design for the Passage of River Herring in the Northeast
Katey Plymesser, *USFWS/Montana State University Fisheries/Civil Engineering*, Jesus Morales, *U.S. Fish and Wildlife Service*, Curt Orvis, *U.S. Fish and Wildlife Service*, Brett Towler, *U.S. Fish and Wildlife Service*, Bryan Sojkowski, *U.S. Fish and Wildlife Service*

Members of the U.S. Fish and Wildlife Service (USFWS) Region 5 fish passage engineering team will present a history of river herring (Alosa pseudoharengus & Alosa aestivalis) passage systems in the northeast. An evolution of design ideas will be explored and the recent practice in the northeast for river herring passage will be described. Case studies of unique designs will be presented including examples of successes and failures. We will conclude with the current goals and objectives of the USFWS for the passage of river herring.

Katey Plymesser, Katey Plymesser received her undergraduate degree in Civil Engineering in 2001 from Case Western Reserve University in Cleveland, Ohio. After working as a consulting engineer in land development for six years, she decided to return to graduate school full-time. She is currently a PhD Candidate in the Civil Engineering Department (Water Resources) at Montana State University and is working in the Student Career Experience Program (SCEP) with the US Fish and Wildlife Service at the Region 5 headquarters in Hadley, MA. Her research work includes three-dimensional computational fluid dynamics modeling and fish passage energetics. She recently received a Hydro Research Foundation fellowship which was designed to help outstanding early-career researchers facilitate research related to hydropower.

Operations and Maintenance of Fishways for River Herring in New Hampshire Coastal Rivers
Cheri Patterson, *New Hampshire Fish and Game Department Marine Division*

Operation, maintenance, and field modification are critical for effective performance of upstream and downstream fish passage systems. This talk draws on 35-years of experience operating, maintaining, and modifying upstream fish passage systems for river herring in coastal New Hampshire rivers. Specific topics include planning for seasonal operations, staffing, costs, maintenance, as well as preferences and suggestions by professionals responsible for overseeing and maintaining upstream fish passage systems.

The New Hampshire Fish & Game Department owns, operates, and maintains seven upstream fish passage systems in coastal New Hampshire rivers where river herring are the target species for upstream passage. These fishways are primarily denil, but also pool-and-weir and Canadian step-weir (removed in 2010) that are operated and maintained each spring for upstream passage of river herring. This talk discusses the experience of staff maintaining, modifying, monitoring and operating these fishways based on practical experience to maximize fish passage with the actual designed structure.

Cheri Patterson, Cheri Patterson is a marine biologist and the Supervisor of Marine Programs for the NH Fish and Game Department's Marine Division. She has been involved with river herring and American shad restoration projects and has worked with the seven coastal fishways in NH for the past 35 years.

Methodologies for River Herring Passage Evaluations, Monitoring, and Assessment of Population Restoration Success
Alex Haro, *U. S. Geological Survey S. O. Conte Anadromous Fish Research Laboratory*, Theodore Castro-Santos, *U. S. Geological Survey*

Although numerous structures have recently been built to provide upstream and downstream passage of river herring at migratory barriers, few have been quantitatively evaluated for their performance. Basic monitoring of these passage structures by simple visual counts of fish also tends to be relatively qualitative in nature, and often inaccurate. The scale of passage structures for river herring offers many opportunities for comprehensive evaluations and monitoring that are often not feasible with other anadromous fishes. Several technologies have been developed to perform more quantitative evaluations and accurate monitoring of passage structures and river herring runs, ranging from mark-recapture studies, automated video recording, and telemetry; these methods are reviewed and summarized in terms of level of effort, cost, and data return. Newly-developed numeric methods for analyzing data to estimate attraction, spatial/temporal passage performance, and assessment of passage performance relevant to restoration goals are also described.

Alex Haro, Dr. Alex Haro is a Research Ecologist at the S.O. Conte Anadromous Fish Research Laboratory (U.S. Geological Survey) at Turners Falls, Massachusetts, USA and serves as a Principal Investigator and Section Leader of the Fish Passage Engineering Section at the Conte Lab. His present work involves migratory fish behavior, design, engineering, and evaluation of fish passage structures, fish swimming performance, and ecology and management of American eels. Dr. Haro provides extensive basic and applied research and advice to state, national, and international agencies, NGOs, and the private sector on fish passage technology and operations. He is also an Adjunct Associate Professor at the University of Massachusetts Department of Environmental Conservation and serves as a major advisor for graduate students, as well as an instructor for courses in fisheries biology

A6

Fish Passage at Natural "Barriers"
Theodore Willis, *University Southern Maine Environmental Science*, Michael Chelminski, *Stantec*

The range of river herring (A. pseudoharengus and A. aestivalis) is much smaller now than historical records represent during the pre-colonial and pre-industrial revolution phases of New England settlement. Many water control structures in New England are built on top of falls and other natural flow constrictions that were not impediments to river herring passage during antiquity, but are now, despite implementation of technical fish pass design criteria. There are locations in New England, especially in Maine, where river herring ascend falls and other natural features that appear to exceed accepted fish passage criteria. Upstream fish passage at a given site is dependent upon multiple factors, including swimming characteristics of target fish species/life stages and hydraulic conditions during seasonal migration periods. Technical fishpass design criteria are intended to provide for fishpass designs that are conservative in terms of maximum flow speeds, heights of hydraulic drops, and holding area turbulence as defined by an energy dissipation factor.

Are there characteristics that allow for upstream fish passage that are not considered in the design criteria? Here we present specific examples of sites where adult river herring pass upstream over seemingly impassable features during seasonal spawning migrations. We identify characteristics of each site relevant to upstream fish passage and compare those natural barrier metrics to commonly used metrics for design of upstream fish passage systems. Our objective is to inform decision making and design implemented in watershed-scale fisheries restoration planning and the design of technical and "nature-like" fishpass systems.

Designing Sustainable Fish Passage
Matthew Bernier, *IM Systems Group Contractor, NOAA Restoration Center NOAA Restoration Center - Northeast Region*

The design and construction of fish passage--especially fish ladders--for diadromous fish is not new in Maine. At Damariscotta Mills, an original fishway constructed in 1807 has been rebuilt many times, and is currently undergoing another renovation. Other fishways of even more recent construction have fallen into deterioration, or have become ineffective due to the partial or complete failure of dams. The landscape of failed and failing fishways offers important lessons to modern day practioners of fish passage design, including the need to maintain dams and fishways and the need for more sustainable passage design. The NOAA Restoration Center approaches the issue of fish passage sustainability in various ways, including feasibility studies to assess if dam removal is a better option for fish passage, operations and maintenance plans as a requirement of publicly-funded projects, dam inspections and dam repairs by owners as a condition of fishway installation, and more sustainable, low maintenance fish passage designs. Examples of low maintenance designs currently being considered include aluminum baffles (rather than wood baffles) in Denil fish ladders, aluminum stop logs, rock ramp fishways, dam removals, and the replacement of undersized, perched culverts with open bottom arch culverts. Sustainability also requires a realistic assessment of fish passage effectiveness, and the need to diversify fisheries restoration across many watersheds of varying size and habitat quality as a buffer against the failure of individual fishways and the presence of natural barriers. The restoration of diadromous fish in watersheds without dams, especially hydropower dams, should be encouraged as an additional tool for sustainability.

Matthew Bernier, Matt Bernier is a civil engineer and contractor with the NOAA Restoration Center based in Orono, Maine, where he is a project manager who oversees restoration projects including dam removals, nature-like and technical fishways, and culvert replacements. Prior to joining the Restoration Center in 2008 he worked for 19 years as an engineering consultant on water resources projects including dams, hydropower, fish passage and stream restoration. He has a B.S. degree in Civil and Environmental Engineering from Cornell University, and is a licensed professional engineer in Maine. Most of his work is presently focused on fisheries restoration in Maine, including the large scale Penobscot River restoration project.

A 10 Year Retrospective Look at the Current Condition and Success of Nature-Like Fishways Installed on Three Maryland Rivers
Kathy Hoverman, *KCI Technologies, Inc Natural Resources Management*

This abstract is intended for "the state of knowledge on passage of river herring" session. Over ten years ago the Maryland State Highway Administration (SHA) began the process of restoring anadromous fish runs targeting river herring on three highly urbanized rivers in the greater Washington DC area. This comprehensive effort, part of the environmental mitigation for the Woodrow Wilson Bridge Project, sought to mitigate 23 barriers with nature-like fishways. These fishways used riffle grade controls and flow constrictor / step pools and were the first of their kind in the mid-Atlantic. SHA conducted intensive monitoring on all 23 structures for 5 years. The monitoring included structure stability, habitat quality, and fish and benthic macroinvertebrate collection and identification. DC Fisheries has continued to monitor for fish and eggs in one of the rivers after the 5 year period resulting in 7 years of fish passage data. These data can be combined to assess the success of the nature-like fishways over a

longer period of time than many others on the East Coast.

Kathy Hoverman, Kathy Hoverman is a lead stream restoration designer with KCI Technologies, Inc. in Sparks Maryland. She has a BS in Civil Engineering and an MS in Biology and is a registered professional engineer in several states. She has 11 years of experience in stream assessment and design in the Midwest and Mid-Atlantic with specialization in nature-like fishways in the Mid-Atlantic and New England.

Fish Passage, Ecohydrology, and More: A Comprehensive Approach to Protect River Herring in the Wild and Scenic Taunton River, WA

Alison Bowden, *The Nature Conservancy*

The Taunton River, a ~500 sq mi watershed on Southeastern Massachusetts' coastal plain, hosts one of the largest river herring runs in New England as well as numerous rare aquatic and wetland species. The River received Federal Wild and Scenic designation in 2009, but is located in the heart of the fastest developing region of Massachusetts. Protecting the Wild and Scenic values for future generations demands a comprehensive approach to watershed protection as well as linking freshwater, estuarine, and marine conservation strategies for migratory fish, which have great cultural as well as ecological significance in the watershed's 43 communities. With multiple public and private partners, The Nature Conservancy has collected detailed baseline data on water use and water transfer throughout the watershed to develop a water balance tool; assessed hydrologic conditions and ecological indicator conditions in >100 sub-watersheds to target management strategies; designed 6 projects to demonstrate innovative water management practices; and identified the highest priority dams, road-stream crossings, and parcels of land for conservation action. Collectively, we are working on removal or fish passage at 7 dams, protection of over 2000 acres of land in the watershed, with much more in the pipeline. These site based strategies are linked with statewide policy efforts such as establishing streamflow standards and easing permitting of restoration projects, and regional scale research and fisheries management to reduce bycatch of river herring in ocean fisheries.

Alison Bowden, Alison Bowden is Freshwater Program Director with The Nature Conservancy in Massachusetts. Her work focuses on developing and implementing innovative science and policy tools to protect and restore rivers as well as linking freshwater and marine conservation for migratory fish. Alison has worked on a wide range of policy issues including transportation, water resource management and fisheries management and is a member of the Atlantic States Marine Fisheries Commission Shad and River Herring Advisory Panel. She earned a M.S. in Water Resources from the University of New Hampshire and a B.A. in Environmental Science from American University.

A7

A Systematic Approach to Improve Passage at Dams Necessary for Recovery of Endangered Atlantic Salmon in Maine

Dan Kircheis, *NOAA's National Marine Fisheries Service Protected Resources Division*, Marty Phillips, *Kleinschmidt Associates*, Tara Trinko Lake, *NOAA's National Marine Fisheries Service*, Steve Knapp, *Kleinschmidt Associates*, Jennifer Austin, *Kleinschmidt Associates*

Atlantic salmon in Maine are in danger of extinction. Dams are a major threat to Atlantic salmon recovery because they limit access to historic spawning and rearing habitat; they directly kill and injure a significant number of salmon on both upstream and downstream migrations; and they degrade the productive capacity of habitats upstream by inundating formerly free-flowing rivers, reducing water quality, and changing fish communities. Historically there were approximately 713,000 units (1habitat unit = 100m2) of accessible spawning and rearing habitat for Atlantic salmon. Because of dams, only 39,000 units of fully accessible and suitable spawning and rearing habitat remain. Recovery goals, habitat quality scores and habitat quantity scores used in identifying critical habitat (pursuant to the Endangered Species Act) have

provided us with the resources to plan for, and direct connectivity projects for Atlantic salmon. One of the Atlantic salmon recovery goals is to achieve 90,000 units of fully accessible and suitable spawning and rearing habitats. To achieve this goal, we implemented a strategic approach to improve access to important habitats blocked by dams. This approach includes physical surveys of over 400 dams in Maine and their respective owners. The physical survey confirms dam locations, documents dam features and dimensions, and the presence or absence of fish passage. The dam owner survey targets dam owners to learn their interests and concerns in respect to their dams; how their dams are used; and if they would consider installing fish passage, improved fish passage, or dam removal if resources were available to help.

Dan Kircheis, Dan is a Fisheries Biologist for the National Marine Fisheries Service (NMFS) with 19 years of professional experience working with anadromous fish. Dan started his career with the U.S. Fish and Wildlife Service in 1993. In 2000, Dan joined NMFS as a Fisheries Biologist tasked with the management and restoration of depleted populations of anadromous fish, particularly Atlantic salmon, and more recently alewives and blueback herring. While working with NMFS, Dan has studied the effects of stream acidification on the ability of juvenile Atlantic salmon to transition from the freshwater environment to the marine environment. In recent years, Dan has focused his efforts on improving access to freshwater habitats necessary for the success of all anadromous fish. Dan's efforts on restoring connectivity comes as dams and culverts have been identified as blocking or impairing access to nearly 90 percent of all freshwater lakes, rivers and streams that anadromous fish require for spawning and juvenile rearing.
Marty Phillips is a Senior Resource Economist with Kleinschmidt with 20 years experience in applied survey design and implementation. Marty began her career as a Research Assistant at the University of Maine estimating the value of Maine's fish and wildlife resources, later interning with the US Fish and Wildlife Service, working on the National Survey of Fishing, Hunting and Wildlife-Associated Recreation. Marty entered consulting in 1993 working at HBRS and Hagler Bailly Consulting. She joined Kleinschmidt in 1996, where she has worked extensively in the hydroelectric industry estimating public preferences and demand for outdoor recreation opportunities, nonuse valuation of natural resources, and economic impacts. Marty holds a Master's Degree in Agricultural and Resource Economics from the University of Maine.

Estimation of Turbine Passage Survival for Atlantic Salmon Entrained at Penobscot River Hydroelectric Projects

Celeste Fay, *Alden Research Labratory, Inc.*, George Hecker, *Alden Research Labratory, Inc.*, Stephen Amaral, *Alden Research Labratory, Inc.*, Norman Perkins, *Alden Research Labratory, Inc.*

The National Marine Fisheries Service (NMFS) is in the process of developing a population model for endangered Atlantic salmon to assist in determining acceptable levels of incidental "take" at hydro projects on the Penobscot River in Maine. Salmon smolts and kelts migrating downstream will pass the project through a bypass (if available), over the spillway, or through the turbines. To assist with the assessment of overall project impacts, survival of smolts and kelts passing through each of 65 turbines installed at 15 Penobscot River dams was estimated. As the projects located within the basin are considered low head (<100 ft), the primary injury mechanism leading to mortality was assumed to be blade strike. Utilizing an established blade strike probability model and blade strike mortality test data, estimates of turbine passage survival associated with strike were developed for each turbine. Required turbine data associated with estimating strike survival included parameters such as runner diameter, rotational speed, number of blades, leading edge blade thickness, wicket gate angle, wicket gate trailing edge diameter, and wicket gate height. As some of this information was not always available from project owners, unknown turbine features were estimated using trends derived from available information on similar projects, as well as professional judgment. Turbine diameters ranged from about 2 to 16 ft, while the fish lengths evaluated ranged from 130 mm (about 5 inches) to 800 mm (about 31 inches). For some projects, the fish length evaluated was relatively large compared with the turbine diameter. Therefore, additional analysis was

completed to estimate the impacts on survival associated with fish passing through narrow wicket gate openings and blade spacing. Final survival estimates for each turbine were completed over a range of flows and are a function of the strike probability analysis and the physical interactions with various turbine components.

Celeste Fay, Celeste N. Fay is a Project Engineer in the Environmental and Engineering Services Group at Alden Research Laboratory, Inc. She received her B.S. degree in civil engineering from Worcester Polytechnic Institute in 2008. Ms. Fay, who has been working in the hydropower industry for the last nine years, is responsible for the conceptual design of fish passage and protection facilities and evaluations of turbine passage survival. Prior to working in the engineering field, Ms. Fay worked as a hydropower mechanic, providing a unique perspective on hydropower related evaluations.

Estimation of Total Project Survival for Atlantic Salmon Passing Downstream at Penobscot River Hydro Projects

Stephen Amaral, *Alden Research Laboratory, Inc. Environtal and Engineering Services*, Celeste Fay, *Alden Research Labratory, Inc.*, George Hecker, *Alden Research Labratory, Inc.*

The National Marine Fisheries Service (NMFS) is in the process of developing a population model for endangered Atlantic salmon to assist with the determination of acceptable levels of incidental "take" at hydro projects on the Penobscot River in Maine. A major component of the population model will be estimated losses of smolts and kelts at each project during their downstream migration. Atlantic salmon smolts and kelts migrating downstream may be subject to mortality due to injuries sustained during passage through turbines and fish bypasses, or over spillways. In addition to direct mortality associated with these passage routes, indirect mortality may result from increased predation rates or reduced fitness associated with the stress of downstream passage and migration delays. Cumulative effects from passage at multiple projects may also lead to increased mortality during the in-river migration and after fish reach the estuary and marine environment. Consequently, we developed estimates of downstream passage survival of smolts and kelts at 15 hydroelectric projects on the Penobscot River and its tributaries. To accomplish this, we estimated entrainment rates of smolts and kelts of various lengths and calculated turbine survival for entrained fish using an established turbine blade strike probability and mortality model. Survival rates for fish passing downstream over spillways or through fish bypass facilities were also estimated for each project based on existing site-specific data or using information from other projects with similar design features. Spillway passage was assumed to be proportional to flow. Bypass efficiencies were based on bar rack spacing, available literature, and field studies conducted at two of the projects. Fish not assigned to spillway or bypass passage were assumed to be entrained through a project's turbines. Using the proportion of fish passing through each route and applying route-specific survival rates, total project downstream passage survival was calculated for each project over a range of river discharges.

Stephen Amaral, Steve Amaral is a Principal Fisheries Biologist with Alden Research Laboratory, Inc., and has more than 20 years of professional experience in the development and evaluation of fish passage and protection technologies. He has been a lead investigator in several studies examining injury and morality of fish passing through conventional and hydrokinetic turbines. Steve has a B.S. and M.S. in fisheries biology, both from the University of Massachusetts.

Dam impact analysis on Atlantic salmon recovery in the Penobscot River, Maine

Julie Nieland, *NOAA Fisheries Service*, Timothy Sheehan, *NOAA Fisheries Service*, Rory Saunders, *NOAA Fisheries Service*, Jeffrey Murphy, *NOAA Fisheries Service*, Tara Trinko Lake, *NOAA Fisheries Service*

Atlantic salmon populations in Maine are listed as endangered under the Endangered Species Act (ESA), and dams have been identified as a major contributor to their historic decline and current low abundance. Under the ESA, federal agencies must ensure their actions, such as the licensing of hydroelectric dams by the Federal Energy Regulatory

Commission, do not preclude population recovery. To help meet this requirement, we developed a model to quantitatively evaluate the impact of federally licensed dams on Atlantic salmon dynamics. We examined the Penobscot River, a large river system in Maine that produced approximately 75% of all US adult Atlantic salmon returns in recent years. This highly modified river has multiple hydroelectric facilities that reduce passage rates for downstream migrating smolts and upstream migrating adults on both mainstem and major tributary reaches. We developed a life-stage specific model to compare the population dynamics of the current state of passage success to a hypothetical scenario of 100% passage success (i.e., no dams). Downstream passage survival distributions were generated for each dam using site- and facility-specific attributes, as well as biological and river flow data, accounting for both direct mortality and indirect secondary effects, such as increased passage time. Empirical field data were used to verify these distributions and also to develop upstream passage survival distributions. This general approach allowed for the development of more accurate passage distributions for dams with and without prior data. Model outputs include probability density functions for smolt and adult abundance, dam-induced losses at each hydroelectric facility, and natural mortality losses at key life stages. This model will allow the National Marine Fisheries Service to develop dam passage survival standards for downstream and upstream migrating salmon that will not significantly reduce the recovery of the species. The model will also help prioritize future passage improvement efforts to maximize the benefits to the Penobscot River Atlantic salmon population.

A8

The Hudson River American Eel Project: low-cost fish passage through citizen science

Chris Bowser, *New York State Department of Environmental Conservation and Cornell Water Resource Institute HudsonRiver Estuary Program and Research Reserve*, Sarah Mount, *National Audubon/TogetherGreen*

The Hudson River Eel Project involves over 200 diverse community members in shared goals and methodologies to study juvenile eels during their migrations from sea to stream. March through May, fyke nets staked in ten tidal tributaries to the Hudson are checked daily by teams of trained citizen-scientists. Since 2008, over twenty thousand eels have been counted, weighed, and released above barriers.

Volunteers are trained by state scientists, and very simple data collection and ID sheets have been developed to follow Atlantic States Marine Fisheries protocols and maximize accuracy. Volunteers include a wide range of socio-economic backgrounds and ages, from high school students to watershed groups, which cascades into considerable outreach value and public awareness.

At most sites, eels are placed above the nearest barrier, dam, or rapids. Last year, we implemented an additional low cost "trap-and-pass" eel ladder that caught over 1400 eels of various sizes in its first six months of use. Participants answer questions about recruitment along the tidal estuary from urban streams to quiet creeks. Data yield information about the timing and strength of eel migrations, suggest favorable conditions, and help managers prioritize restoration efforts in barrier passage, all in an economic framework that takes advantage of the public's fascination of migratory fish in their own neighborhood.

Fish Migration Day

Herman Wanningen, *Wanningen Water Consult*, Lonneke Fust, *Wanningen Water Consult*, Niels Breve, *Dutch Angling Association*

Free migration of fish is necessary to achieve healthy fish stocks. Several species, including salmon, sea trout, sturgeon and eel, migrate between the sea and rivers. These species are particularly threatened by barriers such as weirs, dams and sluices, built for water management, hydropower and land drainage. Water and nature managers in Europe have been improving the situation with fish passes and by-pass channels around barriers, to help fish on their journey.

An essential aspect of working on fish passage issues is raising awareness and creating commitment within communities in the different river basins. By creating commitment on all levels of the communities and stakeholders measures can be carried out more

efficiently and financial opportunity can be maximised. The Fish Migration Day is a new concept to achieve greater understanding and community involvement (including children and parents).
The first Fish Migration Day was held on the 14th of May 2011. The event was organized by the Living North Sea Project, which is funded by the European Union. On more than 25 locations in 7 countries in the North Sea Region interested children and parents could learn about a variety of topics, including: different species of fish, fish passage solutions, water and nature management issues, fisheries, research, aquatic insects and could play the Eel Game (www.elyeel.eu). At the end of the day 5000 persons had visited the event and it turned out to be a big success. The idea is to organize a follow up worldwide in 2013/2014.
The presentation will highlight the goals, activities and results of the Fish Migration Day and will give an insight in the plans for World Fish Migration Day in 2013/2014.

Herman Wanningen, Herman Wanningen is an aquatic ecologist with more than 15 years experience in freshwater ecology and operational water management. In the Netherlands he has worked for the regional Water Authority Hunze and Aa's on river and lake restoration projects. He developed fish migration visions and policies and gave advice on implementing different fishway techniques. He initiated and coordinated the production of the European guidance on fish migration "From sea to source" which was published in 2006. In 2007 Herman started Wanningen Water Consult. Since then he gives advice on national and international projects dealing with the theme fish migration and river connectivity. Currently he is working on the worldwide guidance "From sea to source".

