Session A1 - Large-Scale Migratory Fish Testing Facilities I

FISHPASS: Developing selective bi-directional fish passage in the Great Lakes

Dr. Daniel Zielinski

Dr. Zielinski is a computational engineer for the Great Lakes Fishery Commission (GLFC). He is a lead on GLFC selective bi-directional fish passage research and provides technical direction for development of the FishPass experimental fish passage facility. His research focuses exploiting computational resources and experimental technology to better understand how environmental stimuli influence physical and behavioral responses of fish.

In the Great Lakes, control of the invasive sea lamprey (Petromyzon marinus) depends on barriers that restrict access to spawning habitat. Those same structures block desirable species, impair ecological function, and change water quality. To address the inherent tension associated with barriers, the Great Lakes Fishery Commission is leading fisheries biologists and managers, engineers, and sea lamprey control agents in developing novel and effective tools to selectively pass desirable fishes while simultaneously blocking invasive species. An experimental facility will be constructed at the Boardman River’s Union Street Dam (Traverse City, MI) to engage in experiments that integrate a suite of technologies and techniques for bi-directional selective fish passage. At the proposed facility, tools developed during the past 50 years to manipulate sea lamprey behavior and remove them from systems will be integrated with fish passage solutions. Not only will the facility be designed to meet regulatory and research requirements, but the location of the facility near the city center will offer a unique opportunity for public outreach and education. This presentation will discuss the status of the development of the selective fish passage facility including conceptual designs, research agenda, and next steps. Project funding is provided by the Great Lakes Fishery Commission via the Great Lakes Restoration Initiative.
Session A1 - Large-Scale Migratory Fish Testing Facilities I

Opportunities and limitations: Lessons learned from 20 years of research at a large flume facility dedicated to fish passage research

Dr. Theodore Castro-Santos

Researcher at the Conte Lab for over 20 years. Focusing on locomotion and movement as well as development of appropriate standards for evaluating and monitoring fishway performance.

The S.O. Conte Anadromous Fish Research Center was commissioned in 1990 to allow for direct laboratory testing of fishways using unconfined, actively-migrating fish. Modeled after a similar facility built on the Columbia River in the 1950’s the hope was to achieve similar success in passing East Coast diadromous fish as had been achieved with Pacific salmonids. More than a dozen different fishway designs have been tested at this facility for both upstream and downstream passage. Although reductionist laboratory approaches offer opportunities for advancing understanding of basic biological principles that contribute to passage, studies are most effective when coupled with field testing of prototypes. We present an overview of several projects performed at the Conte Lab, highlighting successes, but also pointing out those studies that have produced less satisfactory results, and offer consideration for how these experiences might guide design concepts for future facilities.
A new laboratory flume facility to study migratory fishes of the Great Lakes Basin

Dr. Nicholas Johnson

I study fisheries with a focus on invasive species control and native species restoration in the Great Lakes through enhanced understanding of their sensory ecology and population demographics. I earned my B.S. degree from the University of Wisconsin – Stevens Point, and M.S. and Ph.D. degrees from Michigan State University. I became a research ecologist with USGS, Great Lakes Science Center, Hammond Bay Biological Station in 2009, serve in adjunct appointments at several universities in Michigan, and am an associate editor of the Journal of Great Lakes Research. My research is mostly in collaboration with the Great Lakes Fishery Commission where I am a member of the Sea Lamprey Trapping Task Force and Barrier Task Force.