Beaver Island Wetland Restoration Project
Michele Stottler, *Gomez and Sullivan Engineers, PC*, Ed Alkiewicz, Steve Schoenwiesner

In 2011, the New York Power Authority (NYPA) completed construction of the Beaver Island Habitat Improvement Project (HIP) on Grand Island on the Niagara River. The project restored 8.3 acres of hemi-marsh (emergent marsh and shallow open water habitat interspersed in roughly equal parts in a complex pattern), which historically (before 1960) occurred at the site. Around 1960, the area was filled and the hemi marsh was replaced with mowed lawn.The improvement project consisted of the removal of fill material that was placed at the historic emergent river marsh, site grading to create wetland contours, planting of wetland and riparian botanical species and invasive species-control. The restoration of the wetland has created a new viable habitat, providing food and cover for wildlife and aquatic species.
Since the project is located within Beaver Island State Park, the NYPA engaged in a collaborative design process with the New York State Office of Parks, Recreation, and Historic Preservation the owners of the site and the New York State Department of Environmental Conservation which was interested in restoring a historic emergent wetland in a highly developed urban river corridor. While the primary goal of the project was wetland restoration, other features were added through the collaborative process for recreation and as a means to dispose of 70,000 CY excavated fill from the wetland restoration. These features include a canoe/kayak launch, an osprey pole, shallow breakwaters and shoreline stabilization, a walking trail and overlook, and conversion of a paved parking lot to a "green" parking lot. Multiple project features posed permitting challenges with the U.S. Army Corps of Engineers since their Nationwide Permit Program focus is on projects with a single purpose.
The overall success of the HIP depended on the establishment of native wetland vegetation and the corresponding lack of extensive stands of invasive species. In order to successfully achieve these habitat goals, designers used data for "reference condition" areas (i.e. areas of existing habitat with desired and undesired characteristics that can be used as a reference for restoration design including water depths, substrate texture, bathymetry, plant species, etc.) to design conditions for the wetland restoration project. In additions to selecting the right species and elevation to restore native wetland vegetation, a wildlife deterrence system was constructed to keep out species like geese and carp from overgrazing on the newly planted vegetation. The newly constructed wetland will be monitored for 5 years to ensure the ecosystem is functioning as intended and will be viable into the future.

Michele Stottler, Michele Stottler, P.E., is Senior Water Resources Engineer and Project Manager with Gomez and Sullivan Engineers, P.C. She is responsible for the environmental and engineering analyses for the licensing of hydroelectric power projects. Michele's duties include stakeholder outreach, agency negotiation, environmental and engineering licensing studies, preparation of FERC license applications, permitting, and license compliance. Michele's technical experience includes hydrologic and hydraulic modeling, instream flow investigations, water quality monitoring and modeling, and civil site design of recreation and wetland restoration projects.

Emerging Concerns of Fish Passage and Aquatic Habitat Restoration Projects in the Great Lakes: The potential short and long term
Andrea Ania, James Boase, Justin Chiotti, Jeremy Moore, and Lisa Williams *U.S. Fish & Wildlife Service National Fish Passage Program*, Chris Freiburger, Jim Baker, and Joe Leonardi *Michigan Department of Natural Resources*, Brent Murry, Tracy Galarowicz, Clarence Fullard, and Gabe Madel, *Central Michigan University*, and Dan Hayes and Jacob Stoller *Michigan State University*

Projects marketed and designed to benefit aquatic organisms and/or aquatic habitat restoration should be evaluated to ensure they are meeting intended restoration objectives. Multi-partner collaboration is necessary to fully evaluate efforts due to the interdisciplinary nature of these projects and shrinking agency staff size. Furthermore, it provides an opportunity to contribute to the growing science of aquatic habitat restoration.

Andrea Ania, Andrea is a biologist with the U.S. Fish & Wildlife Service in Alpena, Michigan. She coordinates fish passage and aquatic habitat restoration projects in tributaries to Lake Huron and western Lake Erie under the National Fish Passage Program and Great Lakes Fish Habitat Partnership.

B1

Behavior, impingement, and entrainment of shortnose sturgeon at a vertical bar rack: with and without a bypass orifice
Boyd Kynard, *BK Riverfish, LLC Department of Environmental Conservation*, Don Pugh, *Trout Unlimited*

Tests with Connecticut River shortnose sturgeon (sns), Acipenser brevirostrum, in the Conte AFRC flume (36.6 m long x 6.1 m ft wide x 4.3 m deep) observed sns behavior, impingement, and entrainment as they encountered a vertical bar rack (5 cm clear spacing). Cultured juveniles (yearlings and older, larger fish), and wild adults were observed. Three mean approach bottom water velocities (30.5 cm, 61, and 91 cm/s) were used in tests with no orifice in the rack; other tests observed sns at 61 cm/s approach velocity to the rack with an orifice (1 m2 opening) in the rack. Underwater video camera and TIRIS PIT systems monitored sns movement and behavior at the bar rack. Most sns were oriented tail downstream when they were 60 cm upstream from the rack, so fish were backing down the flume. Initial movement at the rack of some fish in all age classes was to swim upward. No adult or older juvenile was impinged or entrained during any approach velocity. No yearling was impinged at 30.5 cm/s, but 7.7–12.5 % was impinged at 61 cm/s, and 33.3–40.0 % was impinged at 91 cm/s. The entrainment of yearlings at the three approach velocities follow: 4.3–9.1% at 30.5 cm/s, 7.1–27.8% at 61 cm/s, and 66.7–80.0 % at 91 cm/s. Number of sns tracked at the rack with the orifice and the number (%) that entered the orifice follows: 21 yearlings tracked and six (28.6 %) entered the orifice; 17 older juveniles tracked and 7 (41.2 %) entered the orifice; nine adults tracked and zero entered. All of the 13 fish entering the orifice approached on or just above the bottom. Four swam headfirst downstream through the orifice, the remainder (nine sns) went tailfirst. Six of 13 fish swam in and out (upstream) of the orifice, the remainder swam one-way downstream through the orifice. Some juveniles (even yearlings) will enter an orifice with no attraction flow. The low number of sns using the orifice could be due to the colder than

normal water temperatures, orifice characteristics, etc. and needs study.

Boyd Kynard, Retired in 2008 after 30 years as a migratory fish research biologist for the FWS, BRD, and USGS (Conte AFRC). Presently collaborating on migratory fish research and fish passage in Brazil, China, and Romania.

Biological and Engineering Studies of American Eel Anguilla Rostrata at the Conowingo Project
Kimberly Long, *Exelon Power Corporation*, Ray Bleistine, *Normandeau Associates, Inc. Hydro*, Chris Avalos, *Normandeau Associates, Inc.*, Charles Barnes, *Normandeau Associates, Inc.*, Thomas Sullivan, *Gomez and Sullivan Engineers, P.C.*

As part of a broad bioengineering investigation at Conowingo Hydroelectric Dam, MD, the distribution and abundance of juvenile American eel, Anguilla rostrata, downstream of the dam was studied for two years. Results of the study were expected to provide potential location and feasibility information as part of the broader bioengineering analysis.
Elvers and yellow eels were sampled between 24 June and 6 September 2011 using elver ramps (with Enkamat® and AkwaDrain™ substrates) and eel pots (for yellow eels). A total of 1,159 eels (1,100 elvers collected from the elver ramps and 59 yellow eels in pots) were collected in the spillway side downstream of Conowingo Dam compared to 166 elvers and 92 yellow eels collected in 2010. Capture of elvers differed between substrate type and location of ramps. The East ramps (located farther from the powerhouse), collected 539 elvers, with 133 collected in the Enkamat® substrate, and 406 elvers collected in the AkwaDrain™ substrate. The West ramps (located near the powerhouse) collected 561 elvers, with 405 collected in the Enkamat® substrate, and 156 elvers collected in the AkwaDrain™ substrate. High elver collections on both sides were ramps parallel to walls suggesting elvers orient themselves upstream to structure. The collection locations of elvers were subject to spillage during the study period which caused extensive damage to the collection gear, and it was observed that the integrity of any potential structure below the spillway could be at risk during spillage.
Elver lengths ranged from 87 to 188 mm TL, with an average size of 124.9 mm. Yellow eels harvested from the eel pots totaled 151 for both study years; with the exception of one, all yellow eels were collected near the powerhouse location. The length range of eels collected in pots ranged from 300 to 689 mm TL, with an average length of 515.4 mm. Most elvers were split at age I or II, and III to V years of age at 30%, respectively. A large gap in age at year VI to VIII was apparent; larger eels were aged IX to XVII, plus one at XIX years of age.
The study compared lunar cycle and rain events to eel collections; a strong relationship was not observed. Three nighttime surveys conducted in 2011 documented areas of elver congregation in the spillway

Kimberly Long on behalf of Ray Bleistine, Ms. Kimberly Long is an Environmental Specialist with Exelon Power (Exelon) in Kennett Square, Pennsylvania. As an Environmental Specialist, she serves as a subject matter expert in the areas of NPDES permitting and compliance, stream and wetland encroachments and aquatic biology. Ms. Long provides environmental compliance support to various fossil and hydro facilities in the mid-Atlantic region, Massachusetts and Texas. Ms. Long also provides support to hydro FERC relicensing activities and natural resource aspects of Exelon Wind.
Mr. Ray Bleistine is a Senior Scientist with Normandeau Associates, Inc. (Normandeau) in Drumore, PA. As a Senior Scientist, he serves as a subject matter expert in upstream fish passage, fish passage facility operations, fisheries and water quality, and environmental report preparation and review. Mr. Bleistine also conducts and provides support to studies relating to FERC relicensing activities.
Mr. Chris Avalos is a Fisheries Biologist with Normandeau Associates, Inc. in Drumore, Pennsylvania. Mr. Avalos serves in the areas of fisheries, including the American shad restoration project, upstream eel passage, macro invertebrate bioassessments, endangered species restoration, and aquatic biology.
Mr. Charles Barnes is a Fisheries Biologist with Normandeau Associates, Inc. in Drumore, PA. As a biologist, he assists with numerous field projects related to the FERC relicensing of power stations

located on the lower Susquehanna River. Mr. Barnes' extensive field work has dealt primarily with freshwater and anadromous fish species; he also assists in numerous field studies collecting water quality data on the Susquehanna River. Mr. Barnes recently became recognized by the American Fisheries Society as a Certified Associate Fisheries Professional.

Management of migrating European eel (Anguilla anguilla) in Irish rivers used for hydropower generation.

T.Kieran McCarthy, *National University of Ireland Galway Zoology, Ryan Institute, School of Natural Sciences.*, R. MacNamara, *Ryan Institute, School of Natural Sciences, National University of Ireland Galway*, D. Nowak, *Ryan Institute, School of Natural Sciences, National University of Ireland Galway*, J. Grennan, *Ryan Institute, School of Natural Sciences, National University of Ireland Galway*, A. Bateman, *Ryan Institute, School of Natural Sciences, National University of Ireland Galway*, B. Conneely, *Ryan Institute, School of Natural Sciences, National University of Ireland Galway*,

An extensive decline in European eel stocks, which prompted the European Union to provide a legislative framework (E.U. Regulation No. 1100/2007) for conservation of the species, has been recognised in Ireland for over two decades. In 2008, a National Eel Management Plan (EMP) was adopted which required specific actions to be initiated. Prior to development of the eel management plan, an attempt was made to estimate the current and historical spawner biomass escapement from Irish river systems and this lead to the conclusion that particular eel conservation measures were needed in Ireland. Among the actions specified in the National EMP were: closure of eel fisheries and markets; improvements to eel habitats, including water-quality; reduction in adverse effects of barriers and hydropower generation. Results of research undertaken on migrating eel populations in three Irish river systems (River Lee, River Shannon and River Erne), regulated for hydropower generation, and current eel conservation programmes, will be outlined in this presentation. The stocking of juvenile eels, undertaken since the 1960's for fishery enhancement reasons, has declined due to poor natural recruitment. Therefore the main focus of recent research has been on determining the numbers, biomass and spawner quality of the downstream migrating silver-phase eels. Monitoring of population dynamics and turbine passage mortality rates has involved: analysis of daily and annual catches at eel fishing weirs; mark-recapture experiments; population surveys undertaken using DIDSON acoustic cameras; acoustic telemetry and mathematical modelling. Capture of silver-phase eels for release downstream of dams is currently the main hydropower mitigation measure. In the period 2009-2012, over 135 t were safely released. Options for development of alternative conservation measures, such as deflection to spillways, are being explored. However, spawner quality issues (fat content, parasite infection and maturation status) are of increasing concern.

T.Kieran McCarthy, Dr T. Kieran McCarthy has been researching Irelands freshwater ecosystems for over 40 years. He and his research team have undertaken extensive studies on the biology of European eel in Ireland. The current focus of his eel research is on determination of the effective spawner biomass escapement from Irish rivers used for hydroelectricity genereation.

Effect of Upstream Fish Passage Structure Entrance Design and Head Differential on Attraction and Entry of Adult American Shad

Alex Haro, *U.S. Geological Survey S.O. Conte Anadromous Fish Research Laboratory*, Theodore Castro-Santos, *U. S. Geological Survey*, J. Noreika, *U. S. Geological Survey*,

Physical and hydraulic characteristics of upstream fish passage structures (e.g., fishways, fish lifts) are critical for effective attraction and entry of target species to be passed. These characteristics may be species specific, but have not been extensively quantified. We evaluated attraction and entry of adult American shad and lake sturgeon to experimental surface and submerged orifice entrance structures at several entrance head differential (water velocity) and siting (center of channel, side of channel) conditions, under controlled laboratory conditions. Initial attraction of American shad to both entrance types was relatively rapid under all conditions and was

highest for the lowest test entrance velocity . For surface weirs, attraction rate appeared to decrease with increasing head differential. American shad entered surface weirs preferentially over orifices; head differential appeared to have no effect on orifice attraction rate of American shad. Lake sturgeon appeared to be more attracted to surface weirs than orifices at the lowest head differential; attraction to orifices and surface weirs at the higher head differential was roughly equivalent. Sturgeon appeared to display no preference for entry via surface weirs or orifices, but overall proportion of fish passing was low, which may have limited statistical precision of results. Both species appeared to show little preference for either center or side entrances, except that American shad strongly selected the side surface weir at the 0.30 m differential. Results from this study show a degree of interplay between attraction and passage for various entrance configurations and hydraulic conditions. Depending on species, one particular combination of factors may elicit strong attraction, but only modest passage.

Alex Haro, Alex Haro is a Research Ecologist at the S.O. Conte Anadromous Fish Research Laboratory (Biological Resources Discipline, U.S. Geological Survey) at Turners Falls, Massachusetts, USA and serves as a Principal Investigator and Section Leader of the Fish Passage Engineering Section at the Conte Lab. His present work involves migratory fish behavior, design, engineering, and evaluation of fish passage structures, fish swimming performance, and ecology and management of American eels. Dr. Haro provides extensive basic and applied research and advice to state, national, and international agencies, NGOs, and the private sector on fish passage technology and operations. He is also an Adjunct Associate Professor at the University of Massachusetts Department of Environmental Conservation and serves as a major advisor for graduate students, as well as an instructor for courses in fisheries biology.

B2

Critical Linkages: Assessing Connectivity Restoration Potential for Culvert Replacement and Dam Removal in Massachusetts

Scott Jackson, *University of Massachusetts Amherst Department of Environmental Conservation*, Brad Compton, *UMass Amherst*, Kevin McGarigal, *UMass Amherst*

The University of Massachusetts Amherst, working in partnership with The Nature Conservancy and state agencies, integrated data related to landscape connectivity and human development, and completed a comprehensive analysis of areas in Massachusetts where aquatic connectivity can best be enhanced by culvert replacement and dam removal. The Critical Linkages project builds on the existing Conservation Assessment and Prioritization System (CAPS), a computer model developed by UMass that incorporates biophysical and anthropogenic data to compute an index of ecological integrity (IEI). Because CAPS provides a quantitative assessment for IEI as well as each metric used in ecological integrity models it can be used for comparing various scenarios. Scenario analysis involves running CAPS separately for each scenario, and comparing results to determine the loss (or gain) in IEI or specific metric units. In Phase 1 of the Critical Linkages project we used the scenario testing capabilities of CAPS to assess changes in the aquatic connectedness metric for dam removal and culvert/bridge replacement projects. A baseline assessment of aquatic connectedness provided a statewide base scenario for comparison of restoration options. Scenario-testing software was developed to efficiently assess restoration potential for large numbers of possible restoration projects and then applied statewide to road-stream crossings and dams. Results of these analyses indicate that a relatively small proportion of culvert replacement and dam removal projects would result in substantial improvements in aquatic connectivity.

Scott Jackson, Scott Jackson is Extension Association Professor in the Department of Environmental Conservation at the University of Massachusetts Amherst and Program Director for

UMass Extension's Natural Resources and Environmental Conservation program. Research interests include: ecology and breeding biology of amphibians, vernal pool ecology, wetland assessment and monitoring, impacts of roads and highways on wildlife, and landscape-based ecological assessment. He has been involved in the use of underpass systems to facilitate wildlife movement across roads and development of methods for evaluating the effectiveness of animal passage structures. He lead efforts to develop standards for road-stream crossing structures, survey protocols for assessing crossing structures, and approaches for prioritizing structures for replacement.

Identifying Opportunities for Barrier Removal and Fish Passage Improvements within the Hudson-Raritan Estuary

Diana Kohtio, *USACE, New York District Planning*, Leonard Houston, *USACE, New York District*, Heather Morgan, *USACE, New York District*, Erin Nagel, *USACE, New York District*, Catherine Mulvey, *USACE, New York District*, Robert Smith, *USACE, New York District*

The Hudson-Raritan Estuary (HRE) is one of the most urbanized estuaries in the world, and centuries of urban and industrial land uses have resulted in severely degraded ecological conditions. The Estuary spans the boundaries of many municipalities within New York and New Jersey (including New York City). Planning for restoration within such an ecologically and politically diverse system poses many challenges.

The New York District with its partner the Port Authority of New York and New Jersey in a collaborative effort with over 60 organizations in partnership with NY/NJ Harbor Estuary Program released the Draft Comprehensive Restoration Plan. The Plan established 11 goals for the HRE to create and restore a mosaic of habitats within a human dominated landscape. One of the goals, Tributary Connections, aims to reconnect freshwater streams to the estuary and provide a range of quality habitats to aquatic organisms. Historically, anadromous spawning runs of alewife, blueback herring, striped bass and American shad and catadromous runs of American eel were common in the HRE. Poor stream conditions and an increased number of obstacles to upstream migration, like tide gates, culverts and dams have reduced these species' migration opportunities. An integral component of the Tributary Connection initiative will be the identification and prioritization of potential locations to restore diadromous fish passage.

Currently the HRE Region has no prioritization or assessment strategy procedures for identifying potential locations. To advance this strategy, the study team is developing a process to inventory and screen barriers and their associated ecological settings. Information collected through this process will be used to determine viability of sites for barrier removal or bypass and successful re-establishment of fish passage in the HRE. The objective of this project is to develop a systematic method for identifying and assessing fish passage barriers within the HRE. The first step of this process will be accomplished by creating as detailed and complete a database of blockages as possible through desktop analysis. As a next step, barriers and tributary reaches will be reviewed to create a thorough database of habitat, biological, structural and landscape attributes. Field assessments will be conducted to identify undocumented obstacles and supplement desktop analysis. Ultimately, these metrics will be used to rank, compare and prioritize individual barriers for restoration potential.

Assessing, Prioritizing, and Implementing Numerous Small Culvert AOP Projects in a Short Period of Time - A Case Study of a Time

Roy Schiff, *Milone & MacBroom, Inc.*, Jessica Louisos, *Milone & MacBroom, Inc.*

When the Addison and Chittenden County Regional Planning Commissions and the Lewis Creek Association of Charlotte, Vermont learned about the 2013 repaving project on Vermont Route 116 the groups realized that many culverts could be improved for both conveyance and aquatic organism passage (AOP) along the roadway in a very short timeframe. Existing assessment data indicated that many fish blocks existed along this roadway. In addition, unassessed culverts could quickly be looked at using the Vermont Bridge and Culvert Assessment Protocols, as well as the AOP and Geomorphic Compatibility Screening Tools, to rapidly assess and determine if retrofit or replacement could improve

AOP. The fortunate timing in advance of the repaving project allowed for collaboration to improve AOP over the road corridor in two Towns.
The Vermont Agency of Transportation was contacted to inquire when the typical replacement of the deteriorated or problem smaller culverts would take place. Vermont Fish and Wildlife was contacted for fish and habitat data. The Towns joined the group understanding that infrastructure improvements were on their way. The group coalesced, the project was developed, and consulting services were obtained to perform the project. Collaboration will expand the standard practice focusing on structural integrity and conveyance to improve AOP.
At the time of the writing of this abstract the project kick-off meeting has just taken place and some assessment data have been gathered. At the time of the conference ten or more culverts are expected to have been replaced to improve AOP. Assessment, prioritization, hydraulic calculations, and design recommendations are planned to improve AOP at all of the smaller structures where suitable fish habitat exists. The presentation will cover each phase of the collaboration and report on the level of success of the approach and whether it can serve as a template for rapidly improving AOP.

Roy Schiff, Roy Schiff is a Water Resource Scientist and Engineer with Milone & MacBroom, Inc. MMI is based out of Cheshire, CT, and Roy manages their Vermont branch office that he helped open in 2005. He received his PhD from the Yale School of Forestry and Environmental Studies in 2005 where his research focused on the effects of stream restoration practices on the physical, biological, and chemical components of aquatic ecosystems. Roy is a licensed Professional Engineer in Vermont and frequently works on applied projects including channel and floodplain restoration, dam and levee removal, fish passage improvement, and bank stabilization. He has developed stream management protocols used in New England such as guidelines for channel restoration, protocols for screening culverts for fish passage and geomorphic compatibility, and habitat assessment methods. Roy regularly gives presentations that illustrate the importance of working with, not against, natural river form and processes to protect water resources and reduce risks. Roy lives in Montpelier, VT with his lovely wife, two adorable daughters, and quirky dog.

Assessing fish passage connectivity at the watershed scale: Truckee River case study
Jock Conyngham, *Environmental Laboratory, ERDC, USACE,* J. Fischenich, *Research Civil Engineer, U.S. Army Corps of Engineers, Environmental Laboratory, Vicksburg, Mississippi*, S. McKay, *Research Civil Engineer, U.S. Army Corps of Engineers, Environmental Laboratory, Athens, Georgia*

Traditionally, fish passage engineers, restoration practitioners, and environmental managers have focused assessments of alternatives and benefits at a single site. Effective restoration of populations in many fragmented systems, strategic allocation of resources, and prioritized sequencing of passage and related restoration efforts often demand larger scale tools that recognize benefit dependencies among actions at multiple sites and that effectively compare alternatives that target multiple species, age classes, bi-directional movements, and even non-passage goals. This presentation discusses one such approach that was developed in a rapid time frame with a diverse technical and stakeholder group to assess fish passage alternatives at 17 barriers in the Truckee River in Nevada for a guild of native species. Currently, we are developing a more flexible and powerful generic model borrowing from landscape ecology techniques and utilizing graph-theoretic algorithms to assess system-wide connectivity for fish passage problems, compare alternatives, and predict benefits. The case study is meant to demonstrate the potential value of watershed-scale analytical tools, solicit input on alternative techniques, and identify strengths and weaknesses in efforts to restore connectivity at sub-basin or basin scales.

Jock Conyngham, Jock Conyngham is a Research Ecologist in the Environmental Laboratory of the Engineer Research and Development Center (ERDC). His specialties include multi-scaled assessment, restoration, and monitoring of watersheds, streams and rivers, riparian zones, and aquatic populations. Jock has provided technical

support for ecosystem restoration, fish passage projects, dam removals, and environmental benefits assessments across North America for thirty years. He received a Master of Forest Science and a Master of Philosophy in population ecology and anthropology from Yale University. Prior to joining ERDC in 2002, Jock was Director of Watershed Assessment and Geomorphic Restoration for the national office of Trout Unlimited. Among other committee memberships, he has sat on the AFS-BES working committee Emerging Technologies in Fish Passage since its inception.

B3

Assessing Fish Passage through Culverts in Midwest Streams: Identifying Design Parameters that Correlate with Passage Success

Hans Tritico, *Youngstown State University*, D Baral, *Youngstown State University, Department of Civil/Environmental and Chemical Engineering*, B Rayamajhi, *Youngstown State University, Department of Civil/Environmental and Chemical Engineering*, TM Robinson, *Youngstown State University, Department of Civil/Environmental and Chemical Engineering*, AN McMillen, *Youngstown State University, Department of Civil/Environmental and Chemical Engineering*

Fish connectivity analyses on the East and West coasts of the United States have traditionally focused on studying the passage of salmonid species through culverts. Such studies have not been conducted for the Midwest region, where it has generally been assumed that there is not a major migration/connectivity problem. A study has been carried out to investigate the percentage of culverts in Northeast Ohio that are barriers to a range (10 different species) of endemic fish species. Further, the design parameters that correlate to passage success in Midwest fish species are also being studied. A database of 5,837 highway culverts was made available by the Ohio Department of Transportation, out of which 90 were chosen for analysis based on the presence of fish species and the possibility of extracting all necessary information for analysis. Regional databases were used along with GIS to obtain refined data of stream morphology, discharge, and slope which was then used as input to carry out the study using the FishXing software. Fish passage through culverts was analyzed at four different flows - minimum average monthly flow (usually September), maximum average monthly flow (Usually March), 2 year high flow, and 25% low flow. The results of the study have shown that 23 culverts were partial barriers for fish passage, meaning they allowed passage for some fish species under certain flow conditions. The remaining 67 culverts were complete barriers to all fish species under all flow conditions. It was noted that the ratio of partial barriers to complete barriers was higher in interstate routes as opposed to highway routes. This could be for a number of reasons including differing design standards or differences in local hydrology around I-80. It was also discovered that the average slope in the partial barrier culverts was significantly (student's t-test, $p < 0.05$) lower (0.6%) than the average slope in the complete barrier culverts (1.6%). Culvert diameter and length were not significantly different between complete and partial barriers. Additional results discussing causal factors for fish passage through culverts in Midwest streams will be presented. It is expected that the results will provide a clearer view about the true extent of the connectivity problem in Northeast Ohio and will prompt policy discussions. The analysis method presented is expected to be easily replicable for any region or watershed.

Hans Tritico, Darshan Baral is a master's student at Youngstown State University studying Environmental/Water Resources Engineering. Prior to coming to YSU he graduated with a BS in Engineering and worked in Nepal on hydropower projects.

Road crossings limit nothern pike access to seasonal spawning habitat

Matthew Diebel, *Wisconsin Department of Natural Resources*, Tammie Paoli, *Wisconsin Department of Natural Resources*, Peter McIntyre, *University of Wisconsin*, Daniel Oele, *University of Wisconsin*, Evan Childress, *University of Wisconsin*, Jeffrey Maxted, *The Cadmus Group, Inc.*, Andrew Somor, *The Cadmus Group, Inc.*

Recruitment of juvenile northern pike in Green Bay of Lake Michigan has been reduced by loss of tributary spawning habitat, through both habitat degradation and barriers to access. Upgrading or improving road crossings (typically culverts) to facilitate fish passage has the potential to be an efficient way to increase pike recruitment because management action at a very small scale - the width of a road - can lead to accessibility of large expanses of breeding habitat. However, because there are thousands of crossings whose improvement could potentially benefit pike, rigorous methods for prioritizing restoration efforts are needed. We used a GIS-based analytical approach to evaluate barriers on the proximity, amount, and quality of habitat that would be reconnected by their removal. Prioritization is based on this measure of benefit divided by the estimated cost of replacing a barrier with a fully passable structure, and also accounts for potential inland spread of invasive round goby and sea lamprey. Because successive barrier removals have non-linear effects on connectivity, an iterative modeling approach was used to adjust priority rankings based on the sequence of barrier removal. These methods provide a quantitative basis for optimizing efforts to restore tributary network connectivity and spawning habitat for migratory fishes.

Matthew Diebel, Matt Diebel is a fisheries and aquatic research scientist at the Wisconsin Department of Natural Resources. He has an MS in water resources management and a PhD in limnology from the University of Wisconsin-Madison. Prior to joining Wisconsin DNR, he worked as a scientist for the Cadmus Group, Inc. His research focuses on landscape-scale patterns in aquatic ecosystems and on methods for restoration and protection of these resources.

Road crossings as barriers to pearly mussel distribution in the southwestern Lake Ontario basin

Marie Schrecengost, *U.S. Fish and Wildlife Service Habitat Restoration*, Christian Castiglione, *U.S. Fish and Wildlife Service, Lower Great Lakes FWCO*, Jenny Landry, *New York State Department of Environmental Conservation, Region 8*, Raymond Li, *U.S. Fish and Wildlife Service, Lower Great Lakes FWCO*, Karolyn Lock, *U.S. Fish and Wildlife Service, Lower Great Lakes FWCO*, Amy Mahar, *New York State Department of Environmental Conservation, Region 8*

The U.S. Fish and Wildlife Service (FWS), Lower Great Lakes Fish and Wildlife Conservation Office is partnering with the New York State Department of Environmental Conservation (DEC), Bureau of Fisheries to evaluate aquatic organism passage(AOP) in targeted NY subwatersheds of Lake Ontario. Specifically, FWS surveyed road crossings on streams found to support pearly mussel populations to determine AOP; DEC surveyed those same streams for mussel populations. The objectives of the study are to 1) determine the locations of AOP barriers caused by road crossings, 2) determine the locations of the mussel populations, primarily Species of Greatest Conservation Need, 3) determine if the AOP barriers are impeding the movements of potential host-fishes, thereby limiting the distribution of mussel populations, and 4) prioritize AOP barriers for restoration efforts. Throughout the field seasons of 2010 and 2011, 29 streams were surveyed, which included over 400 road-crossings. Road crossing data was assessed using a slightly modified version of the Vermont Culvert Aquatic Organism Passage Screening Tool, a coarse screen model to determine AOP. This model categorized crossings as completely passable, completely impassable, or reduced AOP; crossings categorized as reduced AOP were further assessed using FishXing Version 3.0 Beta to determine for passability for specific species and streamflow conditions. Several crossings did not have sufficient data for FishXing to analyze; these were visually reviewed to determine passability. The road crossings analysis resulted in 318 passable, 104 impassable, and 6 partially passable crossings. We compared the locations of the impassable road crossings to the locations of live mussels found in the DEC surveys using Arc Map; this allowed us to locate the road crossing barriers that may restrict distributions of pearly mussel populations. Further analysis is currently being completed.

Marie Schrecengost, Marie Schrecengost is a Fish Biologist with the Lower Great Lakes Fish and Wildlife Conservation Office, U.S. Fish and Wildlife Service (FWS). She received her Bachelor's degree

in Environmental Biology from Clarion University of Pennsylvania and her Master's degree in Natural Resources from The Ohio State University. She has worked for FWS for 6 years; 3 years in northern California, and 3 years in Buffalo, NY. Currently, she works on the Habitat Restoration program coordinating with partner organizations to restore and enhance aquatic habitat.

Understanding and responding to the impacts of road-stream crossings in Maine

Slade Moore, *Gulf of Maine Council on the Marine Environment,* Alex Abbott, *Gulf of Maine Council on the Marine Environment*

The origins of impaired stream connectivity in the Gulf of Maine can be traced to the 17th Century, most notably when the power of moving waters in the region was first harnessed by dams. In addition to blocking the movements of resident and long-distant migrant fish, these structures have acted as barriers that prevent or hinder a range of native stream processes that are essential to creating and sustaining fish and wildlife habitat, like sediment transport and deposition, movement of woody debris, and tidal flow. Successful stream restoration efforts in the Gulf of Maine have largely focused removal of dams, yet recent studies demonstrate that road crossings frequently act as barriers and contribute to impaired connectivity. Using data from Maine, we will discuss the high prevalence of road-stream barriers and associated habitat implications. We also discuss the ways that restoration practitioners in Maine are adjusting to an emerging understanding of this widespread infrastructure issue, which far exceeds the limited capacity of traditional restoration funding sources.

Slade Moore, Slade Moore is a fish and wildlife ecologist working with others to overcome the technical, fiscal, and social challenges that hinder progress in restoring aquatic systems in the Gulf of Maine.

B4

Differences in frequency and range of trout movement through culverts in headwater streams

Erin Rodgers, *Antioch University New England; Conte Fish Research Center,* Benjamin Letcher, *US Geological Society, Conte Fish Research Center*, Jason Coombes, *National Forest Service, Northern Research Station*, Todd D'ubueil, *US Geological Society, Conte Fish Research Center*

There are nearly 10,000 registered dams in New England that block fish passage in larger rivers, but there are over 25 times as many culverts affecting passage in smaller streams and tributaries. Even in non-anadromous fish, free movement through streams necessary for a variety of life history functions, upstream migration for spawning in particular. However, different types and shapes of culverts can have a significant impact on fish movement. A network of three proximate tributaries in the West Brook watershed (Whately, MA) show the marked difference culverts have on population and individual movement of brook trout (Salvelinus fontinalis) and brown trout (Salmo trutta). This study tracked fish movement using passive integrated transponder (PIT) tags in trout, stationary antennas at each culvert, and portable backpack antennas during the years of 2002 to 2010. After 2004 additional antenna were added to account for direction movement through culverts. One culvert in the study area was classified by The Nature Conservancy as passable, the second culvert was classified as severe, while a third tributary was impassible due to a natural barrier.

Trout movement was analyzed for frequency of movement through the culverts, number of unique individuals moving through the culverts, attempts and successes of movement, and overall patterns of distances moved in and between these streams. Overall frequency of movement through the two culverts was significantly different; the passable culvert was used for a large number of both short and long distance movement. The severe culvert was not completely impassable, but was often a vector for downstream movement from the tributary to the main stem of the river, or less often longer distance movements into the headwater stream. There were

also significant differences in movement between species; brook trout attempted and succeeded in passing through the severe culvert significantly more than brown trout, while there was little difference in species' ability to move through the passable culvert. The differences between the culverts have interesting implications for larger patterns in trout movement once above the culverts.

An Exploratory Evaluation of the Swim Path Selection of Western Blacknose Dace in a Modified Flow Field

Michael Goettel, *State University of New York at Buffalo Civil, Structural and Environmental Engineering*, Joseph Atkinson, *State University of New York at Buffalo*, Sean Bennett, *State University of New York at Buffalo*

The goal of this study was to observe the response of Western Blacknose Dace (R. obtusus) to a turbulent flow field by comparing their swim paths to selected flow metrics in the hopes of garnering relationships between the two that could improve future research project designs.

Experiments were carried out in a hydraulic flume populated with baffle-like obstructions under various flow conditions into which the dace were released. Fish movement was tracked with video cameras to catalog swim-paths, and acoustic Doppler velocimeter measurements were taken to characterize the hydraulic conditions encountered by the swimming dace.

The motivation for this study was the need for biologically-based criteria to compare against results obtained from computational fluids dynamics (CFD) models. The ability to compare CFD model outputs to species-specific behavioral and performance–based criteria can facilitate more accurate evaluations from a fish passage perspective, increasing the likelihood of enhanced passage efficiencies at hydraulic structures such as recessed or baffled culverts and bypass channels.

Preliminary results indicate that multiple flow parameters or metrics will be required to predict fish paths given the character of the flow measurements obtained here and the lack of a priori behavioral knowledge of this species. It is hypothesize that fairly sophisticated analyses, that incorporate considerations for fish behavior and physiology, will be required to understand and explain a fish's ability and desire to navigate a particular flow field in this type of study.

In this presentation a brief explanation of the motivation, experimental set-up, preliminary results and initial conclusions will be delivered in conjunction with experimental images and videos.

Michael Goettel, Mr. Goettel is currently a masters candidate in the Department of Civil, Structural and Environmental Engineering at the State University of New York at Buffalo. He worked for ten years with the Wisconsin Department of Natural Resources as a Water Resources Engineer and a Water Management Specialist, and also spent three years as a research assistant at Cornell University in the Department of Natural Resources. He holds a P.E. license in the State of Wisconsin

Estimating entrainment of juvenile bull trout in Lake Creek (Montana), a desk-top vs. field study approach

Jesse Wechsler, *Kleinschmidt Fish Passage Division*

Kleinschmidt was retained by Northern Lights, Inc. (NLI) to perform a full-depth tailrace netting study to assess the level of entrainment of juvenile bull trout potentially occurring at a small FERC- regulated hydro facility in northwestern Montana. Bull trout are listed as a federally-threatened species pursuant to the Endangered Species Act (ESA). The entrainment study was recommended by the U.S. Fish & Wildlife Service (USFWS) and the Montana Department of Fish, Wildlife, and Parks to provide information for analyses associated with formal ESA Section 7 consultation for the relicensing of the hydro facility. Kleinschmidt's fish passage engineers and scientists designed a small floating collection trap and full-depth entrainment netting system that was deployed in the tailrace of hydro facility. Sampling was performed once a week for 24-hours for 22 weeks throughout the spring, summer, and fall of 2010. Bull trout genetic samples were collected and processed using methods derived from the USFWS's Abernathy Fish Technology Center in Longview, Washington, to distinguish between pure and hybridized bull trout. The entrainment estimate for juvenile bull trout was based on the sampling efficiency of the net and catch per unit effort. Based on field data, we estimated that

approximately 40 juvenile bull trout are entrained annually at the Project. In their final Biological Opinion, the USFWS, using methods similar to those employed in NLI's initial desk-top analysis, estimated annual entrainment of bull trout to be approximately 670 fish. The results of actual entrainment sampling indicate that far fewer fish are entrained than originally predicted by NLI or by the USFWS. NLI and the stakeholders are currently in the process of developing mitigation for the documented take of bull trout, which may include conservation of important spawning habitats or in-stream habitat improvement projects.

Jesse Wechsler, Mr. Wechsler is a member of Kleinschmidt's Fish Passage and Protection Team, and is responsible for the development of fish passage effectiveness testing and fish passage protection measures at hydro facilities. Mr. Wechsler also provides support to Kleinschmidt's regulatory and hydro relicensing department through the development of pre-and post-license studies (e.g., instream flow studies, baseline fisheries surveys, habitat assessments) and through administration of FERC-relicensing proceedings.

Log Jam Distribution and Carbon Storage in Headwater Streams in Colorado's Front Range
Natalie Beckman, *Colorado State University Department of Geosciences*, E.E. Wohl, *CSU Dept of Geosciences*

Historical documents and recent field studies suggest that resource use within the Colorado Rockies during the past two centuries has reduced the wood loads and frequency of wood jams along most forested streams. Log jams tend to provide habitat for fish, slow the transport of carbon, and encourage its uptake in the riverine environment and therefore may have effects which extend beyond stream. To evaluate the effects of past disturbances, wood loads and jam frequency are compared based on stream characteristics, forest age, and flow alteration. In addition, sediment samples from reaches with and without log jams are compared based on organic matter (OM) content and Total Carbon (TC) content. Samples taken from behind log jams are compared to samples taken from other backwater areas along a river reach. Preliminary results of the 2010/2011 field seasons indicate that log jams on streams draining old growth forest (more than 200 years since last disturbance) average 45/km, while streams draining younger stands average 15/km, indicating reduced habitat variability for fish in disturbed reaches. In addition, sediment samples taken from log jams (regardless of forest age) have an overall average of 5% OM, as compared to an average of 1% OM in samples taken from non-jam areas. Samples taken from log jams on streams draining old growth forests have an average of 12% OM, indicating an overall decrease in stored carbon in disturbed reaches.

B5

Breaking the speed limit--comparative sprinting performance of brook trout and brown trout
Theodore Castro-Santos, *USGS-S.O. Conte Anadromous Fish Research Center*, Javier Sanz-Ronda, *Universidad de Valladolid*, Jorge Ruiz-Legazpi, *Universidad de Valladolid*,

Sprinting behavior of free-ranging fish has long been thought to exceed that of captive fish. Here we present data from wild-caught brook trout (Salvelinus fontinalis) and brown trout (Salmo trutta), volitionally entering and sprinting against high velocity flows in an open-channel flume. Performance of the two species was nearly identical, attaining absolute speeds of >300 cm/s or 28 bl/s. These speeds far exceed previously published observations for any salmonid species, and contribute to the mounting evidence that commonly accepted estimates of swimming performance are low. Brook trout demonstrated 2 distinct modes in the relationship between swim speed and fatigue time. This was similar to the shift from prolonged to sprint mode described by other authors, but in this case the shift happened at speeds > 19 BL/s, this is the first demonstration of multiple modes of sprint swimming at such high swim speeds. The similarity in performance between species suggests convergent adaptation to lotic environments""it also suggests that hydraulic barriers to movement may not be effective strategies for selective exclusion of either species. Neither species optimized well for distance maximization, however, indicating that physiological

limits alone are poor predictors of swimming performance. By combining distributions of volitional swim speeds with endurance, however, we were able to account for 82 % of the variation in distance traversed for both species.

Theodore Castro-Santos, Dr. Castro-Santos is a Research Ecologist at the S.O. Conte Anadromous Fish Research Center. He has been working on fish passage issues for more than 20 years. He uses an integrated approach, combining novel telemetry and statistical techniques to understand the interplay between hydraulics, physiology, and behavior and how these can function together to provide safe, timely, and effective passage for riverine and migratory species

Modelling brook trout (Salvelinus fontinalis) passage success through road culverts: from theory to reality

Elsa Goerig, *Institut National de la Recherche Scientifique (INRS), Centre Eau, Terre et Environnement PhD program in earth sciences*, Normand Bergeron, *Institut National de la Recherche Scientifique (INRS)- Centre Eau, Terre et Environnement*

Under specific hydraulic conditions, culverts may constitute velocity barriers impeding fish upstream movements. The main objective of this project is to develop a predictive model of brook trout passage success as a function of fish size, culvert dimensions and hydraulic conditions, and water temperature. Fixed Passive Integrated Transponder (PIT-tag) antenna systems are used to determine the passage success of brook trout through culverts under natural variable field conditions and to compare these results with passage success predictions made from swimming capacity data obtained in laboratory studies. The experimental design allows the determination of passage attempts and success of individual fish marked with 23 mm PIT-tag as well as their swimming speed throughout the culvert. The experiments were conducted in circular culverts made of smooth concrete or corrugated metal. 950 brook trout (fork length 90 to 270 mm) were tested under variable water temperature (1.4 to 19 ˚C) and mean culvert flow velocity (0.39 to 1.99 m s-1) conditions. Fish swimming speeds, maximal ascent distances and passage success observed in the experiments are compared with predictions obtained using the theoretical approach of Castro-Santos (2005). The results indicate that most fish adopted a distance-maximising strategy by swimming at speeds very close to the predicted optimum. However, the results also indicate a tendency for the theoretical approach to underestimate the passage success of smaller fish (< 120 mm) and to overestimate the one of larger fish (> 150 mm). Potential explanations of these results are discussed and other components of the project are briefly presented.

Elsa Goerig, Elsa is a PhD student at Institut National de la Recherche Scientifique (INRS) in Quebec, Canada. Her PhD project focused on brook trout passage through road culverts, in collaboration with the Quebec Department of Transports. Prior to coming to INRS she graduated with a BS in Geography at University Laval and worked as a project manager at the Saint-Maurice river basin association.

The effect of temperature and ammonia exposure on swimming performance of brook charr (Salvelinus fontinalis)

Christian Tudorache, *Leiden University Institute Biology Leiden*, Robyn O'Keefe, *University of New Brunswick*, Tillman Benfey, *University of New Brunswick*

The effects of water temperature and ammonia concentration on swimming capacity of brook charr (Salvelinus fontinalis, Mitchill, 1814) were determined by measuring gait transition speed (Ugt, cm/s), maximum burst speed (Umax, cm/s), tail-beat amplitude (a, cm), tail-beat frequency (f, Hz), maximum acceleration of bursts (Amax, cm/s2), number of bursts, distance of bursts (cm) and total swimming distance (cm) in a 4.5 m long experimental raceway with increasing upstream water velocity. Temperatures other than the acclimation temperature of 15 °C signi!cantly reduced swimming characteristics of gait transition, i.e. Ugt and Amax, while increased ammonia concentration reduced the measures of swimming after Ugt: Umax, the relationship between f and swimming speed above Ugt, a, Amax and the distance travelled with each swimming burst above Ugt. This study, using a novel

raceway set-up shows various effects of temperature and ammonia exposure on the swimming performance of brook charr and can be used to establish threshold values for environmental management.

Christian Tudorache, Dr. Christian Tudorache received his PhD from Antwerp University, Belgium, for his work on the swimming physiology and behaviour of migrating freshwater fish, titled: "Aspects of Swimming Physiology and Behaviour - Consequences for Migrating Fish". He continued his work at the University of New Brunswick, Canada, and at Leiden University, The Netherlands, where he currently studies the enigmatic migration of the European eel.

Culvert Roughness Elements for Native Utah Fish Passage

Suzanne Monk, *Brigham Young University Civil and Environmental Engineering*, Rollin Hotchkiss, *Brigham Young University*, Lindsay Wait, *Brigham Young University*, Mark Belk, *Brigham Young University*

Fish passage designs for culverts rely mainly upon the comparison between the average flow velocity and the sustained swim speeds of fish, a method developed by studying salmonid species and their swimming patterns. This method does not recognize the role of reduced velocities near boundaries. Laboratory and field tests have been performed to test the use of these reduced velocities by several native Utah fish: leatherside chub (Lepidomeda aliciae), longnose dace (Rhinichthys cataractae), and speckled dace (Rhinichthys osculus). Laboratory flume tests were conducted using leatherside chub and longnose dace with three boundary conditions: a smooth boundary, a smooth boundary with strategically placed and sized cylinders, and a boundary consisting of natural substrate collected from the field. The key finding from these tests was that substrate that scaled with the fish length required the least energy expenditure, provided sufficient refuge to allow the fish to behave naturally, and allowed for successful passage. Field tests were performed in a southern Utah stream (Salina Creek) with speckled dace and leatherside chub. Fish were captured, marked, and recaptured at three locations: an arch culvert with a coarse substrate bottom, a double barrel concrete box culvert, and a stream section between the two culverts. Results showed that passage alone was not an adequate indicator of ability since not all fish attempt to pass upstream. Instead, population estimates within each of the sites were calculated to estimate use and the quality of habitat within the culverts. Population estimates were slightly higher at the arch culvert site than at the box culvert site. Velocity measurements were also taken near the boundary at each site to characterize the amount of variation within the culvert and population estimates correlated to the amount of variation found at each site. Providing fish with velocity variation by placing substrate instead of simply matching the average flow velocity to their swim speed may allow more fish to pass upstream and use the culvert as habitat rather than treating it as a barrier.

B6

Ask The Hydropower Experts

Tim Brush, Normandeau Associates
John Ragonese, TransCanada
Kimberly Long, Exelon Corp.
Kevin Bernier, Brookfield Renewable Energy
Sean Moran, Avista Corp.

B7

The Lower Susquehanna River: 3 Fish Lifts & 3 Fish Passage Results

Joshua Tryninewski, *Pennsylvania Fish and Boat Commission Bureau of Fisheries*, Michael Hendricks, *Pennsylvania Fish and Boat Commission*

The lower Susquehanna River has four hydroelectric dams with technical fishways constructed to pass American shad and other alosines. The first three dams; Conowingo, Holtwood and Safe Harbor, have fish lifts constructed in 1991, 1997 and 1997, respectively. The fish lift at Safe Harbor Dam performs very well, passing an average of 72% of the American shad that pass Holtwood, eight river miles downstream. There is also evidence that the Safe Harbor fish lift passes American shad with little delay, passing large numbers of shad one day after large numbers are passed at Holtwood. Unfortunately, the fish lifts at Conowingo and

Holtwood perform poorly in comparison. A radio telemetry study, conducted in 2010, estimated that only 45% of the American shad in the Conowingo tailrace were passed. The Holtwood fish lift passes an average of 31% of the American shad passed at Conowingo, 15 river miles downstream. A radio telemetry study, conducted in 2001 estimated that Holtwood passed 34% of the fish that reached the project. Fish passage must be significantly improved at these projects to permit successful shad restoration.

Joshua Tryninewski, Joshua has worked as a Fisheries Biologist for Pennslyvania Fish and Boat Commission since 2008. He holds a B.S. in Naturual Resources from Cornell University

Santee-Cooper: A Lock on Fish Passage Success
Steven Leach, *Normandeau Associates*

Despite radical perturbations, the Santee-Cooper, South Carolina American shad population persisted and expanded. In 1941, approximately 80% of Santee River flows were diverted to a dam and hydroelectric project on the adjacent Cooper River, historically a coastal plain tidal river. In 1985, a portion of the flow was restored to Santee River via a new canal and hydroelectric dam. A navigation lock on the Cooper River project provided upstream passage of anadromous fish since the initial diversion and since 1957 has been operated for fish passage. The Rediversion Project construction included a site-specifically designed fish lock that as of 2010 has passed more than 6 million American shad with annual average passage of nearly 400,000. Radio-telemetry study results indicated that the navigation lock had an attraction rate of 66% and passage effectiveness of 90% of attracted fish or 60% of available fish. Passage counts are unavailable for the navigation lock, but through recreational fishery surveys and hydroacoustic passage monitoring, it is reasonable to conclude that annual American shad passage into the Santee-Cooper system has approached and exceeded one million fish in some years. The unique characteristics of these inter-related fish passages will be discussed.

Steven Leach, Steve Leach is a Senior Biologist with Normandeau Associates in Westmoreland, NH where he has worked since 2006, specializing in diadromous fish behavior and passage at hydroelectric dams. Steve grew up in Maryland, earned a B.S. in biology from Elon College, North Carolina in 1990, and an M.S. in oceanography and coastal science / coastal fisheries from Louisiana State University in 1993. Steve's work experiences range from academic to state resource agency to environmental consulting, including: investigations of estuarine-dependent larval fish transport on the Gulf Coast of Louisiana, anadromous species larval production, trophic dynamics of the Chesapeake Bay; Diadromous fish passage and restoration, endangered shortnose sturgeon research, and FERC hydroelectric project relicensing and license compliance issues.

Putting together the pieces: Multi-Dam passage of American shad on the Connecticut and Columbia Rivers
Theodore Castro-Santos, *USGS-S.O. Conte Anadromous Fish Research Center*

Iteroparity is an important characteristic of American shad life history. Most fish passage provisions, however, have focused solely on upstream passage of adults and downstream passage of juveniles—downstream passage of adults has gotten very little attention. Bioenergetics models and recent survey data suggest that delays incurred in association with fishways may be acting to reduce migratory range, spawning success, and post-spawning survival. A group of researchers on the Columbia and Connecticut Rivers are collaborating to better understand migratory dynamics and the role of fish passage and delay on post-spawning survival. These studies have yielded data that challenge long-held assumptions about American shad. For example, upstream passage at most Columbia River dams is poor (< 50% of entrants). This is troubling, because Columbia River fishways were the prototypes from which many shad fishways on the East Coast were designed. Also, behavioral and energetic data appear to suggest that upstream migration is far more directed than previously thought, and evidence is mounting that spawning may be primarily associated with downstream migration. This has important implications for prioritization of fish passage and protection. Much more work is needed on fundamental life-history aspects of American shad in support of holistic management strategies that

balance the need for access to habitat with protection of populations.