In 1950, a decommissioned U.S. Coast Guard Station on the south shore of Lake Huron was converted to a research station to study invasive sea lamprey, a jawless fish native to the Atlantic Ocean that feeds on fluids of large fishes. The facility was responsible for discoveries that led to development of a successful control program for sea lamprey, namely the design of effective sea lamprey barriers and discovery of selective toxicants. However, the existing facility is too old to cost-effectively maintain and was not designed with an overall design concept that will facilitate future research. With funding from the U.S. Geological Survey and Great Lakes Fishery Commission, construction of a new laboratory and flume facility began during 2016 and will be complete in 2019. A 1-million gallon water storage tank will supply Lake Huron water to two 4-m wide, 13-m long, and 2-m deep indoor flumes that will be able to produce water velocities similar to Great Lakes tributaries. Each flume will be capable of being subdivided by insertion of aluminum panels. This presentation will summarize lessons learned from the original facility as well as design rationale and anticipated future of the new facility, including coordinated research with the Great Lakes Fishery Commission’s field scale fish passage experimental facility.
Session A1 - Large-Scale Migratory Fish Testing Facilities I

Using a temporary in-river experimental flume to study the influence of hydraulics on passage of Amazon migratory fishes

Mr. Raoni Rodrigues

I am PhD in Ecology, Conservation, and Wildlife Management from the Federal University of Minas Gerais, Belo Horizonte, Brazil. I’ve been working all my career in fish ecology and behavior. In the early years, I worked in natural history of Amazonian fish. More recently, I’ve been studying impact of hydropower plants, fish migration and fishways. I use, preferably, biotelemetry (radio, acoustics, and RFID system) methods. I’ve worked on several large Amazonian hydropower plants in Madeira, Teles Pires and Xingu rivers. Also, I’ve taught Zoology and Ecology classes for undergraduate and graduate.

The Santo Antônio Dam, Porto Velho, Brazil, blocked the migrations of many fish species important to fisheries in the Madeira River, a major multinational Amazon River tributary. During its construction, we designed a temporary concrete experimental flume (EF) in a rapid to study the influence of hydraulics on fish passage. The EF was 51 m long, 3.75 m wide, and 4.6–5.5 m high. The test area was 30 m long with a slope of 3%, and had side-baffles to dissipated flow energy. The discharge in the EF was determined by the water level of the Madeira River. Fish could voluntarily enter the lower reach of the flume through a 4x3 m lateral introduction tank. Fish movement was tracked using a RFID system and observed at critical locations with a DIDSON sonar. We analyzed fish passage of 20 species in response to baffle hydraulic head, mean depth, energy dissipation factor, and flow velocity for two openings (1.1 and 1.6 m) of the side-baffles during Feb-May 2011. Fish passed best (lower passage time, higher passage rate, and higher passage/attempt rate) in higher flow velocity and energy dissipation factor, more frequently associated with the 1.6 m opening. The positive aspects of the study were teamwork by engineers and biologists, proximity of the EF to the fish capture sites, ability to test structural configurations, and use of the RFID system to monitor fish movements. Also, we used the results to design the fishway at the dam. Aspects that need improvement are better DIDSON performance in highly turbid conditions, better location and design of the fish introduction tank, and better control of the discharge in the EF. Moreover, during the peak of the Madeira River water level, tests in the EF was not possible.
Session A2 - Large-Scale Migratory Fish Testing Facilities II

Fish guidance and passage across 52 data sets (17 years) from tidal rivers to large dams: findings from a method for confronting changes in fish response to unchanging hydraulics

Dr. R. Andrew Goodwin

Dr. Goodwin conducts research into the movement behavior of individual and groups of individual animals in aquatic, terrestrial, and avian environments.

Initial fish avoidance of an experimental weir in a flume followed by eventual passage is a simple illustration that fish, like most animals, are highly adaptive and often change their behavior/response to stimuli such as fixed hydraulics. While the role of ‘context’ in interpreting how/why an animal responds to stimuli is not new, still no method presently exists than can thoroughly describe the context of an animal’s decision for mathematical and statistical analysis. The immediate need for new ways of looking at fish behavior is evident from the intersection of several realities: (a) the continued difficulty of achieving robust, successful fish passage solutions, (b) water resources management that cannot wait for a full build-out of all the relevant behavioral mathematics that underlie the success of fish passage designs and (c) fish continue to dictate the success of engineered structures through their own, independent decision-making that humans do not mostly understand at field scales. I present findings and status of a method that tackles some of the ‘context’ effects of fish behavior relevant to guidance/passage. While imperfect, the method and lessons learned from applications across more than 50 data sets over 17 years highlights opportunities and limitations in (i) porting findings from the laboratory to the field, (ii) porting findings from one field site to another, and (iii) looking at behavior in different ways.
Session A2 - Large-Scale Migratory Fish Testing Facilities II

The value of ‘big data’: insights from two decades of Columbia River fish passage research

Mr. Matthew Keefer

Keefer has 20 years of experience in aquatic and fisheries science and is an expert in salmon, steelhead, and Pacific lamprey behavior and ecology. Keefer has been one of the lead research scientists and analysts at the University of Idaho Fish Ecology Research Laboratory (FERL) for ~15 years, and has focused on data management, data analyses, and presenting and publishing research results. The focus at FERL is on anadromous fish monitoring using biotelemetry techniques (radio, acoustic, and PIT-based) and optical and acoustic (DIDSON) video monitoring.

The recent fish passage literature has included a healthy and productive debate about how to best assess the effectiveness of fishways and other passage structures. An oft-cited ‘gold standard’ in this debate is dam passage by adult Pacific salmonids (Oncorhynchus spp) in the Pacific Northwest. While dam and fishway passage efficiency estimates for adult salmonids are often high relative to other species, we think the ‘gold standard’ language mischaracterizes the complex passage challenges these species face. Furthermore, among-species and among-location efficiency comparisons can be misleading for a variety of biologically-based reasons (e.g., philopatric versus non-philopatric breeders). In an effort to better summarize adult salmonid behaviors at dams and fishways, we evaluated passage metrics from a very large radiotelemetry dataset collected in the Columbia River basin. Studies conducted from 1996-2014 included ~27,500 upriver-migrating spring-, summer- and fall-run Chinook salmon (O. tshawytscha), sockeye salmon (O. nerka), and steelhead (O. mykiss); these radio-tagged fish were monitored as they passed eight large hydroelectric dams in the Columbia and Snake rivers. Our presentation will include summaries of traditional fishway attraction, passage efficiency, passage attempts, passage time, and passage effectiveness metrics. Lastly, we will address passage efficiency and effectiveness in a broader biological context by linking fish passage behaviors – including failure to pass – to migration outcomes. We think that the integration of spatially-intensive monitoring with quantitative analytical techniques has substantively advanced our understanding of the complex relationships fish behaviors, environmental variation, and the structural and operational elements of fishways. We further suggest that future evaluations strive to assess both local effects (e.g., passage behavior) and post-passage delayed effects (e.g., fitness-based metrics). The general research framework and analytical tools we have used in the Columbia River basin can be applied to a wide range of fish passage assessments, including for species with different life history strategies.
Evaluation of fishway design for German Federal Waterways by means of fish studies

Mr. Gerrit Fiedler

B. Sc. in Maritime Technology 2011 M. Sc. in Environmental Engineering 2015 since 2015 Research Engineer at Federal Waterways Engineering and Research Institute, Germany; Focus on Ecological Connectivity for Fish

Scientific knowledge does not cover all aspects of fishway design on German Federal Waterways. Therefore, the German Federal Institute of Hydrology (BfG) and the German Federal Waterways Engineering and Research Institute (BAW) together with the German Federal Waterways and Shipping Administration (WSV) address research questions in an R&D program. The R&D schedule includes the investigation of auxiliary discharge, entrance location and other aspects of fishway design. Fish experiments under defined hydraulic conditions are pivotal for the success of the program. To investigate the impact of different flow scenarios (e.g. flow near screens; recirculation areas; near field attraction flow) on autochthonous species, BfG and BAW set up a large recirculating flume. Where fishways compete with hydro-power in terms of attraction flow and discharge, research questions can only be addressed adequately by in situ evaluation of hydraulic parameters and fish movement. Therefore, six fishway pilot sites with extensive research infrastructure are planned at barrages with hydro-power on major German Federal Waterways. Challenges arise out of the fact that main hydraulic parameters in the experiments, such as discharge and flow velocities, are not independent from each other. Furthermore, a change of any of these parameters is often associated with a change of the geometric boundary conditions, such as flow width and depth. This may hamper the unambiguity of the results with respect to the target parameter. Furthermore, the investigation of a large range of discharge scenarios at pilot sites requires large constructions. These may be suitable for large discharges but critical for small ones which can also bias the results. The joint presentation of BfG and BAW consists of two parts (also Wey & Henning). This part gives an overview on current research and focusses on the above challenges in the planning and operation of the experiments.
Session A2 - Large-Scale Migratory Fish Testing Facilities II