Theodore Castro-Santos, Dr. Castro-Santos is a Research Ecologist at the S.O. Conte Anadromous Fish Research Center. He has been working on fish passage issues for more than 20 years. He uses an integrated approach, combining novel telemetry and statistical techniques to understand the interplay between hydraulics, physiology, and behavior and how these can function together to provide safe, timely, and effective passage for riverine and migratory species

York Haven Shad Migration: Which Way Did They Go?
Stephen Arnold, *HDR Engineering, Inc. Hydropower Services*, Doug Royer, *Normandeau Associates, Inc.*

The York Haven Hydroelectric Project is fourth in a series of hydroelectric dams on the lower Susquehanna River with upstream passage facilities for American shad and other species. As part of relicensing studies at York Haven, resource agencies have requested that a radio telemetry tracking study of American shad be performed to estimate upstream passage efficiency at the existing Project fish ladder and to evaluate migratory patterns within the larger Project area. In response to this request, a two tiered radio telemetry study of both long distance migration efficiency and near field movements and behavior was conducted in the spring of 2010. American shad were captured at the downstream dam fishway and 180 radio tagged fish were tracked over 26 miles of the Susquehanna River via a network of 17 monitoring stations with 21 antenna zones. Tier 1 study results showed that 70 percent (127 shad) migrated the 26 miles of river between dams, and 4 percent of those arriving at York Haven (5 shad) successfully passed upstream through the fishway. Tier 2 detailed analyses of shad movements and migratory behavior within the large and complex study area at the base of the York Haven dams was also undertaken. This analysis revealed a diverse array of shad migratory behaviors, and also some very consistent patterns. Overall, every fish arriving at the project visited the powerhouse tailrace at least once and generally spent the majority of time there. Beyond this common behavior however, many of the shad moved beyond the powerhouse tailrace, and displayed a wide array of searching migratory patterns in the study area. These study results have now led to an evaluation of possible fish passage enhancement scenarios at York Haven.

Stephen Arnold, Steve Arnold is a Senior Aquatic Scientist and Professional Associate at HDR Engineering, Inc. in Portland Maine. He obtained an MS in Biology from Michigan Technological University, in 1981. He has worked as a fisheries consultant for 29 years and has provided services exclusively to the hydropower industry for 22 years. Steve's professional interests include upstream and downstream passage of anadromous and catadromous fish, fish population dynamics, instream flow and associated habitat for aquatic organisms, and multiple-use resource conservation principals.

B8

Biological Purposes for Fish Passage
Alex Hoar, *U.S. Fish and Wildlife Service*

Hydropower projects can fragment a river system, impede or block fish movement, and kill or injure fish. The viability and mobility of fish species that would otherwise move to and from different habitats within the river system may diminish substantially, if not completely, due to a hydropower project. These species can be important components of marine food webs and can support populations of commercially and recreationally important fish that are of economic significance to the Nation. Fishways help mitigate the impact of hydropower projects by providing safe, timely, and effective fish passage around or through a project so species can satisfy their biological needs. They are: spawning, rearing, feeding, growth to maturity, dispersion, migration, and seasonal use of habitat. These are the biological purposes of a fishway. This presentation identifies those purposes and provides an example of each. This presentation provides a context for better understanding why, to be successful, fishways must be constructed, operated, and maintained in consideration of the fish species' biological requirements and in consideration of how their behaviors are influenced by the structural and nonstructural elements of the project.

Modelling fish passage response to instream flows on run-of-river hydroelectric projects

Katie Healey, *Ecofish Research Ltd.*, FJ Adam Lewis, *Ecofish Research Ltd.*

Run-of-river hydroelectric projects do not have many of the environmental issues associated with large storage facilities; however, the flow regimes associated with these projects have the potential to delay migration in streams where anadromous fish are present. These projects are typically designed to maximize head (i.e. elevation differences between the intake and powerhouse), and hence the stream reach subject to reduced flows is generally high gradient, consisting of falls, cascades, and chutes that may only be passable by fish at certain flow levels or impassable altogether. If instream flows are released at a fixed magnitude during the migratory period, flows suitable for fish passage at these obstacles may be less frequent or absent altogether, and fish migration can be delayed or obstructed. Pulsed flow releases that vary in magnitude can be an efficient means of providing the flow levels necessary for fish passage.

In contrast to storage-type facilities, a fixed schedule for pulse flow releases on run-of-river facilities is not possible, as flow levels must be present naturally in order to be released. Pulse flow regimes must instead be defined by specifying ideal frequency, flow magnitude, and a period over which releases will take place. We present a mechanistic model to assist in the design of these pulse flow regimes; the model predicts how alternate pulse flow design considerations affect fish passage success relative to natural conditions, based on the stream hydrograph and assumed flow conditions for fish to pass obstacles to migration.

Katie Healey, Katie Healey is a Senior Analyst at Ecofish Research Ltd. in Vancouver, B.C. Canada. As part of the Ecofish team, Katie applies her background in applied mathematics and ecological modelling to quantify the environmental effects of water use through modelling, statistical analysis, and development and use of custom software.

Ecological Monitoring to Evaluate the Benefits of Dam Removal and Passage Efficiency of Fish Ladders

Amy Soli, *Stony Brook-Millstone Watershed Association*, Olaf Jensen, *Institute of Marine and Coastal Sciences, Rutgers University*

Dam removal has gained significant momentum within the past 10 years as a means of stream and wildlife restoration. However, the ecological impacts of dam removal are still an area of active research. Pre- and post-removal monitoring data is of particular value for understanding impacts. Therefore, the Stony Brook-Millstone Watershed Association (Watershed Association) designed a program in coordination with NOAA to monitoring the biological, chemical, and habitat characteristics of the Millstone River before and after dam removal. In addition, researchers at Rutgers University have partnered with NOAA, the New Jersey Department of Environmental Protection, and the Watershed Association to evaluate migratory fish passage efficiency through a ladder located near the confluence of the Millstone and Raritan Rivers. These monitoring studies are designed to provide in-depth information on the habitat and biota of the Millstone and Raritan Rivers before and after dam removal such that the benefits of dam removal can be quantified and habitat quality protected. The monitoring project focuses on the biological community of the Millstone and Raritan Rivers, especially as it is influenced by habitat and water quality of the rivers. River reaches upstream of dams, within the impoundment, have habitats that differ from those downstream of dams and upstream beyond a dam's influence. Therefore, it is expected that the fish and benthic communities above and below dams will reflect these varying conditions before removal but will become more similar after the removal. In addition, the passage efficiency of migrating fish, most notably shad and river herring, through the fish ladder will be evaluated using passive integrated transponder (PIT) tags and an automated antenna/reader system. The effects of these anadromous fishes and their marine derived nutrients on upstream food webs will be evaluated using analysis of stable isotopes of nitrogen in fish and benthic invertebrates. Understanding the ecological changes associated with dam removal on

the Raritan and Millstone Rivers will provide guidance on changes that might be expected following future dam removals on low gradient rivers in the mid-Atlantic region.

Amy Soli, Amy is currently the Science Director of the Stony Brook-Millstone Watershed Association in Pennington, New Jersey. Prior to joining the Watershed Association, Amy was an environmental consultant for almost 10 years. Amy has also been an adjunct professor of biology and geology at Raritan Valley and Middlesex Community Colleges. Amy earned her PhD from the Univeristy of Maryland's Marine-Estuarine-Environmental-Sciences Program; her area of expertise was stream monitoring to assess the impacts of golf course management practices.

Spawning migrations of American shad in the Columbia River

Christopher Caudill, Chris Noyes, Tami Clabough, Steve R. Lee, *Department of Fish and Wildlife Sciences Fish Ecology Research Laboratory University of Idaho;* Ted Castro-Santos, *U.S.G.S. S.O. Conte Anadromous Fish Research Center;* John Beeman, Michael Parsley, *U.S. Geological Survey Western Fisheries Research Center Columbia River Research Laboratory*

We sampled American shad, *Alosa sapidissima*, in the Columbia and Snake Rivers during 2005-2007 & 2010 to characterize basic migration biology of the population, as a model system to test general migration ecology hypotheses, and to determine if dam passage metrics for shad in the Columbia River are better than those for eastern United States populations, which are imperiled. We PIT-tagged and released 2496 adults during the 2005-2007 study period. Analyses demonstrated that: 1) individual adults returned to the Columbia Basin spawn in multiple years; 2) the adult populations at Lower Granite Dam (rkm 695) were younger and male-biased compared to adults at Bonneville Dam (rkm 235); 3) that mean initial lipid content of adults detected at McNary Dam (rkm 470) was higher than adults detected only at Bonneville Dam in some years; and 4) juvenile growth rates were higher in upstream reaches of the basin, particularly in the Snake River reservoirs. In 2010, we radio- and PIT-tagged 234 adult fish to estimate individual passage behavior and success at the four lower Columbia River dams. A total of 26% of the tagged fish passed Bonneville Dam. A total of 78% of the fish passing Bonneville Dam passed The Dalles Dam, 45% of those passed John Day Dam, and 48% of those passed McNary Dam. A seasonal effect was evident, with higher passage probability for adults collected earlier in the season. Collectively, the results suggest that: 1) shad passage behavior and performance at dams differs from salmonids; 2) that adult upstream migration behavior appears to be relatively flexible, may be dependent on life history stage and/or initial condition of individuals, and may affect offspring growth and survival; 3) the ecological effects of adults in reservoirs differs longitudinally; and 4) indicate greater passage success than observed in East Coast rivers.

Christopher Caudill, Chris Caudill is a Research Assistant Professor in the Department of Fish and Wildlife Resources at the University of Idaho. His broad interests are in the ecology and evolution of animal movement and the conservation of aquatic resources. He holds a MS from the University of New Hampshire (1995) and Ph.D. from Cornell University (2002). He conducted postdoctoral research at Georgia Tech before joining the Fish Ecology Research Lab at the University of Idaho in 2003 for a second post-doc. He has directed the FERL program since 2008, largely focusing on the migration ecology of adult salmon, Pacific lamprey, and American shad in the Columbia, Snake, and Willamette rivers.

C1

Stream Functions Pyramid Framework

Richard Starr, *U.S. Fish and Wildlife Service Chesapeake Bay Field Office*, Will Harman, *Stream Mechanics*

The Stream Functions Pyramid, developed by Harman (2008), provides a framework that organizes stream functions in a pyramid form. The Pyramid illustrates that stream functions are supported by lower level functions in a hierarchical structure. The Pyramid is a useful tool in goal setting, developing and reviewing stream assessment methodologies, and creating standard operating procedures for regulatory and non-regulatory stream restoration programs. The

Pyramid framework consists of four components that increase in detail. These four components comprise the Stream Functions Pyramid Framework. First, the broad-level view shows the five functional categories (Levels) with the underlying controlling variables of geology and climate. Second, function-based parameters are provided for each functional category. Third, measurement methods are provided for each function-based parameter. And fourth, where possible, performance standards are provided for the measurement methods. This presentation will briefly describe the Stream Functions Pyramid Framework and it potential applications.

Richard Starr, Richard Starr is Chief of the Habitat Restoration Division within the U.S. Fish and Wildlife Service Chesapeake Bay Field Office, Annapolis, Maryland. He manages the Partners for Wildlife Program, Stream Habitat Assessment and Restoration Program, and Schoolyard Habitat Program. The division promotes watershed based assessment and natural stream restoration methodologies and has three focus areas: training and education, technical assistance, and demonstration projects. Richard has over 20 years experience in watershed assessment, planning management, and restoration. He has conducted numerous geomorphic watershed and stream assessments; implemented stream restoration and fish passage projects; developed a variety of stream assessment protocols and tools; produced numerous technical and planning documents, and developed and delivered training courses on stream protection, assessment, and restoration.

Applying the Stream Functions Pyramid to Geomorphic Assessments and Restoration Design
Will Harman, *Stream Mechanics*

The Stream Functions Pyramid is a framework that can be used to better link stream restoration activities to functional improvement. This presentation will focus on Levels 1-3 of the Pyramid, Hydrology, Hydraulic, and Geomorphology functions and parameters. Examples will be provided showing how the Pyramid can be used to create function-based restoration goals, develop geomorphic assessments that show restoration potential based on functional improvement, and how to evaluate project success. Restoration potential is defined as the highest level of restoration that can be achieved given watershed conditions and project constraints. Case studies of stream restoration projects will be provided showing how the Pyramid was used to determine restoration potential and document project success.

Will Harman, Mr. Harman is the founder of Stream Mechanics, a small company dedicated to advancing the science and application of stream restoration. Prior to forming Stream Mechanics, he was Vice President of Ecosystem Restoration with Michael Baker Corporation. In the course of his 20-year career, he has participated in hundreds of stream restoration projects, representing a wide variety of settings and techniques. He teaches stream restoration workshops to federal, state, and local agencies, universities, and private engineering firms. He has a Master's degree in Geography from the University of North Carolina at Charlotte and Bachelors degree in Geography from Appalachian State University. He is a licensed Geologist in North Carolina.

Comparing the Fish and Benthic Macroinvertebrate
Scott Stranko, *Maryland Department of Natural Resources*, Robert Hilderbrand, *University of Maryland*, Margaret Palmer, *University of Maryland*

Urbanization is associated with substantial losses to stream biological diversity throughout the United States' midAtlantic. Stream restoration has been used to improve stream conditions and, in part, to ameliorate these losses. However, the relationship between restoration and recoveryof biological diversity is unclear. Our objective wa to critically examine the efficacy of urban stream restoration with regard to biological diversity. Wcompared restored urban streams to urban nonrestored, nonurban, and reference (minimally degraded) streams using five measures each of fish and benthic macroinvertebrate diversity. Both multivariate and univariate statistical analyses show biological diversity of restored urban streams to be similar to nonrestored urban streams and lower than nonurban and reference streams. Restored urban sites showed no apparent increase in biological diversity through time, while diversity decreased at two of the reference streams coincident

with increased urban development within their catchments. Our results indicate that restoration approaches commonly used regionally as in these urban streams are not leading to recovery of native stream biodiversity. Evidence from several sources indicates a need for dramatic changes in restoration approach, and we argue for a watershed-scale focus including protection of the least impacted streams and adopting other land-based actions within the watershed where possible.

Scott Stranko, Scott Stranko has worked at the Maryland Department of Natural Resources since 1994, where he currently manages the Aquatic Inventory and Monitoring Program. His main research interests include fish and salamander ecology, land use impacts, biotic homogenization, restoration effectiveness, biodiversity conservation, and coldwater streams. He hopes to be a conservation biologist when he grows up.

Case Study - Project Application of the Stream Functions Pyramid Framework
Ben Hutzell, *US Fish & Wildlife Service Chesapeake Bay Field Office*, Richard Starr, *US Fish & Wildlife Service*

Over the past two decades there has been a significant advancement in the science of stream restoration. Much effort has been spent on understanding channel dimension, pattern and profile. However, not as much consideration has been given to understanding how stream functions influence channel dimension, pattern and profile. Harman et al. has produced the Stream Functions Pyramid Framework which addresses this issue and provides guidance on applications relevant to stream restoration. This presentation provides a case example of how the framework can be applied on a reach specific stream restoration project. The U.S. Fish & Wildlife Service used the Stream Functions Pyramid Framework to conduct functional and stability assessments, set quantifiable restoration goals and objectives, create design criteria and establish quantifiable monitoring performance standards for the Mossy Creek Stream Restoration Project, Augusta County, Virginia.

Ben Hutzell, Ben Hutzell is a Biologist with the US Fish and Wildlife Service. His expertise includes stream restoration assessment, stream restoration design and project implementation management. Ben has been directly involved with the implementation of over 25,000 linear feet of stream restoration and is currently working on multiple stream restoration projects and dam removals across the Mid-Atlantic region. He holds a BS degree in Environmental Analysis and Planning.

C2

The art and science of assessing stream gradient and bankfull width
Steven Koenig, *Project SHARE*

The basic premice for applying Stream Simulation for restorig ecological function at road/stream crossings is to desgn a channel through the crossing that mimics a local reference reach. Key design elemnets are to: reestablish the natrural stream gradient and creating a channel that typically is 1.2 x the bankfull width of the reference reach. While these elements are conceptually easy to understand, dificulties can be encountered during site assessments where there may be no reference reach to emulate or historic site specific alterations may be dramatic. We will examine a number of case stidies to demonstate how longitudinal profiles, transects, aerial photography, as well as GIS have been interpreted to establish gradient and bankfull width at not so obvious restoration sites.

Steven Koenig, Steven Koenig is the Executive Director of Project SHARE, a 501(c)(3) organization pursuing the restoration of salmon habitat and natural ecosystem function in Eastern Maine. Over the past 11 years, he has worked with diverse partners to develop a nationally-recognized habitat restoration program completing 125 + restoration projects to date. In 2009 the National Fish Habitat Action Plan recognized Mr. Koenig with its first national award "for Extraordinary Action in Supporting Fish Habitat Conservation." In addition to being DEP-certified in Erosion and Sediment Control Practices and trained by the US Forest Service in Natural Stream Channel Design, Steven has a Bachelor's of Science degree in

cellular biology from the University of Michigan and has studied oceanography and limnology at the University of Wisconsin and fish physiology at West Virginia University.

Bed and Bank Design Considerations When Selecting Culvert Width
William Rice, *U.S. Fish and Wildlife Service Habitat Restoration*

Selection of culvert width is driven by project objectives, site characteristics and stream type and while not the only consideration, significantly guides culvert bed and bank design. In stable channels, almost all standard guidelines recommend a width that varies from bankfull width or larger and many vary the guideline by entrenchment ratio. In streams that are unstable, sizing a culvert to be a bit larger or smaller than the creek width may be a design need as it comes to equilibrium conditions. Once the bankfull width is determined, a selection of culvert width larger than bankfull results in the need to include stable banks to maintain the width to depth ratio of the stream. Within the design process, this may result in a larger culvert than anticipated due to the size of rocks necessary to maintain stable banks. Throughout the process of width selection, preventing low flow fish passage issues, problematic aufeis formation and sediment deposition is paramount and may result in selection of a smaller or larger culvert than originally desired. Low flow channels in the bed also need to be stable, and the ratio of the low flow channel to channel width can be maintained by structures such as boulder clusters or rock bands within the channel bed. In consideration of culvert width, the purpose of streambanks should be fully evaluated. For instance, are the streambanks necessary for fish habitat or can rock clusters or other roughness features perform the same function? Is there a need to provide other ecological functions such as animal passage along the banks or would a floodplain culvert accomplish the same need? These questions and more must be answered and no one standard can fit all situations.

William Rice, William (Bill) Rice is a hydrologist and engineer for Region 7, U.S. Fish and Wildlife Service in Anchorage, Alaska. For the past eight years, he has conducted geomorphic and habitat assessments while designing and constructing over 70 fish passage and stream restoration projects. Bill also conducts a popular 2-day fish passage workshop across Alaska, and participates on national fish passage initiatives. He has a Bachelor's of Science degree in Geology and Geological Engineering from the Colorado School of Mines and Masters of Science degree in Watershed Science from Colorado State University.

Stream Simulation: Analytical versus Standards based design methodology
Robert Gubernick, *USDA Forest Service Eastern Region Engineering*, Dan Cenderelli, *USDA Forest Service Stream Systems Technology Center*, Mark Weinhold, *USDA Forest Service White River National Forest*

Stream simulation by USFS definition is a channel that simulates characteristics of the adjacent natural channel (reference reach), and presents no more of a challenge to movement of aquatic organisms than the natural channel. How to design the channel and road crossing varies in detail widely from state to state. Standard requirements can force a design rather than inform it. Analytical based design provides the designer with an understanding of potential channel adjustments and risks at the site based on differences in channel types and geomorphic context on which to base design decisions. Common pitfalls in stream simulation design and application will be discussed along with recent stream simulation flood response from Hurricane Irene.

Robert Gubernick, Bob is the principal designer and reviewer for watershed restoration projects (river restoration and aquatic organism passage at road crossings) across all 15 national forests and grasslands of Eastern Region 9 of the USDA Forest Service. Responsibilities include; geomorphic assessment, hydraulic analysis and modeling, design and contract development including plan development & cost estimates for road stream crossing and restoration projects, acting as Level 3 COR on restoration project using time and equipment, teaching and educating young professionals and other federal, state and private agency staff on AOP and restoration design and implementation, and working with management for policy development.

He is also member of the FishXing development team www.stream.fs.fed.us/fishxing and the San Dimas Technical Aquatic Organism Passage team; involvement includes teaching and lecturing (10 years) about geomorphic site assessment and fish passage, authoring papers and publications on stream simulation design and fish passage assessment and assisting in development, application and training of team developed software. He is also a member of the technical advisory committee for HEC 26 (FHWA national fish passage manual).

Stream Simulation in the DOT World: The Challenges, the Constraints, and the Costs
John Perry, *Maine Department of Transportation*

In recent years there has been a strong push towards designing stream crossings to achieve at least bankfull width (BFW) of the stream, or ideally 1.2 BFW and larger. There are at least two ways to achieve this, either through a stream simulation design or spanning the stream entirely with traditional bridges. At MaineDOT this push towards larger crossings is ever growing, enforced largely via the most recent revisions to the Army Corps of Engineers Maine General Permit (2010) and the designation and recent interpretations of Critical Habitat for federally endangered Atlantic salmon. MaineDOT understands the science and the ecological benefits of providing these types of crossings; however, they create significant challenges to the Department including scour and other design issues, logistics and site constraints, rights-of-way obstacles, and impacts to the traveling public--issues not typically encountered in the forest industry and other sites in Maine where stream simulation has been ongoing. Logistics notwithstanding, the costs incurred by MaineDOT with building larger crossings are not comparable to costs incurred by these other entities, so direct cost comparisons and general project experience are of limited use. With this presentation MaineDOT hopes to add perspective by relating some of the constraints a state transportation agency may face in fitting 1.2 BFW crossings into a large transportation capital investment program.
MaineDOT has started building larger crossings designed using the hydraulic-based method similar to that developed by the Federal Highway Administration (FHWA) in HEC-26. These crossings are much larger than MaineDOT has historically built, and we are in the process of collecting preliminary data on not only fish passage but also on use by other aquatic organisms, as well as other physical characteristics within the crossings. These structures are not intended to be a substitute for 1.2 BFW crossings but are seen more as a compromise to providing passage over a much wider range of flows than traditional DOT structures, yet at a cost lower than 1.2 BFW open bottom crossings. An overview and preliminary findings of several of these structures will be discussed.

John Perry, John Perry is a biologist with the Field Services and Mitigation Unit at the Maine Department of Transportation. He has a BS in Biology from the University of Maine. He started his professional career as a biologist with Central Maine Power Company conducting fish, wildlife, and botanical impact studies associated with the Federal Energy Regulatory Commission relicensing of hydroelectric facilities. He started in Maine State Government with the Department of Environmental Protection in 2001 and joined MaineDOT in 2004. Since then, John's work has focused on assisting MaineDOT programs to develop cost-effective fish passage strategies to meet permitting requirements, as well as conducting the post-construction monitoring to determine their efficacy. Other duties include consulting under Section 7 of the Endangered Species Act for projects impacting Atlantic salmon and other federally endangered species, constructing and monitoring several stream relocation and restoration projects, and investigating treatments to reduce animal collisions at high crash locations throughout Maine.

C3

Fish Passage Restoration at the Briggsville Dam: Using Sediment Transport Analysis for Natural Channel Design
Jessica Louisos, *Milone & MacBroom, Inc.*, James G. MacBroom, *Milone & MacBroom, Inc.*, Roy Schiff, *Milone & MacBroom, Inc*.

The removal of the Briggsville Dam reconnected over 30 miles of headwater streams along the North Branch of the Hoosic River. The removal of the dam restored local fish passage and improved local habitat for cold water river species including the eastern brook trout (Salvelinus fontinalis), longnose sucker (Catostomus catostomus), and slimy sculpin (Cottus cognatus). The project also reduced flood hazards associated with removal of a deteriorated dam that could fail and lead to flood hazards.

A preliminary channel design specified many rock grade control structures to establish a suitable channel profile and protect a bridge with shallow footings located 750 feet upstream of the dam. Geomorphic assessment, steady state bridge scour modeling, and ultimately quasi-steady state sediment transport analysis predicted a suitable sediment equilibrium channel slope without fixing the bed in place. The analysis indicated that a naturally dynamic channel bed was possible, and this alternative was designed and constructed.

A final design was implemented that removed the dam and accumulated coarse sediment upstream of the dam. A compound channel with vegetated flood benches and several stone riffles was constructed, and the existing armor on the bridge abutments was reinforced. Instream habitat features such as root wads and large boulders were placed in the channel bed to "seed" the channel prior to larger channel forming flows that would provide natural habitat features.

Channel bed elevations were measured at the bridge pre-construction, weekly during construction, and post-construction after floods including Tropical Storm Irene in August 2011. Bed elevations following the flooding were similar to model predictions, yet the channel width increased. This case study shows that understanding of sediment transport regimes in a river can guide an appropriate design and in some cases greatly reduce construction costs.

Jessica Louisos, Jessica Clark Louisos is a Water Resource Engineer at Milone & MacBroom, Inc. She specializes in hydraulic and hydrologic studies for dam removal and repair, flood control and river and habitat restoration, including modeling, analysis, mapping, and field assessment. She received a master's degree in civil and environmental engineering at the University of Vermont where her research focused on forming links between the geomorphic condition of small streams and the hydraulic fish habitat available. Jessica is a registered professional engineer in Vermont and is currently the President-Elect of the Vermont Section of the American Society of Civil Engineers and serves on her local Planning Commission. Jessica lives in South Burlington, Vermont with her husband and beloved dog Maple.

Understanding Stream Connectivity: Linking Structure with Fish Community

Shad Mahlum , *Memorial University of Newfoundland, St. John's, NF, Canada;* David Cote , *Parks Canada, Glovertown, NF, Canada*; Dan Kehler, *Parks Canada, Halifax, NS, Canada*; Robert G. Randall , *Great Lakes Laboratory for Fisheries and Aquatic Sciences, Fisheries and Oceans Canada, Burlington, ON, Canada*; Les Stanfield , *Ontario Ministry of Natural*; Yolanda Wiersma , *Memorial University of Newfoundland, St. John's, NF, Canada*

Movement corridors are a critical aspect in maintaining healthy and viable stream populations. Stream fragmentation is presumed to alter fish community assemblages and recent advances in riverscape connectivity models have allowed us to assess the varying levels of fragmentation. Here, we analyze whether landscape scale community-level patterns of fish species assemblage in five watersheds in southern Ontario, Canada correlate with riverscape connectivity as measured using the Dendritic Connectivity Index (DCI). These watersheds have a wide range of stream fragmentation with large numbers of barriers which may impede fish movement. We demonstrate how the DCI can be measured using different criteria for estimating barrier passability where it is unknown. These results will allow us to determine if and how biological patterns reflect aquatic connectivity.

Pullen Mill natural Constructed Pool and Weir Fish Passage Project

Daniel Baumert, *USDA/Narural Resources Conservation Service (Maine) Engineering*

The Pullen Mill Fish Passage project is a natural constructed pool and weir fishway to provide fish

passage primarily for alewives around the remnants of an old mill dam on the West Branch of the Sheepscot River in South China, Maine. A pool and weir fishway was designed to bypass around the dam restriction. The design incorporated existing topographic, geological, and soil features to provide a fishway constructed primarily from existing on site materials. Basic pool and weir fishway design principles were used to located and size the fishway. The design also had to incorporate the site access limitations and types of construction equipment that could be used. This presentation will discuss the Pullen Mill Fish Passage project from design through construction and the first year of operation monitoring.

Daniel Baumert is a State Conservation Engineer for the USDA/Natural Resources Conservation Service. He has 33 years of experience with NRCS in Kansas, Rhode Island and Maine and has worked for 12 years in Maine on various fish passage and stream connectivity projects.

Geddes Brook and Ninemile Creek Channel and Floodplain Restoration at Onondaga Lake
Ryan Davis, *Anchor QEA*, Tracy Drury, *Anchor QEA*

Ninemile Creek is a major tributary to Onondaga Lake, located in Syracuse, New York. Geddes Brook is the last major tributary to Ninemile Creek before it enters the lake. The brook and lower part of the creek were the pathway for historical industrial discharges. A ROD was issued for Geddes Brook and Ninemile Creek in 2009. The remedy includes removal of contaminated material followed by placement of a habitat layer to support resident fish and benthic macroinvertebrate species. The remedy also calls for relocating Geddes Brook and a portion of Ninemile Creek to facilitate remediation and channel and wetland restoration.
Anchor QEA developed a HEC-RAS model to support developing channel restoration designs and water budgets for adjacent wetland areas. In addition, an HSPF model was developed for Geddes Brook to provide hydrology for the HEC-RAS model. The HEC-RAS model was updated with recently acquired high-resolution bathymetry and topography and calibrated using USGS gage data. Model outputs for high and low flow scenarios were used to evaluate water surface elevations, water depths, and calculate stable particle sizes. The stable particle sizes were compared with the habitat suitability index (HSI) requirements for fish species present in the creek to develop designs for the habitat and erosion protection layers.
The HEC-RAS and HSPF models were also used to develop a detailed water budget to floodplain wetlands. The wetlands receive most of their hydrology from spring floods and snow melt and various design alternatives were investigated to optimize hydrologic inflow during the growing season to create deeper water to reduce the chances for colonization by Phragmites australis (an invasive species). Water surface elevations and flood frequency were used to delineate habitat types to be restored within the stream corridor and floodplain.

Ryan Davis, Dr. Ryan Davis is a partner and senior managing scientist with more than 18 years of experience in estuarine, riverine, lacustrine and wetland habitat assessment, restoration design, construction management, and pre- and post-restoration monitoring. His project experience includes developing and implementing SAV habitat restoration and monitoring programs, wetland restoration design and construction management, and stream restoration designs. Dr. Davis is currently managing the habitat replacement and reconstruction program for the Upper Hudson River PCB remediation project and is a member of the Habitat Technical Workgroup developing the habitat restoration and enhancement components of the Onondaga Lake remediation project to incorporate habitat restoration into remedial designs.

C4

"If You Remove It, They Will Come..." The Maxwell Pond Dam Removal / Black Brook Restoration Success Story
Stephen Landry, *NH Department of Environmental Services Watershed Assistance Section*

A century-old dam across Black Brook created an impoundment called Maxwell Pond, which was a site for ice harvesting, fishing, swimming and other recreation. Over time, sediment from poorly managed

industrial sites accumulated in the pond, which became stagnant and shallow. As a result, the NH Dept. of Environmental Services (DES) added Maxwell Pond to the 2002 Clean Water Act (CWA) section 303(d) list of impaired waters. Stakeholders collaborated for seven years to restore water quality by reducing upstream sediment sources and removal of the dam in 2009. Once Black Brook returned to its free-flowing condition, the dissolved oxygen level rebounded and the brook could once again support its aquatic life designated use. As a result of the improvements, in 2010 DES removed the former Maxwell Pond portion of Black Brook from the state's CWA section 303(d) list of impaired waters for dissolved oxygen.

Funds for this $685,000 restoration project were derived from a diverse portfolio of stakeholders that included the City of Manchester, EPA, DES, NH Fish & Game, NH State Conservation Committee, NH Corporate Wetlands Restoration Partnership, American Rivers/NOAA, Gulf of Maine Council/NOAA, Fairpoint Communications, National Grid, Aggregate Industries, Amoskeag Fishways, Dubois & King, Inc., and Trout Unlimited. Thanks to the incredible collaboration and innovative funding strategies employed to restore Black Brook, this project was accepted as a Section 319 Nonpoint Source Program Success Story by the EPA in 2011. In addition to the local community accolades for flood relief, elimination of a public safety hazard, and the state and federal acknowledgement of successful restoration of impaired surface waters in NH, the Black Brook Restoration Project also garnered national attention in 2010. American Rivers selected this project as one of three in the United States to be featured in their Restoring America's Rivers "“ Preparing for the Future DVD that focused upon flooding, community decision makers, and restoration of vital habitats for fish and wildlife.

This presentation will provide attendees with an overview of the dam removal process on Black Brook, the project management and funding collaborations that lead to success, data gathered pre and post-dam removal that demonstrate the return of state and federally listed fish species (Bridle shiners, Sea lamprey, American eel, Tesselated darters, Atlantic salmon) to Black Brook, and geomorphic indicators that demonstrate ongoing channel evolution and a return to the reference condition within the former impoundment.

Stephen Landry is the Merrimack Watershed Supervisor for the NH Department of Environmental Services. Steve holds a B.S. in environmental science and aquatic toxicology from the University of Massachusetts Amherst. Steve manages federally funded Watershed Assistance and Restoration Grants for high quality and impaired waters within the Merrimack River Watershed. Steve is also project manager on several fluvial geomorphology-based projects throughout New Hampshire. Most recently, he coordinated the removal of the Maxwell Pond Dam and restoration of Black Brook in Manchester, NH. He serves as vice chair of the Upper Merrimack River Local Advisory Committee and sampling supervisor of the Upper Merrimack Monitoring Program.

Removal of the Merrimack Village Dam

Mark Wamser, *Gomez and Sullivan Engineers, PC*

For decades, a dam was located on the Souhegan River, roughly 1,800 feet upstream of its confluence with the Merrimack River. The dam, known locally as the Merrimack Village Dam (MVD), was located in a highly visible location in Merrimack, NH. The former owner of MVD, Pennichuck Water Works (Pennichuck), is a water supply company who purchased the dam in the 1960's as a potential water supply source, but it was never developed. In the mid 2000's, the New Hampshire Department of Environmental Services (NHDES) who regulated dam safety, issued Pennichuck a letter highlighting several deficiencies with the dam requiring extensive costs. NHDES also indicated that as an option to repairing the dam, they offer a program to assist owners with removing dams.

After weighing the cost associated with dam repair, on-going liability, on-going operation and maintenance costs and the ecological restoration benefits, Pennichuck opted to conduct a feasibility study to determine if it was practical to remove the structure. Pennichuck applied and received numerous grants to help partially defray the cost of conducting a feasibility study and the eventual removal of a 20-foot high, 180 foot-long concrete and stone masonry dam in 2008.

This paper discusses the pitfalls and environmental benefits of removing the MVD as well as the changes that have occurred as documented via monitoring the site for the past couple of years.

Mark Wamser is a water resource engineer having graduated with a BS in Civil Engineering from UNH in 1988. He has worked at Gomez and Sullivan Engineers since 1993 specializing in dam removal and river restoration projects throughout New England and New York. Mark also has a long-history working on the relicensing of hydroelectric projects with the Federal Energy Regulatory Commission.

Pawtuxet Falls Restoration: Lessons from Narragansett Bay's Largest Dam Removal
Andrew Lipsky, *EA Engineering, Science, and Technology, Inc.*, Thomas Ardito, *Narragansett Bay Estuary Program*

In August, 2011, the Pawtuxet River flowed freely into Narragansett Bay, R.I., for the first time in more than 200 years. The removal of Pawtuxet Falls Dam was the culmination of years of planning and permitting by the Pawtuxet River Authority, Narragansett Bay Estuary Program, and a partnership of more than a dozen state, federal and non-profit organizations, with technical support provided by EA Engineering, Science and Technology. The project restored seven miles of spawning habitat for American shad and river herring to Narragansett Bay's third-largest tributary. The project team overcame a number of significant design challenges, including public concerns regarding aesthetics and historic preservation; contaminated sediments; poor construction access; concerns about flood vulnerability; and an unprecedented regulatory scale. We'll share innovative solutions and adaptive management approaches that resulted in successful outcomes, and can be applied to similar projects throughout the country.

Andrew Lipsky, Andy Lipsky is a Senior Scientist at EA Engineering, Science, and Technology leading ocean planning and ecosystem restoration efforts. Mr. Lipsky recently completed a two year appointment at the White House National Ocean Council and the Council on Environmental Quality. He also served as USDA NRCS's National Water Quality Leader and the State Biologist for NRCS in Rhode Island.

Calco Dam Removal - Commencing the Restoration of the Raritan River Watershed, New Jersey
John Jengo, *MWH*

An innovative Natural Resource Damages (NRD) Settlement Agreement between the New Jersey Department of Environmental Protection (NJDEP) and El Paso Corporation, formulated to address claimed lost ecological services caused by former industrial operations discharging into several New Jersey rivers, specified the removal of three lowhead dams (Calco Dam, Nevius Street Dam, and Robert Street Dam) on the main stem of the historic Raritan River in central New Jersey. The most downriver dam (Calco Dam), a former chemical dispersion weir located in the vicinity of Bound Brook, was successfully removed between July 18 - August 2, 2011. The dam was initially breached over a specific modeled width, which allowed the upriver impoundment to completely drain by the end of the working day without triggering adverse sediment transport. The subsequent two weeks of work involved removal of the dam's deeper infrastructure, careful severing of the dam where it was underlying a historic 175-yr old canal towpath berm, and removal of all concrete and rebar from the river. The final aspects of the project included grading of the river bed and restoration of embankments back to their pre-dam configuration. This dam removal re-opened 6.1 miles of the Raritan River and 1.5 miles of the Millstone River, in addition to the lower reaches of several significant tributaries, which have widespread sandy and pebbly gravel river bed substrates, ideal spawning habitat for anadromous fish species such as American shad that formerly numbered in the millions. The Robert Street Dam, a sheet-piled supported structure encasing an older concrete gravity dam located seven miles upriver of the former Calco Dam, is slated for removal in July-August 2012, which will then be followed by the breaching of the Nevius Street Dam, thus satisfying the NRD Settlement terms and completing New Jersey's most significant river restoration project to date.

John Jengo, John W. Jengo**,** PG, a licensed Professional Geologist in several Northeastern states and a Licensed Site Remediation Professional in New Jersey, works as a Principal Hydrogeologist in an environmental consulting firm in southeastern Pennylvania. He has degrees in geology from Rutgers University (1980) and the University of Delaware (1982). Over the last 20 years, he has lead the characterization and remediation of large, complex contaminated industrial sites throughout New Jersey, Pennsylvania, and Delaware. He is the technical project manager in the effort to restore historically significant fish spawning grounds of the Raritan River in central New Jersey and successfully managed the removal of the Calco Dam in July-August 2011. He has authored many peer-reviewed geological articles for scientific journals about his stratigraphic and environmental investigative work, as well as scientific aspects of the Lewis and Clark expedition.

C5

Initiating Dam Removal Projects
Lynnette Batt, *American Rivers River Restoration Program*

A well-planned approach to initiating dam removal projects is critical to long-term success, particularly in states like North Carolina where this form of restoration is still relatively new. This talk will compare initiation of two high-priority dam removal projects in NC by considering the following issues: securing landowner support, identifying partners and project managers, obtaining preliminary engineering input on key issues, and acquiring funding. We will focus on key lessons learned and suggestions for how to improve project initiation in the future.

Lynnette Batt, Lynnette Batt is Associate Director of the River Restoration Program in American Rivers SE Region. She manages dam removal projects in NC, provides technical assistance to partners and communities across the region, coordinates state task forces to assist projects and provide input on policy and permitting, and manages the region's American Rivers-NOAA Community Based Restoration Grants. She has a background in aquatic ecology and a master's degree from Duke University in environmental management.

Regulatory Hurdles and Inconsistencies of Dam Removal
Vince Humenay, *Headwater Partners, LLC*, Laura Wildman, *Princeton Hydro*

Dam Removal is becoming a popular concept for river restoration but some states do not view dam removal as restoration or have permitting procedures in place for restoration activities. Added to the complexity that some states have multiple permits (sometimes conflicting), the regulatory process can be the most difficult aspect of a dam removal project. This presentation will outline the basic permitting process in a few states and their general problem areas, and discuss the stream-lined approach that Pennsylvania's Division of Dam Safety has used successfully over the last decade. The presentation will also make suggestions on how to get regulators involved in the dam removal process and some permitting ideas that may work in your state to make your dam removal project more successful.

Vince Humenay, Mr. Vince Humenay is the manager of Headwater Partners, LLC which is a ecological restoration and water resource firm based out of central Pennsylvania. The firm specializes in dam removal and river restoration, but also provides other water resource services such as streambank stablilization, wetland restoration, and lake and pond dredging. Mr. Humenay previously managed Pennsylvania's Department of Environmental Protection's dam removal program for over eight years. Mr. Humenay has been involved in over 200 dam removal projects and his performance has played a critical role in developing Pennsylvania as the national leader in dam removal. Mr. Jumenay has a bachelors degree from Juniata College in Biology and a Master's Degree from Penn State in Environmental Pollution Control. Vince is also an avid angler and canoeist.

Regulatory Reform in Massachusetts: Instituting a General Permit for Dam Removal Projects
Beth Lambert, *MA Division of Ecological Restoration*

Dam removal permitting is frequently described as complicated and onerous. Massachusetts has a complex regulatory framework with overlapping regulatory jurisdictions. Ten permits and additional approvals are required in order to remove an aging dam and restore fish passage. The regulatory process typically takes nine to 18 months to complete. The uncertainty and length of the process has made it difficult to secure and keep grant funding for dam removal projects and is a major barrier for dam owners and river restoration practitioners. Now, the Massachusetts Department of Environmental Protection and the Massachusetts Division of Ecological Restoration have developed proposed regulations and procedures that will significantly streamline dam removal permitting. For eligible dam removal projects, the regulations will reduce the permitting timeline from 18+ months to three months. This presentation describes 1) the original regulatory framework; 2) new regulatory tools including a unified application form for all aquatic habitat restoration projects and a general permit for dam removal; 3) linkages with federal regulatory programs; and 4) public reaction to these regulatory reforms. While many states have general permits for in-stream habitat restoration, few have developed general permits for dam removal projects. The eligibility criteria and standard conditions developed during MA's regulatory reform process may be of use to other states seeking to improve the scope and scale of river restoration.

Beth Lambert, Beth Lambert manages the River Restoration Program for the Massachusetts Division of Ecological Restoration (DER). DER has led or supported 20 dam removal projects and has 30 projects in the planning stages. Beth has an MS in fluvial geomorphology and has 15 years of experience working in watershed restoration in the Pacific Northwest and New England

Top Ten Dam-Bustin' Lessons
Bob Beran, *Beran Environmental Services*, Lisa Hollingsworth-Segedy, *American Rivers*

Despite more than a decade of experience with dam removals for ecological and social benefits, the practice of stream barrier removal continues to emerge. This paper focuses on learning experiences gained from selected dam removal projects in Western Pennsylvania, distilling take-home messages about how project selection, pre-planning, site investigations, and adaptabililty during construction can help to maximize project outcomes, increase cost-effectiveness, and anticipate and minimize construction difficulties.

Bob Beran, Bob is the president of Beran Environmental Services, working closely in partnership with American Rivers to design and construct dam removals and river restoration projects. In addition to these, Bob specializes in wetlands identification and delineation, botanical surveys, instream habitat enhancements, bioengineered bank stabilization, and design, construction and monitoring for Abandoned Mine Drainage mitigation projects.

C6

Replacing Dam Functions when Removing a Dam
Laura Wildman, *Princeton Hydro, LLC*, Dave Monie, *GPM Associates Inc.*
One of the more significant challenges when removing a dam is to replace the current functions the dam may server. Dams can server economically beneficial roles such as providing water supply, flood control, recreational opportunities, and hydroelectric power. These services often justify the costs associated with long term dam maintenance and liability, and can make removing a dam infeasible. Increasingly, however, there are examples of dam removal projects that seek to replace some of these services while still restoring free flowing conditions and fish passage to a river. This presentation will focus on multiple dam removal examples where water intakes were modified to allow for continued flow diversion, dewatered impoundments were configured to enhance flow attenuation, and recreational opportunities were transformed from

values gained from impoundments to values gained from flowing rivers. In addition, as future advancements in free standing kinetic turbines and turbines placed on closed conduit systems continues to progress, we can envision a future in which dams are no longer a necessary component for harnessing power from a river and rivers are allowed to once again flow free.

Laura Wildman, Laura Wildman has worked for over 23 years as a professional water resource/fisheries engineer focusing on dam removal and river restoration. Prior to establishing Princeton Hydro's New England Regional Office in 2009, Ms. Wildman worked on fish passage and dam removal as American Rivers Chief Engineer where she initiated and led the Northeast Stream Barrier Task Force for 8 years. She has been involved in hundreds of dam removal an fish passage projects; working on all aspects of the projects from inception through design and construction. Ms. Wildman is considered one of the foremost national experts in dam removal and alternative fish passage, speaking regularly around the country on these subjects and developing and assisting with the instructing of courses at the University of Wisconsin and Yale in dam removal, fish passage and river processes and restoration. In 2009 she received a Leadership in Restoration award from NOAA's Restoration Center for her many years of dedicated service in fish passage engineering. Prior to working at Princeton Hydro, Ms. Wildman was Chief Engineer at American Rivers and initiated and led the Northeast Stream Barrier Task Force for 8 years. She is a current Governing Board member of the American Society of Civil Engineers Environmental and Water Resource Institute, as well as the President Elect for the American Fisheries Society Bioengineering Section. In addition to dam removal and fish passage issues, Ms. Wildman has a strong background in fluvial geomorphology, fisheries habitat/flow analysis, dam modification/repair, open channel hydraulics, grant coordination, public outreach, policy, and advanced hydraulic and sediment transport modeling.

Is dam removal enough? Finding the balance between economics and channel/habitat restoration.

Nick Nelson, *Inter-Fluve, Inc.*

Removing dams, building fish ladders and bypass channels, and restoring river habitat can be expensive. In this period of funding shortfalls, cutbacks, and layoffs, resource managers are tasked with improving passage and habitat with minimal resources. They must decide which projects can provide the most benefit per dollar spent. With over 3000 dams in MA and hundreds of thousands nationwide, these impediments to water and sediment flow and fish and aquatic organism passage are often targeted as providing the greatest benefit to the resources. Aside from the relatively simple engineering, removing dams is a multi-faceted challenge including permitting, managing historical/archaeological resources, protecting endangered and threatened species, removing the structure itself, water management, managing residents' expectations and concerns, and managing the impounded sediment that may be contaminated. With all of these important aspects to dam removal, the attention given to restoring post-removal aquatic habitat may be overlooked or minimized. Dam removal can remove the impediment to passage but does not guarantee quality aquatic or riparian habitat in the former impoundment. What is the importance of restoring the channel and aquatic and riparian habitat? Is dam removal a success if a formerly wide wetland or swamp becomes a single-thread channel with high banks surrounded by upland because of all the impounded sediment? This presentation discusses the challenges of dam removal and restoration with limited budgets, the importance of coordinating dam removal and channel/habitat restoration, and suggests opportunities when successful dam removal can be accomplished with a minimum of upstream restoration.

Nick Nelson, Nick Nelson is a fluvial geomorphologist and manages Inter-Fluve's New England office in MA. He has over six years of combined experience in fluvial geomorphology and hydrology. Primarily interested in human impacts on rivers, Nick has focused his academic and professional careers on the effects of dams on rivers

and floodplains and the geomorphic-based design of dam removal and river restoration. His work with Inter-Fluve has focused on dam removal and channel restoration/rehabilitation planning and design, geomorphic and habitat assessments, and GIS and hydraulic analyses. Nick is currently involved with over 10 dam removal and river restoration projects in MA alone, working on all phases of these projects from project manager to construction oversight and topographic surveying to restoration design. He has completed geomorphic and habitat assessments on over 200 miles of river in the past five years.

The Effects of Dam Removal on the East Branch of the Eightmile River, Connecticut

Barry Chernoff, *Wesleyan University College of the Environment*, Kate Miller, *Wesleyan University*, Ross Heinemann, *Wesleyan University*, Michelle Tipton, *Wesleyan University*, Adam Welchel, *The Nature Conservancy*

The hydrography of the East Branch of the Eightmile River has been modified since the 1720's when a dam was constructed on the Zemko property. While the dam has occasionally fallen into disrepair, the dam has largely been intact for more than the last hundred years. In 2006, the water in the impoundment behind the dam was drawn down and the dam was completely removed by fall 2007; a rocky connector was constructed between the portion above and below the former dam. We have surveyed fishes, benthic macroinvertebrates (BMI), water chemistry and physical parameters from 2004 through 2010 at the former dam sites and at a control site five river miles downstream. The biological communities have changed dramatically since drawdown and dam removal. The inter-annual variation of the communities in the vicinity of the dam site is significantly higher than at control sites. The data from both fish and benthic macroinvertebrates indicate that the patterns of change or "recovery" differ in the sections of river above and below the dam. We will ask whether there has been recovery from dam removal in this small section of stream. We will also discuss the concepts of resilience and adaptation in relation to the functioning of the streams.

Barry Chernoff, Professor Barry Chernoff joined the Wesleyan Faculty in 2003 where he holds the Robert K. Schumann Chair of Environmental Studies. He currently chairs the Environmental Studies Major and is Director of the College of the Environment. He teaches courses in Environmental Studies, Tropical Ecology, Aquatic Ecosystem Conservation, Quantitative Analysis and Evolutionary Biology for the departments of Biology and Earth and Environmental Sciences. Chernoff's research centers on the freshwater fishes of the Neotropical region, primarily those in South America in the Amazon. His research includes, ecology, evolutionary biology and conservation. He has also led international teams on expeditions designed to conserve large watersheds of the world, having made more than 32 expeditions in 12 countries. Recently, Professor Chernoff and his students have been working on aquatic ecology and conservation of Connecticut watersheds.