Gathering reliable fish data in large scale research facilities on German Federal Waterways

Dr. Jennifer Wey

2001-2007 Study of biology (with a focus on general limnology) at the University of Cologne/Germany 2007-2011
Dissertation about benthic microbial food webs at the University of Cologne/Germany 2011-2013 Research associate at the River Ecology department of the Helmholtz Centre for Environmental research in Magdeburg/Germany Since 2013 Research consultant at the German Federal Institute of Hydrology (BfG) in Koblenz as part of the project group "River Continuity" within the Department of Fauna and Ecology. A key aspect of my work there is to give scientific advice to the German Federal Waterways and Shipping Administration (WSV) concerning the planning of fishways and migratory fish research facilities.

Six fishway pilot sites with considerable research infrastructure are planned by the German Federal Waterways and Shipping Administration (WSV) at barrages with hydro-power on major German Federal Waterways. An extensive R&D program at these facilities will be conducted by the German Federal Institute of Hydrology (BfG) and the German Federal Waterways Engineering and Research Institute (BAW). The primary goal is to develop general fishway design recommendations. The first of the two presentations of BfG and BAW (Fiedler & Wey) focuses on challenges in the planning and operation of experiments. In this second presentation we focus on major challenges associated with gathering statistically reliable and meaningful fish data. When investigating the effect of different treatments (e.g., auxiliary discharge or entrance location), fish counts are routinely used as the main explanatory variable. But in natural situations the high background variability of fish numbers in the river might generate results difficult to interpret or even insignificant. Most scientists investigating fish in natural situations will face comparable problems. Here, we present our solution to this challenge, which is based on carefully chosen treatment intervals. In addition, we will discuss the influence of facility design on the use of different fish detection methods. Depending on e.g. spatial or operational constraints, the method of choice might not be compatible with the facility. To minimize the risk of producing insignificant data by using inadequate fish detection methods or positioning them incorrectly within the fishway, this topic needs to be addressed early in the planning process of new fish testing facilities. With regard to the primary goal of the R&D program of BfG and BAW, we will also present some thoughts about the transferability of results from specially designed pilot sites to real-life fishways.
Large-scale flume evaluations of downstream fish passage and water intake protection technologies have been conducted at Alden for more than 40 years. Initial studies were conducted with various screening technologies for cooling water intakes to meet requirements of the Clean Water Act, which was passed by Congress in 1972. Research expanded in the 1980’s to include downstream passage technologies designed for application at hydropower facilities. The focus of these studies was on the development of effective designs based on observations and data describing hydraulic and biological performance. Alden’s test facilities include two recirculating flumes, one that is 20 ft wide by 10 ft deep with a maximum flow rate of 500 cfs and the other 6 ft wide by 6 ft deep with a maximum flow of 100 cfs. Both facilities have test areas that are greater than 80 ft in length. Downstream fish passage studies conducted at Alden have included evaluations of bar racks and louvers, barrier nets, several behavioral deterrents, and high-velocity inclined screens. Studies have also been conducted to evaluate fish exposure to hydrokinetic turbines (avoidance and survival) and biological effectiveness of various traveling and fixed screening systems designed for protecting fish at cooling water intakes. Study results typically include behavioral response and effectiveness data that are collected using conventional video techniques, DIDSON acoustic cameras, fish tracking methods (PIT tagging, 3D acoustic telemetry, light tags), real-time observations, and fish recovery locations (e.g., entrainment versus bypass collection). When laboratory results have led to design criteria recommendations for a specific site or indicate a technology has potential for effective operation in real world situations, pilot or full-scale field testing is often the next step in the development process. The primary goal of field studies is to validate or verify laboratory data and/or make further design refinements to allow for broader application of a technology or for a permanent installation at a specific site. In general, field evaluations of various technologies evaluated in Alden’s flumes have produced performance data consistent with laboratory results. Several case studies will be presented comparing the results of laboratory flume tests to follow-up field evaluations with pilot or full-scale facilities.
Session A3 - Large-Scale Migratory Fish Testing Facilities III

Actual Fish Migration projects Rhine Delta: Fish Migration River, Haringvliet & Markerwadden.

Mr. Erik Bruins Slot

Erik Bruins Slot is an Eco- and Civil Engineer in big scale wet-nature projects with focus on innovative Dutch Delta management. He worked for Dutch contractors and Government for almost 30 years now on a large number of wetlands projects. Making plans, design and construction and is one of the project leaders of the Fish Migration River in the Netherlands during realisation.

In the Netherlands natural delta’s are severely managed. Streams were canalized, rivers were adapted for navigation, and estuaries were blocked for flood protection. In the past decades many restoration measures were taken. At this moment we are at the brink of the implementation of the three largest restoration measures in Western Europe: Fish Migration River (FMR) The Afsluitdijk Dam that separates the Wadden Sea from Lake IJsselmeer is a large fish migration barrier in the Dutch Delta. To restore the connectivity and allow fish to pass there is an initiative to build the largest fishway in the world, the FMR. It will reopen one of the largest entries for fish of the entire Rhine basin. Reopening Haringvliet In 2018 the Dutch National Water authority plans to allow tidal influence on the waterbody Haringvliet. This former sea arm was cut off from the sea in 1970 with a 5 kilometre long dike. As a result the estuarine environment and fish migration opportunities will be restored. This will reopen hundreds of kilometres of river Rhine branches for migratory species like the Atlantic salmon and sturgeon. Markerwadden Lake Marken is a large fresh water lake and part of the former Zuiderzee estuary. The current ecological status is poor. Now 8km2 of islands and wetlands are built to form one of the largest wetlands in western Europe. This will boost habitat and feeding opportunities for migratory fish species. The presentation includes an overview of the described measure and the interconnection between the three. The FMR and Haringvliet will restore fish migration opportunities at the ‘front door’ of the entire river Rhine while the Markerwadden delivers 8km2 of habitat for migratory species. The cumulative value of the measures offers a huge potential for the restoration of populations of migratory species in the river Rhine.
Session A3 - Large-Scale Migratory Fish Testing Facilities III

Towards a conceptual framework to study tidal migration of diadromous fish

Dr. Ir. Catharina J.M. Philippart

Dr Ir C.J.M. (Katja) Philippart is an estuarine ecologist at the research department of Coastal Systems of the Royal Netherlands Institute for Sea Research (NIOZ), a board member of the Wadden Academy (responsible for the portfolio Ecology) and an Associate Professor on Estuarine Ecology at the department of Physical Geography at the University of Utrecht. Within NIOZ, she is a chief scientist of the Wadden Systems Research Centre (www.nioz.nl/waddenresearch). She studies the trophic interactions between the main primary producers (phytoplankton and microphytobenthos) and primary consumers (bivalves) of shallow temperate coastal waters. More recently, she started to work on migratory fish in coastal marine waters. While the Wadden Sea is her primary study area, research has included studies within the North Sea, Venice Lagoon, Banc d’Arguin, Patagonian Shelf and Barr al Hikman. In addition, her interest in gathering and communicating scientific knowledge on seas and oceans for the understanding and sustainability of our planet is reflected in the coordination of national and international projects with regard to monitoring and outreach of marine sciences such as IN PLACE, WaLTER (www.walterproject.nl) and CLAMER (www.clamer.eu).