Guidelines For Assessing Sediment-Related Effects of Dam Removal

Laura Wildman, *Princeton Hydro*, on behalf of Timothy Randle, *Bureau of Reclamation*, Jennifer A. Bountry, *U.S. Bureau of Reclamation*, Blair P. Greimann, *U.S. Bureau of Reclamation*,

Dam removal is becoming more common in the United States as dams age and environmental concerns increase. Sediment management is an important part of many dam removal projects, but there are no commonly accepted methods to assess the level of risk associated with sediment stored behind dams. Therefore, the interagency Subcommittee on Sedimentation (SOS) is sponsoring the development of a decision framework for assessing sediment-related effects from dam removals.

The decision framework provides guidance on the level of sediment data collection, analysis, and modeling needed for reservoir sediment management. The framework is based on criteria which scale the characteristics of the reservoir sediment to sediment characteristics of the river on which the reservoir is located. To assist with the framework development, workshops of invited technical experts from around the United States were convened October 2008 in Portland, Oregon and October 2009 in State College, Pennsylvania. The decision framework developed at

these workshops is currently being validated with actual dam-removal case studies from across the United States including small, medium, and large reservoir sediment volumes. This paper provides the latest thinking on key components of the guidelines. The paper represents contributions from over 26 entities who have participated in the development of the guidelines. After completion of the case study application, the framework will be finalized and published.

Timothy Randle, Tim Randle is a Supervisory Hydraulic Engineer and Manager of the Bureau of Reclamation's Sedimentation and River Hydraulics Group. He received his B.S. in Civil Engineering from the University of Utah in 1981 and his M.S. in Civil Engineer from the University of Colorado in 2004. He is a registered professional engineer. Also, he is a member of the American Society of Civil Engineers, U.S. Society on Dams, and a Diplomate, Water Resources Engineer with the American Academy of Water Resources Engineers. Mr. Randle has been with Reclamation for 31 years, nearly all of that time with the Sedimentation and River Hydraulics Group. He has developed several computer models and conducted geomorphic and hydraulic studies of many rivers throughout the western United States. Mr. Randle was named Engineer of the Year for 1997 by the Bureau of Reclamation and honored as one of the top ten Federal Engineers by the National Society of Professional Engineers. He managed the interagency team that prepared the environmental impact statement (EIS) for operations of Glen Canyon Dam. Mr. Randle worked on Elwha River Restoration Project, in Washington, which involves the removal of two hydroelectric dams. Mr. Randle also organized and led data collection efforts of the Platte River in Nebraska in 1989.

C7

Channel Damage, Repair, and Recovery after Extreme Floods

James MacBroom, *Milone & MacBroom Inc*.

Extreme floods cause extensive damage to both natural systems and developed communities. A series of major floods in 2012 capped by Hurricane Irene resulted in severe upland erosion, landslides, channel incision and knick points, and mass bank failures along high energy streams, creating high sediment loads. Many low gradient and downstream rivers had severe bed aggradation, channel widening, avulsions, and floodplain deposition. Numerous road culverts and bridges were damaged, blocked, or destroyed. Aquatic habitat impacts include turbidity, substrate siltation, loss of pools, riffles and side channels, wide shallow flow, increased solar exposure, fish passage blocks, and loss of bank vegetation. Even though the preferred option is normally to allow natural processes to heal flood damaged channels, there are unavoidable situations where physical, social, or ecological conditions warrant active intervention.

The first response phase after the flood saw rapid deployment of contractors and public works staff to repair roads, bridges, culverts and channels to protect infrastructure and public safety plus provide emergency services. Several regulatory programs temporarily revised, modified, or waived permits to enable rapid responses. River experts were assigned to assess streams, prioritize repairs, co-ordinate contractors and direct construction work based on rapid geomorphic assessments and field designs. Evaluations of historic and potential river processes were used to review channel sensitivity and ecological risk factors with the goal of adjusting critical reaches toward equilibrium conditions and to discourage further damage by excessive channelization, dredging, straightening and armoring. The initial verbal policies and instructions evolved into written emergency channel repair guidelines for use by technical staff, public works crews, contractors, and landowners. The guidelines provide basic recommendations to classify projects and set clear goals, and select methodologies for proposed channel types and dimensions, slope, alignment, and floodplain connectivity based upon use of analog reference sites and empirical regional hydraulic data, plus use of analytical techniques for sediment continuity by professional staff.

The final step is to monitor both the repaired and unrepaired river reaches to observe and document their recovery to whether other action is necessary

James MacBroom, James G. MacBroom, P.E., earned BS and MS degrees in Civil Engineering from the University of Connecticut and is a registered Professional Engineer in five states. He is Vice President of Milone & MacBroom Inc, a Civil and Environmental Engineering consulting firm located in Cheshire Connecticut, and he developed and teaches graduate courses in River Processes & Restoration and Applied Hydrology at Yale University. He has over 35 years of experience in watershed management, open channel hydraulics, flood control, dam repair and removal, computer modeling, fluvial morphology, stream restoration, and tidal systems. Jim is a member of the ASCE Stream Restoration Committee, American Rivers Technical Advisory Committee, and a speaker at the University of Wisconsin continuing education course on dam removal.
Jim has planned, designed, and inspected numerous river restoration, fish passage, and flood control projects with a special interest in sediment management, channel evolution, and design of natural-like channels. Jim has also participated in dam management projects, including inspecting and repairing unsafe or aging dams and providing fish passage at dams with fish ladders, ramps, and by-pass channels.

Installation of large wood in a homogenous reach of a coastal stream to restore California Central Coast Coho habitat

Denis Ruttenberg, *USDA NRCS and USFWS Partnership*, Jim Robins, *Resource Conservation District of Santa Cruz County*

On the Central Coast of California, through collaborative planning across state, local, and federal resources agencies, including NMFS, the NOAA Restoration Center, and the California Department of Fish and Game (CDFG), the Resource Conservation District of Santa Cruz County (RCD SCC) and NRCS planned and implemented eight innovative large wood log structures along two reaches of San Vicente Creek in Davenport, California. The project fulfills a key recovery action at the southern extent of for the imperiled Central California Coast (CCC) Coho salmon (Oncorhynchus kisutch). The project was collaboratively developed and designed through the Integrated Watershed Restoration Program (IWRP) with significant input from NMFS and CDFG fisheries biologists. Permitting was facilitated through a Permit Coordination program brokered by the RCD SCC.
Prior to construction in Fall 2011, the stream resembled a "bowling alley", with straightened reaches of uniform bed material, high velocities, minimal wood cover and pools, and adverse habitat conditions for young coho and steelhead. The large wood log project on San Vicente Creek is a unique opportunity to increase channel complexity for CCC Coho salmon and test recovery strategies in a stream with year round ocean access, high summer base flows, cool summer temperatures, limited diversions, proximity to the larger Scott Creek watershed, and recent successful implementations of alcove, pond, and backwater restoration. This presentation will discuss the engineering and collaboration to install and anchor large wood in San Vicente Creek. Over time the large wood is expected to create local scour pools and cover for salmonids, sort bed material, trap volunteer wood, and activate the low flood plain through deflection and channel obstruction. During construction, the NRCS design engineer and the SCC RCD staff worked closely with the contractor to optimize wood placement and anchoring, while minimizing impacts to the riparian corridor. The site will be monitored intensively by the RCD SCC and NOAA's Southwest Fisheries Science Center for 5 and 10 years, respectively. In addition, San Vicente Creek is planned as a recipient for planting of CCC Coho salmon from the nearby Monterey Bay Salmon and Trout broodstock program.

Denis Ruttenberg, Denis Ruttenberg is a Stream Engineer at USDA NRCS in the Central Coast of California. He plans, designs, and implements habitat restoration as part of a partnership agreement with the USFWS. He has a Master of Science in Civil Engineering from the University of Idaho, Center for Ecohydraulics Research in Boise (CER) and a Bachelor of Science in Civil Engineering from the University of California Davis. For his thesis at the CER, he created hydraulic models at rock weirs and evaluated effectiveness of fish passage on streams in the Methow River Basin, located in North-central Washington. Since 1992, he has worked in water resources consulting and Civil Engineering, including 10 years of intensive design and

implementation of instream and wetland habitat projects throughout the Central California Coast and San Francisco Bay Area.

Regenerative design applications to sustain baseflow to enhance fish passage in urban channels

Michael Trumbauer, *Biohabitats, Inc.*

Fish passage restoration has historically focused heavily on creating hydraulic conditions within a channel or fishway that are favorable for upstream migration with respect to the physiology of the target fishes. This approach has proven successful for the upstream migration of adult fishes on larger rivers, but does not always translate well to the second and third order streams where the impacts of urbanization are most pronounced. In urban environments the stream hydrology and chemistry has been significantly altered to a point where miles of stream no longer support perennial flow year round. Consequently, upstream migrations can be successful, yet the young of the year and resident fish populations are stressed due to the lack of adequate baseflow. Even the most elegant fish passage or restoration project could be considered a failure if upstream rearing habitats are not sustainable. This presentation discusses two regenerative design applications to restore watershed hydrology and moderate the stream hydrograph such that the baseflows in urban channels a sustained year round and resident fish passage and rearing habitats are enhanced.

The first case study is an in-channel approach that maximizes in channel pool habitat and forces frequent overbank flows to restore the water table in the upper watershed. By storing water in the upper watershed, baseflows in the lower watershed are sustained as the water seeps to the channel through shallow subsurface and hyporheic pathways. Delivering water to the lower watershed through these pathways also influences the stream temperature such that coldwater fisheries can also be enhanced.

The second case study is a project aimed to mitigate the impacts of a planned development that threatened to rob the hydrology and increase water temperature in a regionally unique native trout stream. A regenerative approach to upland stormwater management was applied to mimic the sites natural hydrology and convert surface runoff to shallow subsurface flows that reduced peak flows and elongated the falling limb of the hydrograph such that baseflow and water temperatures were sustained. These applications have the ability to 1) directly restore fish passage by increasing the depth of baseflow in the channel and over obstructions and 2) enhance the success of traditional fish passage projects by creating sustainable in-stream habitats in urban channels.

Michael Trumbauer, Mr. Trumbauer is a restoration ecologist with 12 years of experience specializing in the assessment and restoration of stream and wetland systems. He received his B.S. in Wildlife and Fisheries Management from Frostburg State University and a M.S. in Environmental Science with a concentration in Water Resource Management from Towson University. He has focused professional career on gaining a broad understanding of river mechanics, hydrology, open-channel hydraulics, and the physical processes that shape river systems and applied this knowledge to enhance the ecological function of restoration designs in urban and rural settings. Mr. Trumbauer presently works out of the Chesapeake/Delaware Bay Bioregional office of Biohabitats, Inc. in Baltimore, MD. Biohabitats is a 50-person firm that specializes in ecological restoration, conservation planning, and regenerative design.

Roads, aquatic organism passage and extreme events: lessons from Hurricane Irene

Daniel McKinley, *USDA Forest Service Green Mountain National Forest*, Keith Nislow, *USDA Forest Service Northern Research Station*, Alex Jospe, *UMASS-Amherst Department of Environmental Conservation*

Managers on National Forest and adjacent lands are actively engaged in efforts to inventory and remove potential road-stream crossing barriers to aquatic organism passage (AOP). The preferred strategy is to design crossings with similar dimensions and geomorphic function as the natural streambed (stream simulation). Stream simulation crossings, in addition to increasing population connectivity and resilience, should, in theory, also be less vulnerable to failure

when faced with extreme flow events, providing an added natural resource and economic benefit. Extreme flows resulting from the remnants of Hurricane Irene in Fall 2011 in southern Vermont steams in and adjacent to the Green Mountain National Forest (GMNF) caused numerous road-stream crossing failures provided a unique opportunity to test this idea on the ground. We are currently assessing 1) whether crossings replaced using stream simulation guidelines were less likely to fail 2) across all crossings, which design and environmental setting factors were associated with failure 3) whether crossings predicted to be AOP barriers were more or less likely to fail. Results of this assessment will provide a more integrated estimate of the value of stream simulation, and aid in prioritization schemes which incorporate both habitat connectivity and infrastructure risk.

C8

Sand Creek Meanders Inside Culvert
Bryan Ripp, *Mead & Hunt, Inc.*

The main runway for this general aviation airport requires routing Sand Creek through a 600-foot long culvert under the runway. The Michigan Department of Natural Resources required that the channel within the culvert must contain elements which allow fish passage or more specifically places for fish to rest. This requirement eliminated the typical design of a flat-bottom, lined culvert, such as a typical box culvert. In order to meet the goals of the design, a process-based geomorphic assessment of the creek was conducted, including a longitudinal profile. Using Natural Channel Design, a meandering, two-stage channel within a 24-foot-wide arch culvert was designed. HEC-RAS was used to properly size the culvert to pass the 100-year recurrence flood as well as model the channel shears for choosing and sizing bank and channel treatments. In addition, FishXing software was used to verify fish could travel upstream in the pool/riffle structure planned.
The resulting design was a rock-lined two-stage channel with a pool/riffle structure within the culvert. In the design, the new channel was reconnected to the existing channel, as a two-stage channel with pre-vegetated coir log and rock bank treatments and Newbury rock weir grade controls in a sand-bottom channel. The culvert and channel inside, and the realigned channel with pre-vegetated coir logs were completed in late 2009. Live staking and bare-root planting in the reconstructed floodplain was completed during the spring 2010.
The design team presented this design to the Michigan Department of Natural Resources, including a comprehensive understanding of the geomorphic setting as well as the science and engineering rationale behind the design. Had the team not proposed this design, the project would have been placed on indefinite hold and likely be in litigation. Placing multiple meanders within a culvert is arguably the first of its kind in the US.

Bryan Ripp, Bryan Ripp, P.E., P.G., CPESC has more than 25 years of nationwide and international experience in the engineering properties of earth materials and geomorphic processes. His strong background in earth sciences, engineering, and construction provide a comprehensive approach to the assessment and stabilization of water resources. Bryan's experience in fluvial geomorphology includes geomorphic assessments of streams throughout the Midwest. He is the engineer of record for the Natural Channel Design interventions, including stream energy balance and soil bioengineering structures. His project experience includes storm water management structures design and ecological restoration. Bryan has co-authored several professional papers on the subjects of stream channel geometry, treatment of karst sinkholes and numerical analyses of root wad placements. He has presented several workshops on stream management, including one for plan reviewers sponsored by the United States Environmental Protection Agency (USEPA).

Restoration of fish migration at the Afsluitdijk, The Netherlands, a unique challenge
Kees Dorst, *Ministry of Infrastructure and the Environment Centre for Infrastructure, Department of Hydraulic Engineering and Environment*, Janneke Lourens, *Ministry of Infrastructure and the Environment*, Iris Binken, *Ministry of Infrastructure and the Environment*

The Netherlands is a low lying country with 2/3 of its area below sea level. The country is protected against the sea by an expanded water defence system consisting of dunes, dikes, dams and storm surge barriers. In the south western part, the province of Zeeland, the coastline was shortened by closing of many estuaries with closure dams during the decades after the 1953 storm surge disaster. Separated marine and fresh water systems were born. Also for safety reasons in the northern part of the country in the former Zuider Sea, a 32 km long closure dam was constructed in 1932: the Afsluitdijk. This dam connects the provinces of North-Holland and Friesland and separates the salt Wadden Sea (an international protected wetland) from the lake IJsselmeer. Nowadays this lake is a very important fresh water reservoir, a source for the preparation of drinking water, which is fed by the river IJssel, a branch of the river Rhine. The surplus of fresh water is drained daily through two large discharge sluices at low tides in the Wadden Sea. During high tides the sluices are closed preventing sea water to enter. Also during very dry summer periods the sluices remain closed for several weeks.

It's obvious that this dam is an immense barrier for many migratory fish species. The adults of the strong anadromous counter current swimmers can hardly enter the fresh IJsselmeer due to the very high current velocities in the discharge sluices, already reached several minutes after opening. The anadromous juveniles, together with the katadromous adults are able to reach the Wadden Sea via the open discharge sluices, but during dry periods they have to wait several weeks which might be a problem.

Flounder larvae and glass eel want to enter the fresh water at high tides floating in the flood stream (selective tidal transport). Also weak swimmers as smelts and sticklebacks normally use this water movement to enter inland water bodies.

At the seaside, just behind the closed discharge sluices huge amounts of fish are gathering, waiting to enter, attracted by the fresh water discharge flow during the previous ebb tide. But it is uncertain if fish are able to stay close to the discharge sluices during the flushing period. And even if fish are able to resist this flow, it is very difficult to create an extra attraction flow in a fish way which can be competitive with the huge discharge flow.

The European Water Framework Directive demands an improvement of the ecological quality of water systems. As a result many fish migration routes in The Netherlands have to be restored; also at the Afsluitdijk. This paper describes the ecological demands and design criteria for fish ways at this location as well as several possible solutions to eliminate this fish migration barrier.

Shad and Eel Passage at the Conowingo Project

Tom Sullivan, *Gomez and Sullivan Engineers, PC*, Kim Long, *Exelon Generation Company*, Gary Lemay, *Gomez and Sullivan*, Tom Hoffman, *Gomez and Sullivan*, Tom Tatham, *Gomez and Sullivan*, Kevin McGrath, *Gomez and Sullivan*

Exelon Generation Company, LLC (Exelon) has initiated with the Federal Energy Regulatory Commission (FERC) the process of relicensing the 573-megawatt Conowingo Hydroelectric Project (Conowingo Project) on the Susquehanna River. The current license for the Conowingo Project was issued on August 14, 1980 and expires on September 1, 2014. FERC issued a final study plan determination for the Conowingo Project on February 4, 2010, approving a revised study plan with certain modifications. The final study plan determination required Exelon to conduct studies related to the existing fish lifts and potential American Eel passage measures at the Conowingo Project.

The assessment related to the existing fish lifts required the Licensee to conduct an engineering analysis of the remaining life cycle and maximum fish passage capacity of the two existing lifts, determine the costs and logistics of upgrading or replacing the existing fish passage facilities, and to assess the logistics and cost of utilizing one or both lifts as an interim measure to increase fish passage at the project via trap and transport methods. The alternatives evaluated ranged from simple upgrades of gates and drive motors to full replacement of the existing lifts, therefore costs and additional passage potential varied significantly. The fish lift portion of the report presents an operational history of the lifts, current maintenance and operations methods, potential upgrades, modifications, or replacements to the current passage infrastructure based on the agency requests, and associated conceptual level cost opinions and drawings. Where appropriate, estimates

are provided for the increased passage capacity of the various options.

The final study plan also required the Licensee to conduct biological and engineering Studies of American Eel, which included a literature review of available scientific and commercial eel information, characterizing the local eel abundance via field studies, and examining the engineering feasibility and costs of passage options. For the eel study, conceptual layouts and cost opinions were developed for potential upstream eel passage alternatives. The alternatives ranged from eel passage facilities of limited length with a trap-and-transport program to full-length eel passage facilities that provide the opportunity for full volitional passage to Conowingo Pond.

The existing fish lifts were installed primarily to provide a passage route for American shad, an anadromous species. The American eel is a catadromous, panmictic population. These two competing migratory strategies present an interesting challenge for management agencies and the Licensee. This paper presents a summary of the alternative analyses prepared for both species and discusses the implications of attempting to satisfy the proposed restoration goals for both populations.

Fish Passage Development on the lower Clark Fork River

Sean Moran, *Avista Corporation*, Joseph DosSantos, *Avista Corporation*

Avista Corporation (Avista) operates Noxon Rapids and Cabinet Gorge hydrologic developments on the lower Clark Fork River near the Montana-Idaho border. Avista's pro-active relicensing application process for these facilities involved years of planning and consensus building among 27 stakeholder groups representing state and federal agencies, Indian tribes, and non-governmental organizations. This nationally recognized effort culminated in the Clark Fork Settlement Agreement (CFSA) in 1999. Approved by the Federal Energy Regulatory Commission (FERC) in 2000, the CFSA addressed fisheries management and mitigation efforts through the Native Salmonid Restoration Plan (NSRP). The NSRP utilizes adaptive management in implementing diverse fisheries programs that address fish passage, tributary habitat, pathogens, genetics, and non-native species among others.

Development of upstream fish passage for adult bull trout has been challenging due to the unfamiliarity of this species' fish passage requirements and the dynamic nature of the two tailraces. Extensive tailrace telemetry studies, flow modeling, as well as experimental, smaller scale fish passage facilities culminated in the formation of an expert review panel and an agreement of fish passage proceedings between the U.S. Fish and Wildlife Service (USFWS) and Avista. This agreement led to the design of permanent fishways for both Cabinet Gorge and Noxon Rapids dams. Concurrent with this fishway development process, upstream passage efforts that utilize capture by electrofishing, hook-and-line, and a fish ladder trap, and upstream transport of adult bull trout began in 2001. To date these efforts have passed a total of 365 adult bull trout upstream. Ongoing monitoring of these passage efforts included a genetic parentage study that confirmed the contribution of transported fish to upstream populations. It is anticipated that the operation of fishways in the lower Clark Fork River will build upon this reconnection for not only bull trout but for other native species of the lower Clark Fork River.

Sean Moran, Sean's interest in fisheries began with his passion for fishing growing up in Amherst Massachusetts. His first experience in the field was at a trout hatchery and continued as a volunteer in the Great Smoky Mountains National Park and fieldwork while attending the University of Massachusetts. Sean transferred to the University of Montana in 1993 and received his Masters Degree from Montana State University, in 2001. Sean started with Avista in 2000 as a technician and as was hired as a biologist in 2001. His work with Avista has centered around their cooperative bull trout mitigation programs and has involved various aspects of inland fisheries biology and management. These aspects have included: habitat improvement, non-native interactions and suppression, fish passage efforts, remote sensing, and life history studies, among others; along habitats that have varied from rearing tributaries, to rivers, to reservoirs and Lake Pend Oreille.

D1

Susquehanna River Two-Dimensional Hydraulic and Habitat Modeling
Gary Lemay, *Gomez and Sullivan*, Kimberly Long, *Exelon Generation Company*

As part of the Conowingo Hydroelectric Project's FERC relicensing process, Gomez and Sullivan was asked by Exelon to build a two-dimensional habitat and hydraulic model of the Susquehanna River below Conowingo Dam. Conowingo Dam, located on the main stem of the Susquehanna River in Maryland, is the largest and most downstream of several hydroelectric dams in the lower Susquehanna River before the river flows into Chesapeake Bay. The 4.5 mile study reach extended from the downstream face of Conowingo Dam to the river's confluence with tidal waters. The model's primary objective was to assess aquatic habitat for Conowingo's normal operating flow range (3,500 cfs to 86,000 cfs). The model, built using River2D software, required the compilation and input of several datasets, including combining recent topographic and bathymetric data, sediment survey results and stakeholder-approved habitat suitability index (HSI) criteria. Target species included several life stages for American shad, striped bass, smallmouth bass, shortnose sturgeon, macroinvertebrates (mayfly, stonefly, caddisfly) and several other aquatic species. Several other datasets, including RTK-GPS-derived water surface elevations and ADCP-measured water velocities, were used to calibrate the model to within Â±0.15 ft of the observed water surface elevations.
After the model was calibrated, aquatic habitat was modeled for 23 distinct species, life stages and habitat guilds over the entire study area. Modeled bed shear stresses were used for a separate mussel habitat analysis, based on modeled shear stresses. The model results were compiled to create flow versus habitat relationships, persistent habitat maps, and a habitat time series analysis. The model also provided results for several other relicensing studies that required hydraulic data in the river, including a fish passage barrier analysis and a sediment entrainment analysis. The model results will be used to better inform Exelon, resource agencies and other stakeholders' future flow management decisions for the Conowingo Hydroelectric Project.

Gary Lemay, Gary Lemay has a B.S in Civil Engineering and M.S. in Civil Engineering with a water resources focus, both from UNH. As a graduate student, his thesis assessed stream temperature impacts of culverts and impervious areas on coastal NH streams. Since he started at Gomez and Sullivan two years ago, Gary has been involved with various engineering and environmental studies, including IFIM studies, hydraulic modeling and reservoir sedimentation analyses.

Application of CFD Models in Support of Fish Passage Facilities Design
Mizan Rashid, *AECOM Hydraulic Engineering and Modeling*, Daniel Katz, *USACE Seattle District*

One of the important ecological and environmental concerns at most existing and new hydropower facilities is to minimize impact on fish movement past the power plant. Biologists, engineers, and planners have been working for several decades to design and install upstream and downstream passage facilities. A successful fish passage design is a culmination of understanding of fish behavior under various hydraulic conditions and providing favorable flow conditions throughout the passage. Understanding of the flow field and creation of favorable flow conditions at hydropower facilities often require application of CFD models. This paper will share experience from hydraulic design of fish passage structures using CFD models at the hydropower facilities in the Columbia and Snake River basins in the states of Washington, Oregon, and Idaho. Specific attention will be given to the proper application of CFD modeling to simulate flows to achieve the desired conditions for migrant fish. Results from applications of CFD modeling for designing fish collection and upstream and downstream fish passage facilities will be presented. The design examples and approaches presented in this paper can be applied for similar designs at other hydropower and dam facilities needing improvement in fish migration. This will provide valuable information for hydropower and dam owners, biologists, engineers, and planners interested in the design of such facilities.