Whereas river systems with fish-ways are increasingly well studied, behaviour of migratory fish at tidal gradients and barriers is still poorly understood. As the result of much larger variation and diversity in environmental conditions in relation to behavioural cues, the factors determining attraction and passage efficiency of fish-ways at tidal barriers are different and more complex than at river barriers: river systems have a unidirectional freshwater flow, while tidal barriers are characterized by changing currents and fluctuating salinity gradients due to tidal and discharge regimes. Within the planned Fish Migration River (FMR) in The Netherlands, a Migratory Fish Testing Facility (MFTF) enables studying the role of behaviour on net rate of tidal-driven transport and migration. The design of the MFTF will be based on a conceptual framework, depicting the interplay among (i) local environmental conditions, (ii) individual perception and cognition of these conditions, (iii) individual capacities (e.g. with regard to motion and navigation) and (iv) individual state (e.g., morphology, developmental stage, condition). We will present a generic conceptual framework that addresses all these aspects and that will form the base of our specific experiments on movement ecology of migratory fish in tidal environments in the MFTF. Amongst others, this conceptual framework will aid in the design and management of the Fish Migration River to optimize fish migration success within tidal gradients.
Session A3 - Large-Scale Migratory Fish Testing Facilities III

Fish Migration River: no innovative solution flourishes without public support

Mr. Kees Terwisscha van Scheltinga

Kees Terwisscha of Scheltinga (53) is working as project coordinator on behalf of the initiators of the fish migration river. He has three core tasks: the realization of the fish migration river, a visitor center and a program for recreation and tourism. Mean goal is: connecting people to their landscape.

The Fish Migration River is not an isolated example of an innovative solution. The river is part of a larger movement that draws attention to biodiversity and more specific to migrating fish and clean and healthy rivers, delta’s and oceans. This movement is not easy to channel. It is a broad movement, covering all sorts of backgrounds and classes: school children, concerned citizens, policy makers, fisher man (both professional and recreational) and conservation organizations. Sense of Place Creating awareness and public support, and stimulating real commitment on all levels is essential if one wants to realize a recovery plan like the Fish Migration River. Without social consensus, such a project is pretty much impossible. The relation with society gives the investment both cultural and social economical value and ensures meaningfulness of the location and the solution itself. This is known as Sense of Place. Binding programme A well-known programme is the World Fish Migration Day, with activities at over 600 locations and an effective media campaign that reaches over 70 million people worldwide. In this presentation we want to share how we connect the importance of the Happy Fish, including the Fish Migration River, with society. In our region, in our Country and in Europe. We find ways to relate to people, through experience, education, scientific research, recreation and ecotourism and we keep searching for new keys to open their hearts. We therefore aim at a broad programme: a ‘Wadden Visitor Center’, a shared story about fish migration with other locations like Haringvliet, Marker Wadden and the Rhine, a citizen-science program together with the test facility, universities and knowledge institutions, a campaign with the Dutch Tourism Agency aimed at foreign visitors, an educational, etc. A broad programme to guarantee participation, valorisation and spreading of knowledge and innovation, but above all to – with inspiring examples - show everybody how we want to relate to our environment in the 21st century. This abstract is subsequent to the presentations of mr. Erik Bruins-Slot (abstract title: Actual Fish Migration projects Rhine Delta: Fish Migration River, Haringvliet & Marker Wadden) and mrs. Katja Phillipart (abstract title: Fish Migration River – research facility).
Session A4 - Downstream Passage I

Lake Cushman Floating Surface Collector Downstream Migrant Smolt Evaluation

Mr. Chris Noyes

Chris Noyes is a Fish Biologist for Tacoma Power, focusing on fish passage and water quality concerns at hydroelectric projects and related facilities on the Cowlitz, Nisqually, North Fork Skokomish, and Wynoochee rivers. His background includes studying salmonid, Pacific lamprey, and American shad dam passage behavior on the Columbia and Snake rivers.