Mizan Rashid, Dr. Rashid is a hydraulic engineer with 22 years of experience. He is an expert in application of computer and physical modeling in support of water, wastewater, and energy facilities design. Dr. Rashid has extensive experience in application of physical and CFD modeling techniques for designing and optimizing performance of fish passage falicities. He leads AECOM hydraulic engineering and modeling practice.

CFD Improves Upstream Fish Passage at Hadley Falls

George Hecker, *Alden Research Laboratory*, Songheng Li, *Alden Research Laboratory*, Stephen Amaral, *Alden Research Laboratory*, Greg Allen, *Alden Research Laboratory*, Paul Ducheney, *Holyoke Gas & Electric Department*

A fishway entrance in the flood wall downstream of the Hadley Falls Hydroelectric Project spillway allows migrants moving upstream in the Connecticut River to access a fish lift approach channel. Attraction flow from this fishway entrance is provided to enhance fish passage, but flow over the spillway from the surface bypass weir and adjacent gate at the dam crest interferes with fish finding this entrance. This paper will discuss how computational fluid dynamics (CFD) was used to explore various options to modify the fishway entrance geometry and to effectively dissipate the energy of high velocity flows leaving the spillway apron near the fishway entrance. In particular, three options to improve fishway entrance flow conditions will be presented, including removal of the present entrance deflector wall, use of a fish-friendly turbine discharge, and adding a plunge pool in the spillway apron. For each option, the results of CFD simulations will be presented with an evaluation of the probable impact of flow patterns on upstream fish passage.

George Hecker, George Hecker is currently Senior Consultant at the Alden Research Laboratory, Inc., formerly serving Alden as Director and President from 1975 to 2000. Prior to joining Alden, he worked at Stone and Webster and the TVA. He has published widely on R&D in hydraulic engineering, recently focusing on further development of the Alden turbine of which he is co-inventor. He has worked on fish passage issues at Hadley Falls since the early 1990s. George has engineering degrees from Yale and MIT.

The Efficacy of CFD Modeling at Brunswick Station (Maine)

John Richardson, *ARCADIS, Inc.*, Paul Plante, *NextEra*, Robert Richter, *NextEra*

Downstream fish passage alternatives for the Brunswick Hydro-Electric Station are currently being evaluated using the results of CFD analyses. In addition to this, a field data collection program is being carried out to improve the reliability of the work. Since preliminary modeling was carried out in advance of the field data collection, this project provides a unique opportunity to evaluate the usefulness of computer generated results used to characterize flow at a complicated project location a priori. As part of this presentation a brief outline of proposed downstream fish passage schemes will be provided as well as a comparison of computed and measured flow patterns.

John Richardson, John Richardson received his undergraduate education at Lafayette College (B.S. Mechanical Engineering, 1987) and his graduate education at the University of Maine, Orono (M.S. and Ph.D. Civil and Environmental Engineering, 1992 and 1996). While at the University of Maine, Dr. Richardson performed original research in the area of Computational Fluid Dynamics (CFD). After completing his studies, he relocated to Los Alamos, New Mexico and was employed by Dr. C. W. (Tony) Hirt. Under Dr. Hirt's supervision, Dr. Richardson contributed to the development of the FLOW-3D computer software system. FLOW-3D is a commercially available CFD program used worldwide by scientists and engineers to study complex flow problems (e.g., Inkjet Printer Design, Metal Casting, Aerospace Engineering, and Environmental Modeling).
John is currently employed by ARCADIS as a Technical Expert assisting with numerical modeling projects.

D2

Use of 3D Acoustic Telemetry to Monitor Upstream Passage of American Shad on the Merrimack River in Massachusetts

Timothy Hogan, *Alden Research Laboratory*, Corey Wright, *Blue Leaf Enviromnetal*, Mark Timko, *Blue Leaf Environmnetal*

The upstream passage of American shad (Alosa sapidissima) at hydroelectric dams along the Atlantic Coast of the U.S. has been an ongoing goal for decades. The Boott Station Hydroelectric facility on the Merrimack River in Massachusetts uses a fish lift to move migrating American shad upstream past the project. Research has been ongoing in an effort improve passage success at this site. To this end, a study was conducted in 2011 with three-dimensional acoustic telemetry to track fish movements in the project tailrace. Previous evaluations at this site included radio tracking of tagged fish near the project; however, 3D acoustic telemetry provided greater resolution of fish behavior near the entrance to the fish lift system. During the 25-day study, over 7.5 million tag detections (7.5 GB of raw data) were logged by the system. The behavior of 49 adult shad was tracked in the Lowell tailrace. This paper will review the results of this study and will demonstrate the utility of 3D acoustic telemetry for tracking fish in a turbulent tailrace environment.

Timothy Hogan, Mr. Hogan is involved with various aspects of biological issues related to hydroelectric projects and industrial water intakes. Much of his work focuses on improving fish passage and protection efficiency and minimizing the adverse environmental impacts associated with the operation of hydroelectric projects, power plant cooling water intake structures, desalination facility intakes, and marine renewable energy technologies such as hydrokinetic turbines and ocean thermal energy conversion (OTEC) plants. Mr. Hogan conducts biological evaluations of fish passage and protection technologies in both laboratory and field settings. Recent and on-going projects include: 1) an evaluation of fish protection alternatives for intakes at desalination facilities; 2) a 3D acoustic telemetry study of upstream migrating fish at a hydroelectric project; and 3) a field sampling study of ichthyoplankton at a potential OTEC site in Kauai.

A cabled acoustic telemetry system for detecting and tracking juvenile salmon

Daniel Deng, *Pacific Northwest National Laboratory Energy and Environment Directorate*, Mark Weiland, *Pacific Northwest National Laboratory*, Thomas Carlson, *Pacific Northwest National Laboratory*, Tao Fu, *Pacific Northwest National Laboratory*, Gene Ploskey, *Pacific Northwest National Laboratory*, Tom Seim, *Pacific Northwest National Laboratory*, Brian Lamarche, *Pacific Northwest National Laboratory*, Eric Choi, *Pacific Northwest National Laboratory*, Brad Eppard, *U.S. Army Corps of Engineers*

The Juvenile Salmon Acoustic Telemetry System (JSATS) is a nonproprietary technology developed by the U. S. Army Corps of Engineers, Portland District, for detecting and tracking small fish. The JSATS consists of acoustic microtransmitters; autonomous, cabled, or portable receivers with hydrophones; and data management and processing applications. Each microtransmitter, surgically implanted in fish, transmits a unique 31-bit binary code encoded using binary phase shift keying at 416.7 kHz. Cabled systems are deployed at dams and used to determine passage-route and near-dam behavior for fish. Each cabled system is synchronized to a universal GPS clock and waveforms are saved to the computer before being decoded. Valid detections are separated from spurious detections using filtering processes requiring a minimum of six messages with a pulse interval matching that expected from properly functioning tags within a fixed period. Time-of-arrival information for valid detections on four hydrophones is used to solve for the 3D position of tagged fish. For the cabled system at John Day Dam, the range for 3D tracking is more than 100 m upstream of the dam face where hydrophones are deployed. Cabled systems have been successfully deployed on several major dams to acquire information for salmon protection and to develop more "fish-friendly" hydroelectric facilities.

Juvenile Steelhead Survival and Predator-Prey Interactions Using JSATS through the Priest Rapids Reservoir in 2011

Leah Sullivan, *Blue Leaf Environmental*, Audrey Thompson, *Blue Leaf Environmental*, Mark Timko, *Blue Leaf Environmental*, Curtis Dotson, *Grant County PUD*

Public Utility District No. 2 of Grant County, Washington (Grant PUD) owns and operates two hydropower projects on the mid-Columbia River, Wanapum and Priest Rapids dams. Both developments (dam and reservoir) strive to meet a performance standard of 93% survival for downstream migrant juvenile steelhead. Steelhead survival estimation has been completed annually at both developments since 2006 but performance standards have only been met at the Wanapum Development in 2008 and 2009. Survival standards for steelhead have not been achieved at the Priest Rapids Development. While survival through Priest Rapids Dam has been high, we believe steelhead losses have primarily occurred in the Priest Rapids Reservoir due to piscivorous fish and bird activity. This study was designed to measure the survival of downstream migrant juvenile steelhead and to determine where losses from predators occur in the Reservoir.

A total of 53 JSATS receivers were deployed in cross-river arrays at one-mile increments between Wanapum and Priest Rapids dams. Receivers were also deployed in the forebay of each dam and downstream of Priest Rapids Dam. Nearly two hundred predatory fish (northern pikeminnow, walleye, and smallmouth bass) were captured, tagged, and released in April 2011. Acoustic tags were implanted into 1,032 juvenile steelhead smolts randomly selected from run-of-the-river fish; smolts were released upstream of Wanapum Dam in 18 unique release groups, one release per day, starting on May 8, 2011. Test fish were estimated to be 78% hatchery-reared and 22% wild. Array detection efficiencies were highly variable (range 13-97%), depending on the number of receivers per array and the hydraulic conditions at each array.

The 2011 steelhead survival through the Priest Rapids Development was estimated at 97%, which is 7% higher than the highest survival rate in the last five years. For the first time, Grant PUD has met the performance standard of 93% Development survival. High river flows likely contributed to high survival rates as river flows were twice the 10-year average (300 kcfs in 2011, 150 kcfs 10-year average). High flows contributed to faster steelhead travel time through the Reservoir (40% faster in 2011 than the 2006-2010 average) that likely limited the exposure time of smolts to piscivorous predators.

Additionally, steelhead losses that did occur (3%) were in loosely defined hot-spots that overlapped with the movement of tagged northern pikeminnow. These hot-spots included the tailrace of Wanapum Dam, the entrance to Crab Creek, and the Reservoir immediately upstream of the Priest Rapids Dam forebay. Additional losses from avian predation were confirmed by the recovery of acoustic tags at bird colonies. Though this study was designed to identify zones of migratory steelhead loss between Wanapum and Priest Rapids dams, the measured losses were fewer than expected. We were able to directly measure predation events by northern pikeminnow on migrating smolts, and identify in-river hot-spots of predation.

Leah Sullivan, Leah Sullivan is a Senior Fishery Biologist with 12 years of experience in conducting small and large scale acoustic, radio and PIT telemetry studies with various anadromous and catadromous to assess downstream and upstream migration, timing, and distribution as it is related to hydroelectric projects in the United States Pacific Northwest and East Coast.

She has 10 years of expertise on hydroacoustic telemetry projects, domestic and foreign, primarily using acoustic telemetry to evaluate the fine-scale three-dimensional behavior of migratory species as they pass downstream or upstream of a variety of hydroelectric projects. Ms. Sullivan is a participant of the Priest Rapids Bypass Design Team where she has collaborated with engineers and biologists on behalf of Grant PUD to design a near future top-spill passage alternative at Priest Rapids Dam.

She received an MS in Fisheries Conservation from the University of Massachusetts Amherst in 2005 and a BS in Marine and Freshwater Biology from the University of New Hampshire in 1997.

D3

Fish Passage Monitoring, What's really going on out there?

Brett Towler, *U.S. Fish and wildlife Service Fisheries*, Dan Shively, *U.S. Fish and Wildlife Service*, Brian Elkington, *U.S. Fish and Wildlife Service*, William Rice, *U.S. Fish and Wildlife Service*

Currently, research indicates an overall lack of monitoring on a broad scale for fish passage projects. Projects, in general, are completed and interested parties seem to move to the next project site, without investigating and validating the results of their previous efforts. Although fish passage restoration work continues to be carried out on-the-ground, how certain are we that each project has produced the expected results? Monitoring our work is crucial to ensuring we achieve our project goals and continue to expand the science and knowledge relating to fish passage. Fish passage work is ongoing around the country, much of which is, in part, funded through U.S. Fish and Wildlife Service (Service) programs like the National Fish Passage Program, the National Fish Habitat Partnership, or the Partners for Fish and Wildlife Program. It is important to the long term success of federal programs such as these that monitoring be carried out, as it provides the opportunity for inspired success stories and accountability through the assessment of work completed. But how often is this done, and, when monitoring is completed, what form does it take? Working nationally with our counterparts in the Service, we present the quantitative and qualitative results of a survey intended to investigate the scale and scope of monitoring completed over the past three years through federal programs like those listed above. Example questions asked include: "what projects did your office/program engage in over the last 3 years", "what types of restoration projects have you monitored by taking physical measurements and/or performing aquatic studies," "when monitoring is performed, who is it performed by and how is the Service involved." Each respondent was asked to answer several questions relating to specific projects and the level and types of monitoring performed over that period at his/her field station. Ultimately, these survey results will help us better understand monitoring as it is currently being done through Service-funded programs. This work is also intended to serve as a baseline or jumping off point in an effort to expand monitoring and utilize or improve the science in relation to fish passage barrier removal.

Evaluation of two rock ramp fishways in a Colorado transition-zone stream

Ashley Ficke, *Colorado State University Fish, Wildlife, and Conservation Biology*, Christopher A. Myrick, *Colorado State University Department of Fish, Wildlife, and Conservation Biology*, Matthew C. Kondratieff, *Colorado Parks and Wildlife*

Agricultural diversion structures on South Boulder Creek (SBC; Boulder County, Colorado) have impaired fish movement for nearly 100 years. Although several of these structures have been modified for fish passage, their efficiencies remain unmeasured. Upstream fish movements were compared across two SBC structures and a control site in a 1-yr study. The upstream, channel-spanning structure had a ~7% slope, the downstream partial channel-spanning structure had a ~3% slope, and the control site was located at a small, channel-wide boulder vane. Five species of fish (Oncorhynchus mykiss, Salmo trutta, Rhinichthys cataractae, Catostomus catostomus,and C. commersoni) were marked with PIT tags, and their movements were monitored with paired antenna arrays at each of the three sites. Of the 1153 tagged fish, 663 were subsequently detected at one or more of the antennae. Upstream movement was lowest between November and March at all sites. More fish moved across the control site (n = 66) than across the low-slope (n = 31) or high-slope (n = 26) structures. More movement occurred across the control site in August and from April through June, a pattern also seen at the high-slope structure; movement over the low-slope structure was most prevalent in September and October, with a smaller pulse in April and May. Modifications to these structures have restored connectivity to a 2-km segment of SBC, but upstream fish movement rates remain lower across the structures than at the control site. Differences in upstream passage rates are related to structural design differences between the two fishways.

Physical and Biological Assessment of the Eel River Headwaters Restoration Sites in Plymouth, Massachusetts

Ellen Douglas, *University of Massachusetts Boston Environmental, Earth and Ocean Sciences*, Kevin M. O'Brion, *University of Massachusetts Boston*, Alan D. Christian, *University of Massachusetts Boston*, Alex Hackman, *Massachusetts Department of Fish and Game*

The Eel River Headwaters Restoration Project (completed in August 2010) actively restored 40+ acres of commercial cranberry bogs into stream and wetland habitat. This study involved habitat, fish and macroinvertebrate assessments at 2 actively restored Eel River reaches, 2 passively restored cranberry bog reaches, and 2 reference reaches. Sampling occurred in September 2010 and June 2011 following standard protocols. Furthermore, at the 2 actively restored reaches, we compared 2 prior years of macroinvertebrate sample data to our post-restoration samples. For the post-restoration sampling, the cumulative percent of the variance explained for Principal Components Analysis (PCA) Axes 1 and 2 was 49.38%, 57.41%, and 36.14% for physical habitat, fish, and macroinvertebrates, respectively. In all 3 cases, our PCA results indicated spatial and temporal variability between reaches. Macroinvertebrate Family Biotic Index (FBI) of post restoration samples ranged from 3.83 to 8.12, indicating poor to excellent conditions. For 12 pairwise comparisons of macroinvertebrate data between pre-restoration and post-restoration communities, only 1 pair-wise comparison was significant (Mann-Whitney Rank Sum, $p<0.05$). Results show the initial separation of the active Eel River restoration from the passive restoration and reference.

Lessons from a comprehensive survey of a fish pass by a digital video system in the Reuss River

Armin Peter, *Eawag, Swiss Federal Institute of Aquatic Science and Technology Fish Ecology and Evolution*, Eva Schager, *Swiss Federal Institute of Aquatic Science and Technology*, Samuel Wechsler, , Denise Weibel, , Simon Wueest

The Reuss River in the City of Lucerne (Switzerland) is the regulated outflow from Lake Lucerne. A run-of-river hydropower plant (annual production 4.3 millions GWh) was completed in 1998 on the right river shore. In order to facilitate upstream migration of fishes a fish pass (vertical-slot) with an observation window was included in the fish ladder. The discharge of the fish pass is 800 l/s. The purpose of the fish pass is to ensure migrations between Lake Lucerne and the Reuss River. In order to study the fish migrations we installed a digital video camera system and observed the fish through the observation window. We observed the fishes during a long period over three years. The camera was running during the day, but on selected periods also at night when we installed a light in the fish pass. A total of 72000 individuals were registered and analyzed in the three years. Surprisingly we could not only observe upstream migrating fish but also individuals which migrated in the downstream direction. The most common observed fishes were chub (Squalius cephalus), barbel (Barbus barbus) and brown trout (Salmo trutta fario). These three species contributed to 88 % of all observations. A total of 11 species was observed in the ladder. However in the down- and upstream part of the Reuss River 28 fish species can be found. Some of them in very low densities. The video observations documented that the fish pass was not only used as a migration corridor, but also as habitat, reproduction and feeding area.

Most fish species showed seasonal migration patterns. In June and July we observed the highest migration activities. But also in October there was a clear peak in the migration activities. Most of the cyprinid species stopped the activity in winter (December-March). Brown trout did not show any seasonal migration patterns.

The advantage and disadvantage of video analysis in fish ladders will be discussed. The observation system is very reliable and works very well in clear water under non-turbulent flow conditions, but video observations have also certain limits. The comprehensive study demonstrated that the fish passage is working very well for some specific species. On the other hand no migration observations were made for other species which may have problems with the hydraulic conditions of the fish pass or with the entrance. This is mainly true for the grayling (Thymallus thymallus) and the nase (Chondrostoma nasus), two sentinel species in the River Reuss. The broad analyses with observations

over three years help to identify deficits with the fish passage and necessary improvements for the future.

Armin Peter, Armin Peter studies in biology at ETH Zurich, PhD thesis on trout population dynamics and trout stocking, post doc at the University of British Columbia, Vancouver B.C., Canada, senior reserach scientist at Eawag, Switzerland. Research focus: fish migration, fish habitat, river restoration.

D4

EPRI's Program to Develop, Install and Test the Alden Fish-Friendly Hydropower Turbine
Douglas Dixon, *Electric Power Research Institute (EPRI) Waterpower*, Norman Perkins, *Alden Research Laboratory, Inc.*, Steve Amaral, *Alden Research Laboratory, Inc.*, George Hecker, *Alden Research Laboratory, Inc.*, Greg Allen, *Alden Research Laboratory, Inc.*

In 1996, DOE, EPRI, and industry began a multi-year effort to develop "˜fish-friendly' turbines. This arose from concerns over fish mortality caused by existing turbines, high cost and low performance associated with downstream fish screening and bypasses, and lost generation and water quality issues associated with spillage for fish passage. By 2001, the research produced two design concepts. The first or Kaplan minimum gap runner (MGR) turbine, for modernizing large river projects, has been installed and tested at several Columbia River projects. The second, for new units in smaller rivers and fish bypasses, is the Alden turbine which features a helical-shaped runner with only three blades. DOE pilot-scale/laboratory tests with this turbine demonstrated that fish survival, when scaled to a full-size field installation, would be in excess of 98% for many fish species. Following initial proof-of-concept testing, an optimized conceptual design of the Alden turbine with increased power density to be competitive with existing designs was completed. Once the conceptual design was completed, EPRI and DOE funded Alden and Voith Hydro to enhance the turbine's performance through modification of the hydraulic passageways, including the spiral case, distributor, runner and draft tube. Each design modification was also evaluated for fish passage in order to ensure that the original fish-friendly characteristics of the machine were maintained. The final stage of the Alden turbine design effort included a model test at Voith Hydro's hydraulic laboratory in York, PA, in addition to the updated mechanical and balance of plant equipment sizing necessary for actual field installation. Model testing indicated a maximum calculated prototype efficiency of almost 94% at conditions corresponding to a prototype net head and flow of 92.0 ft and 1,504 cfs, respectively. The next stage in developing the Alden turbine is a field demonstration project. EPRI is planning two demonstration projects "“ one in the U.S. and one in France. Test target species for fish passage survival assessment will include blueback herring, juvenile Atlantic salmon, and American and European eel. The presentation will review the current status of the planned demonstration projects and the schedule for assessing the full-scale deployment of the Alden turbine.

Douglas Dixon, Doug Dixon is a Technical Executive and Program Manager for aquatic resource protection, water quality, and fishery research initiatives in the Environment Sector of EPRI. He manages EPRI’s Clean Water Act 316 (a&b) Fish Protection Issues Research Program as well as EPRI’s program to develop the fish-friendly Alden hydropower turbine. With more than 35 years of wide-range experience in environmental science and engineering research, including 15 years assessing the impacts of power plants on aquatic resources, his expertise spans marine and freshwater species, design and execution of field sampling studies, and statistical analysis of field data. He has extensive knowledge of fish protection and passage centers on the design, construction, performance evaluation of physical and behavioral technologies for cooling water intake structures, and upstream and downstream fish-ways for hydroelectric projects. He received his BA in Zoology from the State University of New York at Geneseo and his PhD from the Virginia Institute of Marine Science, College of William & Mary.

The Science Behind a Fish-Friendly Turbine
Norman Perkins, *Alden Research Laboratory, Inc*. *Environmental*, Steve Amaral, *Alden Research Laboratory, Inc*., George Hecker, *Alden Research Laboratory, Inc*., Songheng Li, *Alden Research Laboratory, Inc*., Greg Allen, *Alden Research Laboratory, Inc*., Douglas A. Dixon, *Electric Power Research Institute*

Fish passing through hydro-turbines are subject to abrasion along surfaces and in small gaps, impact on stay vanes and gates, strike by leading blade edges, rapid pressure drops, flow shear and minimum pressures, all of which may cause injury and even death (Cada, G. et al. 1997). Limiting acceptable values for the flow induced mechanisms concerning pressure and shear have been established and were used in designing the Alden turbine. To determine how well these criteria have been met in various parts of the turbine, computational fluid dynamics (CFD was used to predict the locations and volumes which meet or exceed these limiting values. To gain confidence in the predictions, verification of the CFD simulations was performed by comparing the efficiency "hill chart" derived from CFD simulations with that resulting from physical scale model tests of the Alden turbine. Efficiency is an indicator of flow conditions in the runner. Thereafter, the CFD simulations were used to predict flow parameters related to the allowed limits for shear, pressure change rates, and minimum absolute pressures.
In addition, EPRI has been supporting studies to assess hydro-turbine leading edge blade design parameters that affect fish mortality. Initial testing was conducted with three fish species and several blade thicknesses, strike velocities, and fish lengths. The primary focus of these initial studies was to determine how the ratio of fish length to blade thickness (L/t ratio) influenced strike mortality and to provide data that could be used to improve the "fish-friendliness" of hydro turbines. However, comparing predicted fish survival to the measured survival of the pilot-scale Alden turbine revealed that the mortality predicted from the blade strike data was higher by about 40% on average. One factor that could account for this difference is that fish were oriented perpendicular to the blade in the strike tests, whereas they were likely oriented about 45 degrees to the blade when passing through the Alden turbine. Therefore, additional tests were conducted to examine the effects fish orientation so that more reliable predictions can be made for a wide range of turbine designs. We will present the results of these tests and discus the effect of strike speed and leading edge blade thickness on strike mortality. These parameters are factored into theoretical models for predicting turbine passage survival and the design of fish-friendlier turbines.

Norman Perkins, Norman F. Perkins is a Senior Civil Engineer and Project Manager at Alden Research Laboratory, Inc. He is responsible for conceptual and detailed design engineering efforts related to flow measurement feasibility, debris management, and fish protection and passage at hydroelectric, thermal power, and water resource projects. Norman has a BS degree in Civil Engineering from Wentworth Institute of Technology.