Tacoma Power owns and operates the Cushman Hydroelectric Project, which consists of two dams and impoundments on the North Fork Skokomish River near Hoodsport, Washington. A floating surface collector (FSC), with associated holding, sorting, and transportation mechanisms, was installed in 2015 to enable downstream passage of juvenile salmonids. Acoustic telemetry techniques were used with coho salmon smolts to evaluate two performance metrics in 2015 and 2016. System survival (SS) essentially represents the joint probability of migration, survival, and collection from the top of the reservoir to the downstream sorting facility, whereas fish collection efficiency (FCE) is a metric aimed at evaluating the efficacy of the FSC. Both passage metrics were similar in 2015 and 2016 and below passage objectives for the Project, albeit within the range of values observed at other modified and natural systems in the Pacific Northwest. In addition to biological, environmental, and hydraulic factors that are influencing downstream passage metrics, extensive wandering behavior, residualism, and overwintering have also confounded interpretation of study results. We present results from the 2015 and 2016 study years, as well as 2017 to date.
Session A4 - Downstream Passage I

Effects of attraction flow on downstream passage rates of PIT-tagged juvenile Chinook and steelhead at Round Butte Dam, Madras, Oregon

Mr. Brian Pyper

Brian Pyper is a statistical consultant with 20+ years of academic and professional experience applying quantitative methods to fisheries and environmental data.

Construction of the Pelton Round Butte Hydroelectric Project in the 1960s included a fish passage system. However, bottom withdrawal created confusing reservoir currents in Lake Billy Chinook, contributing to low numbers of smolts attracted to the forebay and fish collector. To improve attraction currents and management of downstream water temperatures, complementary selective water withdrawal (SWW) and fish collection facilities were constructed in the Round Butte forebay, which became operational in December 2009. However, subsequent evaluations of SWW passage rates of Chinook (Oncorhynchus tshawytscha) and steelhead (O. mykiss) smolts were lower than expected. In addition, two years of acoustic telemetry studies failed to elucidate relationships between passage rates and flow through the SWW, in part because of low sample sizes and highly variable hourly and daily attraction flows. In this study, we used generalized linear models (GLMs) and mixed-effects models (GLMMs) to estimate relationships between SWW surface flows and passage rates of run-of-the-river smolts that had been previously tagged with Passive Integrated Transponder (PIT) tags and released upstream in the Metolius, Crooked, and Deschutes rivers. The data spanned five years (2010-2014) and included over 2500 Chinook smolt detections and over 600 steelhead detections at the SWW. The timing of passage and associated SWW flow were matched to the nearest minute. Across years, we estimated strong linear, or slightly exponential, effects of flow on passage rates of both Chinook and steelhead smolts. In addition, accounting for flow relationships often strongly influenced and improved estimates of mean diel patterns (hourly passage rates). Results of mixed-effects models indicated that flow-passage relationships and diel patterns were quite consistent across years for a given species. Collectively, the analyses provide precise estimates of mean flow-passage relationships and diel patterns that should provide a strong basis for evaluating effects of alternative operational scenarios on smolt passage rates.
Session A4 - Downstream Passage I

*A Study of Fish Injury and Survival at the High Head Bypass at Green Peter Dam, Oregon*

Mr. Fenton Khan

Fenton Khan is a Fish Biologist for the U.S. Army Corps of Engineers (USACE), Portland District – Environmental Resources Branch. Mr. Khan has a B.S. degree in Environmental Science from New Mexico Highlands University and a M.S. degree in Environmental Science from Washington State University. He has been leading and conducting fish passage research at multi-purpose dams and fish barriers for over 15 years. Mr. Khan is currently managing several fish passage studies at USACE multi-purpose dams and serving at the lead Fish Biologist on several Product Delivery Teams in the Portland District. Prior to working for the USACE, Mr. Khan was employed at the Department of Energy - Pacific Northwest National Laboratory as a Senior Research Scientist, conducting fish passage research for the USACE at multi-purpose dams on the Columbia and Willamette River Basins.