Assessment of the conditions for fish passage through hydroturbines and the response of fish to passage
Thomas Carlson, *Pacific Northwest National Laboratory Marine Sciences Laboratory*, Daniel Deng, *Pacific Northwest National Laboratory*, Marshal Richmond, *Pacific Northwest National Laboratory*, Joanne Duncan, *Pacific Northwest National Laboratory*

Hydraulic conditions in the water passageways of hydroturbines in conjunction with the likelihood of contact with structure and rapid decompression have been known for decades to be factors that determine the safety of turbine passage for fish. The sensor fish, an autonomous 6 degree-of-freedom sensor, was developed to pass through an operating turbine and acquire data that permits quantification of the conditions affecting the safety of fish passage. Laboratory studies, using live fish, of rapid decompression and shear and turbulence exposure, augmented by observation of the condition of balloon tagged fish following turbine passage, have enabled linkage between sensor fish observations of passage conditions with probable impacts to turbine passed fish. Assessment of the turbine passage survival of fish at the population level has evolved considerably over the past five years with development of micro-

acoustic transmitters, passive acoustic cabled and autonomous receivers, and experimental designs that deliver highly precise estimates of fish survival. The combination of sensor fish and acoustic telemetry, in conjunction with other developments, are permitting fish passage safety to be designed into new hydroturbines and field assessment of turbine operations to optimize the survival of turbine passed fish.

Thomas Carlson, Dr. Carlson has been active in the development and application of tools and application methods to assess the safety of hydroturbine passage for fish for over 20 years. Current activities include redevelopment of the sensor fish to meet present and future needs and development of ultrasmall acoustic transmitters that are impantable by syringe in juvenile fish.

Using Fish Morphological Characteristics to Re-design Hydroelectric Turbines

Glenn Cada, *Oak Ridge National Laboratory*, Peter Schweizer, *Oak Ridge National Laboratory*, Marshall Richmond, *Senior Research Engineer, Pacific Northwest National Laboratory*

Safe fish passage affects not only migratory species, but also populations of resident fish by altering biomass, biodiversity, and gene flow. Consequently, it may be important to estimate turbine passage survival of a wide range of susceptible fish. Although fish-friendly turbines show promise for reducing turbine passage mortality, experimental data on their beneficial effects are limited to only a few species, mainly salmon and trout. For thousands of untested species and sizes of fish worldwide, the particular causes of turbine passage mortality and the benefits of fish-friendly turbine designs remain unknown. It is not feasible to measure the turbine-passage survival of every species of fish for every hydroelectric turbine design. We are attempting to predict fish mortality based on an improved understanding of turbine-passage stressors (pressure, shear stress, turbulence, and strike) and the morphological, behavioral, and physiological characteristics of different fish taxa that make them susceptible to these stressors. Computational fluid dynamics and blade strike models of the turbine environment are re-examined in light of laboratory and field studies of fish passage effects. Comparisons of model-predicted stresses to measured injuries and mortalities will help identify fish survival thresholds and the aspects of turbines that are most in need of re-design. In parallel, we are exploring the use of a Traits-Based Assessment (TBA) approach to group fish species based on their environmental, biological, behavioral, and life history characteristics. TBA provides a framework for identifying species most susceptible to turbine passage and species that share similar sensitivities to turbine passage stressors. TBA could be used to identify representative fish species for testing, assess impacts of new hydropower development, and evaluate the benefits of advanced turbines.

Glenn Cada, Dr. Glenn Cada has been actively involved in research and assessment of hydropower impacts for over 30 years. He provides technical support on environmental issues to the U.S. Department of Energy's Water Power Program. In that capacity, he has conducted research into instream flow assessment methodologies, water quality issues, upstream fish passage, and turbine passage effects on fish, including the development of environmentally enhanced turbines. He has authored over 100 publications on the effects of energy development on aquatic resources.

D5

Estimation of Turbine passage survival of juvenile American shad, Alosa sapidissima, by different methods for practical application

Paul Heisey, *Normandeau Associates, Inc. Hydro*, Paul G. Heisey, *Normandeau Associates, Inc.*, Joanne L. Fulmer, *Normandeau Associates, Inc.*, J. Chris Avalos, *Normandeau Associates, Inc.*, Dilip Mathur, *Normandeau Associates, Inc.*, Kimberly L. Long, *Exelon Power Corporation*

The impetus for our presentation is primarily three-fold: (1) present survival estimate of juvenile American shad, Alosa sapidissima recaptured and examined after passage through a relatively large Francis turbine (hydraulic capacity > 6,000 cfs) at Conowingo Hydroelectric Station, MD and its implications on restoration of the species to the

Susquehanna River, (2) compare fish survival derived from a blade-strike equation, and (3) applicability of using literature based survival estimates for multiple fish size and species without conducting a field study at a hydroelectric project. Limited published data exist on passage survival of juvenile American shad through relatively large Francis units. Survival probability of juvenile American shad (106 to 142 mm total length, average 119 mm) was estimated while passing through an aerated Francis turbine using the HI-Z Tag recapture technique. The experiment utilized 138 hatchery reared juveniles released into the turbine and 76 fish released downstream of the turbine discharge as controls. The turbine passage survival was estimated at 89.9% with 90% ($\alpha = 0.10$) confidence intervals of $\leq \pm$ 5.5%. This estimated survival is within the range (83.5-94.7%) of empirically determined (HI-Z Tag) estimates for similar sized Francis units (runner diameter >110 in, buckets 13-17). While blade-strike derived survival estimates generally show a close correspondence, particularly for salmonids, with empirically determined estimates for Kaplan type turbines, it appears that some differences between the two estimates may occur for clupeid passage through Francis turbines. For the tested Francis turbine at Conowingo, the survival estimate from the blade-strike equation was approximately 5% higher than the empirically determined estimate of 89.9%. Blade-strike equation generated survival estimates maybe higher than empirical estimates because they do not account for potentially higher mortality due to the sensitivity of juvenile shad. Across all Francis type turbines, EPRI field estimated survival of small sized fish was 92%, relatively similar to that estimated herein. While the application of published and/or mathematically derived survival estimates to non-studied sites is encouraged and is useful, caution should be exercised to include only field studies with acceptable control mortality (handling, tagging, and recapture). We suggest control mortality be $\leq 20\%$ for clupeids and $\leq 10\%$ for other species. The life stage and sensitivity of a given species also needs to be considered when using mathematically derived estimates.

Paul Heisey, Ms. Kimberly Long is an Environmental Specialist with Exelon Power (Exelon) in Kennett Square, Pennsylvania. As an Environmental Specialist, she serves as a subject matter expert in the areas of NPDES permitting and compliance, stream and wetland encroachments and aquatic biology. Ms. Long provides environmental compliance support to various fossil and hydro facilities in the mid-Atlantic region, Massachusetts and Texas. Ms. Long also provides support to hydro FERC relicensing activities and natural resource aspects of Exelon Wind.

Before joining Exelon, Ms. Long was employed with FirstEnergy Corporation (FirstEnergy) as an Associate Scientist responsible for drinking water compliance, FERC relicensing support and obstruction and encroachment compliance at generation facilities, transmission and distribution projects. Prior to joining FirstEnergy, Ms. Long worked for the Pennsylvania Department of Environmental Protection as a Watershed Manager for two years and as a Water Pollution Biologist for four years. At the Department, Ms. Long was responsible for conducting stream assessments for the Instream Comprehensive Evaluation program, compliance surveys, general macroinvertebrate and fish indices and point-of-first-use evaluations.

Ms. Long received a B.S. degree in Biology from Millersville University in 1999 and an M.S. degree in Biology from Bucknell University in 2001.

For more than 22 years, Ms Joanne Fulmer has conducted and managed numerous turbine and spillway passage survival studies throughout the United States, Canada, and Europe. Species of interest have included American shad, American and European eels, salmonids and resident species at over 50 hydroelectric dams. Data gathered from many of these studies have been utilized to improve downstream passage conditions for emigrating fish. She has also participated in numerous fisheries studies related to assessing the effects of the various types of power stations.

Barotrauma in Juvenile Salmonids Exposed to Simulated Hydroturbine Passage: pathways, management implications and applications

Richard Brown, *Pacific Northwest National Laboratory Ecology Group*, Alison H. Colotelo, *Pacific Northwest National Laboratory*, Brett D. Pflugrath, *Pacific Northwest National Laboratory*, John R. Stephenson, *Pacific Northwest National Laboratory*, Thomas J. Carlson, *Pacific Northwest*

National Laboratory, Daniel Deng, *Pacific Northwest National Laboratory*, Brad Trumbo, *US Army Corps of Engineers*, Martin Ahmann, *US Army Corps of Engineers*, Colin Brauner, *University of British Columbia, Department of Zoology*

On their seaward migration, juvenile salmonids commonly pass hydroelectric dams. Barotrauma (e.g., swim bladder rupture, hemorrhaging, emboli and exopthalmia) resulting from rapid decompression can be a major source of injury and mortality during turbine passage. The mechanisms of these injuries can be due to expansion of existing bubbles or gases coming out of solution; governed by Boyle's Law and Henry's Law, respectively. It appears that the majority of decompression related injuries observed in juvenile salmonids exposed to simulated turbine passage are due to the expansion of existing bubbles in the fish, particularly the expansion and rupture of the swim bladder. This information is particularly useful for fisheries managers and turbine manufacturers. Reducing the rate of swim bladder ruptures by reducing the frequency of occurrence and severity of rapid decompression during hydroturbine passage could reduce the rates of injury and mortality for hydroturbine passed juvenile salmonids. However, there is little information about how other species, with varying physiological and morphological characteristics (e.g., type of swim bladder), will be influenced by changes in pressure. The implications for fisheries management, hydro management and development and broadening the range of understanding of barotrauma in both salmonids and non-salmonid species will be presented.

Richard Brown, Richard Brown is a senior research scientist with the Pacific Northwest National Laboratory that specializes in fish ecology and physiology with emphasis on fish passage issues.

Downstream Passage Survival of American Eel at the School Street Hydroelectric Project Cohoes, NY

Bryan Apell, *Kleinschmidt Associates Ecological Sercices Department*

The School Street Hydroelectric Project (Project) (FERC No. 2539) is owned and operated by Brookfield Renewable Power (Brookfield). The Project is located in Cohoes, New York, on the Mohawk River, approximately 2.5 river miles upstream from its confluence with the Hudson River. The Project was issued a new FERC License in 2007, which required downstream fish passage for anadromous and catadromous fish, as well as resident/riverine fish species. The construction of the downstream fishway was completed in the summer of 2009 and included; an angled bar rack with one inch clear spacing and a concrete eel diversion structure located at the base of the bar rack, and a fish conveyance system with; two entrance locations, surface and bottom gates, a collection chamber, an overflow weir and a final discharge pipe that descends 90 feet in elevation.

In October of 2011, Brookfield evaluated downstream bypass survival of adult (silver phase) American eel. Prior efforts to collect a sufficient number of adult test eels within the Project waters were unsuccessful in 2009 and 2010 due to limited availability. As such, test eels were purchased from a commercial fishery on the Sebasticook River in Newport, ME. A total of 105 eels was injected into the fishway and recaptured in the tailrace using a customized net pen. Of those released, 56 were recaptured (recapture efficiency = 53.8%) and held overnight in the net pen to investigate latent mortality. Following the 15-hour holding period the condition of the test eels were evaluated as Alive or Dead. All 56 test eels were determined to be Alive and exhibited a bypass survival of 100%.

Bryan Apell, Bryan Apell is a fisheries and aquatic ecologist with Kleinschmidt Associates. He received a Bachelor’s of Science degree in ecology and evolutionary biology with an emphasis on marine ecology and fish biology, from the University of Connecticut in 2004. Mr. Apell joined Kleinschmidt Associates in 2004. Since joining the Kleinschmidt team, Mr. Apell has been involved in a variety of fisheries and aquatic ecological projects including large scale fish passage studies, radio telemetry studies with American eel, shortnose sturgeon, blueback herring, American shad and Atlantic salmon smolts, as well as various habitat/site characterizations and aquatic surveys. He is well versed in physical hydraulic characterization and has

experience conducting instream flow studies using incremental methodologies as well using acoustic Doppler current profiler (ADCP) technology to map velocity profiles and analyze data as a tool to investigate fish passage and other hydraulic issues at hydroelectric Projects. In addition, Mr. Apell has helped to establish an Ichthyoplankton Sampling Protocol, and completed plankton identification and quantification in support of impingement and entrainment studies related to section 316(b) of the Clean Water Act. He has been involved in study scoping and development of standard operating procedures as well as sampling systems design and fabrication for both impingement and entrainment studies, and implementing these procedures in the field and laboratory. Mr. Apell is an expert boat handler and has extensive experience utilizing electrofishing techniques essential for fish survey.

Downstream Fish Migration Systems and Intake Structure Optimization & Possible Synergies
Carl Robert Kriewitz, *ETH Zurich, Switzerland Laboratory of Hydraulics, Hydrology and Glaciology*, Jill Lucas, *Laboratory of Hydraulics, Hydrology and Glaciology (VAW),* Adriano Lais, *Laboratory of Hydraulics, Hydrology and Glaciology (VAW)*

An important aspect of the process of water body restoration deals with the recreation of the flow continuum. This includes enabling the up- and downstream migration of fish, which can be hindered by run-of-river power plants. Currently especially the downstream migration that is vital to the preservation of quite a few European fish species is negatively affected. The introduction of the revised Water Protection Act in January 2011 in Switzerland constitutes that the major damages caused by men to the ecosystem of the Swiss river systems will have to be rectified within the next 20 years. This is going to be a tremendous task for the energy companies and cantons alike.
Therefore the Laboratory of Hydraulics, Hydrology and Glaciology (VAW) conducted hydraulic model tests on a water power station at the river Aare planned to supply the natural river arm with an increased residual discharge of 40 m3/s. To facilitate a save downstream fish migration a guidance screen with horizontal bars and a bypass system was tested. Simultaneously the intake structure was optimized for optimal turbine performance and it was found that both processes went hand in hand. The article gives an overview of the hydraulic model and test results will be presented.

Carl Robert Kriewitz, Mr. Kriewitz is a Project Manager and doctoral student in the Hydraulic Structures division at VAW. His research focuses on measures to facilitate safe downstream fish migration at large Central-European rivers, fish protection technologies, two-phase air-water flows, de-aeration, and supercritical flow at chute junctions

D6

Tide Gates And Their Impacts On Juvenile Coho Salmon In Southern Oregon
Guillermo Giannico, *Oregon State University Fisheries and Wildlife*, Arthur Bass, *Department of Fisheries and Wildlife, Oregon State University*

Tide gates are one-way doors integrated into dyke systems that prevent saltwater intrusion to agricultural land and allow freshwater drainage to the estuary during low tide. Tide gates may act as fish passage barriers for juvenile salmonids, limiting movements during migration and access to rearing habitats. We conducted our research in Coos Bay, one of the many Oregon estuaries with extensive use of tide gates. Our objectives were to 1) develop a methodology for recording fish passage at tide gates 2) describe the conditions under which fish passage occurs and 3) compare fish passage behavior between a top-hinged tide gate, a side-hinged tide gate and a non-gated stream. We installed stationary passive integrated transponder (PIT) antennae around a top-hinged gate, a side-hinged gate and in a non-gated reference system to track the movement of PIT tagged juvenile coho salmon. Our results indicate that coho salmon smolt passed upstream most frequently at the non-gated channel (48% of all smolts detected), than the side-hinge gated site (28%) or the top-hinge gated site (3%). Subyearling coho salmon passed more frequently at a specific range of gate angles and tailwater depths at both top hinged and side-hinged tide gates. Smolts preferred greater gate angles and tailwater depths than average to pass

downstream at both tide gates. Subyearlings passed upstream more frequently during small gate angles and a narrow range of tailwater depths at the top-hinged gate but did not display preference for a particular condition at the side-hinged gate. At the top-hinged gate, conditions favorable for subyearling upstream passage occurred towards the end of the gate open period and therefore subyearlings were severely limited in their opportunities for passage. In addition to these direct physical effects on juvenile salmonid passage, tide gates also seem to influence fish migratory timing by altering environmental conditions around them.

Guillermo Giannico, Dr. Giannico is an Associate Professor and Extension Fisheries Specialist - Department of Fisheries and Wildlife, Oregon State University.

Susquehanna American Shad Model (SASM) - A tool for evaluating various restoration measures
Tim Brush, *Normandeau Associates*, John Rinehart, *Normandeau Associates*, Steve Leach, *Normandeau Associates*

American shad restoration efforts in the Susquehanna River face the obstacle of four hydroelectric dams between the river mouth and suitable riverine spawning habitat, resulting in cumulative attenuation of both adult migration to spawning and outmigration of juveniles. A numerical model was developed to examine the effects of potential restoration measures on the spawning population. Adjustable parameters in the model include upstream and downstream passage rates at each dam, sex ratio, spawning age structure (including repeat spawning), upstream trap and transport, and juvenile stocking. Future recruitment is based on the number of females reaching upstream spawning habitat. Under the assumption that only fish reared upstream will return there to spawn, existing data were used to calibrate the model to a good approximation of adult returns to Conowingo Dam over past thirty years, suggesting that the trends observed over that period are consistent with known numbers for volitional passage, trucked adults, and stocked juveniles. The model will be used to evaluate potential restoration measures.

Tim Brush, Tim Brush has been involved in diadromous fish restoration and biology since 1983. He has worked extensively with American shad and river herring, American eel, Atlantic salmon, shortnose sturgeon, and various Pacific salmonids. Most of his work has been in the Susquehanna, Connecticut, Santee-Cooper, Willamette, and Clackamas basins.

Menominee Hydroelectric Facility Phase II - Fish Lift System
Lucas Stiles, *Kleinschmidt Associates*, Rory Alsberg, *N.E.W. Hydro, Inc.*, Jesse Waldrip, *Kleinschmidt Associates*

Lake sturgeon have been identified as a species of concern in the Great Lakes and their tributaries. As a result, the need for upstream and downstream fish passage at existing hydroelectric facilities has been identified as a measure to reduce habitat fragmentation and restore access to spawning and rearing habitat. The Menominee River has been identified as a key river in restoring lake sturgeon habitat.
The Menominee River forms the border between northeaster Wisconsin and the Upper Peninsula of Michigan. The Menominee River is formed at the confluence of the Brule and Michigamme rivers and flows in the southerly direction for 118 miles before joining the waters of Green Bay. The Menominee/Park Mill Hydroelectric Complex consists of the Park Mill Dam and the Menominee Dam which are the first two barriers to upstream passage on the Menominee River.
Design of the fish passage facilities at these projects is underway and Kleinschmidt Associates has been retained to perform the final design of Phase II of the project, a new state-of-the-art fish elevator with a trap and transport facility. The new lift will be located in an unused turbine bay and will lift fish from the tailrace of the Menominee project into a sorting tank located on the first floor of the powerhouse. Fish will be sorted by biologists from the state and federal fishery resource agencies to remove invasive species such as sea lamprey, or held for screening and collection of sturgeon gametes. The desired fish will then be transported upstream of the Park Mill project. This presentation will focus on the conceptual design process, agency negotiations, the final design of the

new fish elevator, and will discuss the layout of the new trap and transport facility.

Lucas Stiles, Mr. Lucas Stiles joined Kleinschmidt Associates in June 2008 as a Civil/Structural Engineer and is a member of the Fish Passage Team. Mr. Stiles received his Bachelor of Science Degree in Civil Engineering in May 2008 from the University of Maine.

Since joining Kleinschmidt, Mr. Stiles has participated in many fish passage design projects, site inspections, and feasibility studies. His responsibilities include design, inspection, evaluation, and rehabilitation of steel, concrete, and wood structures primarily relating to fish passage and protection. He has performed engineering design and costing for a variety of fish passage facilities including steeppass fishways, denil ladder fishways, vertical slot fishways, fish elevators, natural fishways, eel ladders, and downstream fish passage facilities. Mr. Stiles has also received training in upstream and downstream fish passage from the American Fisheries Society.

Automated Fishway Monitoring Systems
Chris Bunt, *Biotactic Inc*.

Monitoring of species utilization, timing and numbers of fish that successfully use fishways under varying hydraulic and environmental conditions is of primary importance for determining effectiveness of fish passage structures. Beginning in 2004 we developed an automatic self-cleaning video-based underwater monitoring system for counting and identifying species of fish within fishways, bypass channels or other confined locations within dams and other barriers to fish passage. The system uses high-level image analysis to process videographic and sensor data that are streamed live to the internet in near real-time. Operational procedures and protocols will be described and data summaries from 8 months of continuous monitoring at a nature-like fishway in the Beaver River in Thornbury, Ontario will be presented.

Chris Bunt, Despite his well groomed appearance, Chris is a bit of a bushman. He spent three years (minus winters) living in a tent on the Grand River, Ontario, studying fishways, fish barriers and other issues related to fish passage, fish swimming and fish migration beginning in 1994 for a Masters and PhD from the University of Waterloo. Prior to completing two post-docs (Illinois Natural History Survey and James Cook University in Australia), he founded Biotactic Incorporated. He developed underwater fish monitoring systems in 2004 and invented and began testing the self-cleaning underwater camera systems and fish counting algorithms in 2009. In addition, he has authored and co-authored approximately 31 peer-reviewed scientific publications and over 35 other commissioned research reports. For over 14 years Chris and Biotactic Inc. have worked with colleagues and affiliates from around the world to help develop solutions and strategies to monitor, conserve and enhance fish populations, facilitate fish passage and protect aquatic ecosystem. Guide to the Program

Index of Authors

L

Long, K. – B1
Louisos, J. – C3

M

MacBroom, J. – C7
Mahlum, S. – C3
Maltby, A. – A2
McCarthy, T. – B1
McClain, S. - A1
McGowan, M. – A3
McKinley, D. – C7
Monk, S. – B5
Moore, S. – B3
Moran, S. – C8

N

Naumann, B. – A4
Nelson, N. – C6
Nieland, J. – A7

P

Parasiewicz, P. – A3
Patterson, C. – A5
Perkins, N. – D4
Perry, J. – C2
Peter, A. – D3
Plymesser, K. – A5

R

Rashid, M. – D1
Rice, W. – C2
Richardson, J. – D1
Ripp, B. – C8
Rodgers, E. – B4
Ruttenberg, D. – C7

S

Schiff, R. – B2
Schrecengost, M. – B3
Scott, S. – A3
Soli, A. – B8
Starr, R. – C1
Stiles, L. – D6
Stottler, M. – A8
Stranko, S. – C1
Sullivan, L. – D2
Sullivan, T. – C8

T

Towler, B. – D3
Tritico, H. – B3
Trumbauer, M. – C7
Trynewski J. B7
Tudorache, C. – B5
Turek, J. - A1

W

Wamser, M. – C4
Wanningen, H. – A8
Wechsler, J. – B4
Wildman, L. – C6
Willis, T. – A6

Thanks to our sponsors..

Benefactors

USGS science for a changing world

National Program FISH PASSAGE Creating Aquatic Possibilities

University of Massachusetts Amherst 1863

U.S. Fish & Wildlife Service

National Oceanic and Atmospheric Administration NOAA U.S. Department of Commerce

Sponsors

Worthington

Brookfield

Supporters

AIL Atlantic Industries Limited

HDR

SumCo Eco-Contracting

Gomez and Sullivan Engineers, P.C. Engineers and Environmental Scientists

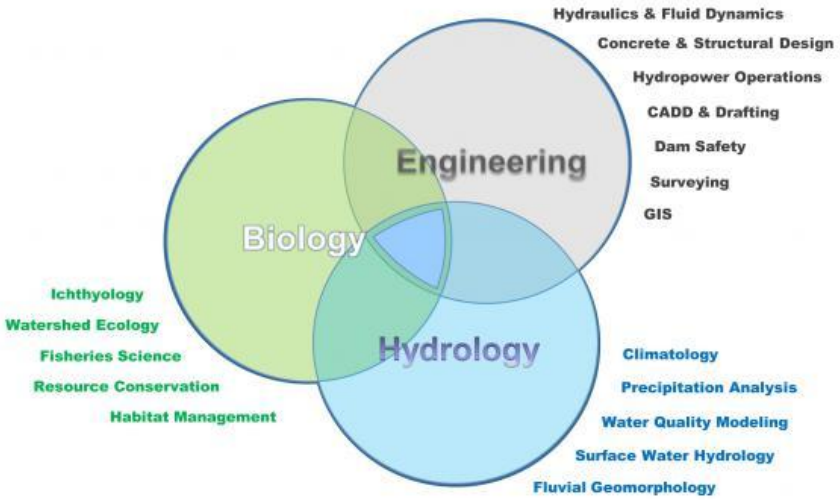
Normandeau environmental consultants

ALDEN

Kleinschmidt

\

The University of Massachusetts Amherst is offering a new graduate degree specialization in Fish Passage Engineering. The degree is offered through the Department of Civil and Environmental Engineering and is intended to provide an engineer with the additional skills in hydraulics and ecohydrology needed to analyze and design solutions for enhancing fish passage in streams and rivers. The curriculum draws from the fields of engineering, hydrology and biology and is offered in collaboration with the U.S. Fish and Wildlife Service.



For more information see our website: http://cee.umass.edu/fishpassage/ **or contact:**

Dr. David Ahlfeld, UMass, Amherst; 413-545-2681; ahlfeld@ecs.umass.edu
Dr. Brett Towler, USFWS, Hadley; 413-253-8727; towler@ecs.umass.edu