High-head dams (>100 m) present immense challenges for fishery managers, engineering design teams, and stakeholders considering alternatives for downstream fish passage. Downstream migrant fishes can pass high-head dams volitionally by way of turbines, spillways, or bypasses. Some high-head dams have surface collectors as a means of capturing fish for transport around the dams. The Corps conducted a fish injury and survival study at the decommissioned juvenile fish bypass system at Green Peter Dam on the Santiam River, Oregon in early summer 2016. The study was performed to inform design considerations for engineered systems to pass downstream migrating fish at high-head dams. The decommissioned bypass served as a prototype scale research platform. The study assessed injury and survival of juvenile Chinook salmon and steelhead that passed through the bypass system. Fish were released through two pressurized, or partially pressurized pipes, under approximately 80 feet of hydraulic head. Flow through each pipe was controlled by a flow control gate valve. The study was conducted under four flow treatments; full flow, 75% open, 50% open, and 40% open. Ancillary data on hydraulic conditions (pressures, accelerations, rotational velocities) were collected using autonomous sensor devices. Sub-samples of post-passage fish were radio tagged and released into the river to evaluate delayed mortality and survival. Results indicate that the configuration of the bypass pipes, under 80 feet of hydraulic head, with flow control valves open ≥50%, should safely pass ≥96% of juvenile fish. Radio telemetry data show 66% of Chinook salmon and 2% of steelhead were detected 10 river kilometers below Green Peter Dam three or more days post-release. These data indicate that it may be possible to pass downstream migrant fishes at high-head dams using conveyance pipes, although further research is needed.
Session A4 - Downstream Passage I

*Juvenile lake sturgeon downstream passage behavior and survival at two hydroelectric dams*

Mr. Jonathan Hegna

I am currently a PhD Student at Michigan State University. I started my program at Michigan State University in 2014, and I have been working to evaluate aspects of juvenile lake sturgeon passage and survival at two hydroelectric dams in Northern Michigan over the past couple years. I have a keen interest in spatial ecology, fish behavior, and survival analysis, as it relates to passage projects. I also have a long standing interest in assessing fish habitat characteristics and benefits. For instance, I have been involved with assessing the utility of beaver reintroduction programs for enhancing stream habitat for salmonids in the past.

Reconnecting lake sturgeon (*Acipenser fulvescens*) populations and rivers through the design and use of passage systems at hydroelectric dams is seen as a vital step toward recovery of the species. However, downstream passage behavior and survival of juvenile lake sturgeon at hydroelectric dams is poorly understood. We used stream-wide RFID antennas and the juvenile salmonid acoustic telemetry system to monitor passage behavior and route-specific survival through two hydroelectric dams on the Black River, Michigan over three years. A total of 62 age-2, 114 age-1, and 792 age-0 lake sturgeon were stocked above Tower Dam, while a total of 60 age-2, 118 age-1, and 817 age-0 lake sturgeon were stocked above Kleber Dam. A total of 25 age-2, 45 age-1, and 198 age-0 lake sturgeon were stocked below both dams to serve as control groups. We will discuss the preliminary results of this ongoing project, including route specific survival estimates for spillways, Kaplan turbines, and type-z vertical shaft turbines. We will also discuss fish screen mortality rates, forebay residency time, reservoir residency time, river residency time, and spatial movement characteristics. The results of this research will be of interest to hydroelectric companies an regulatory and natural resource agencies.
Session A5 - Downstream Passage II

Monitoring the collateral effects of a deep reservoir drawdown for downstream fish passage, Fall Creek Lake, Oregon, U.S.A.

Liam Schenk

Liam Schenk is a hydrologist with the US Geological Survey in Klamath Falls, Oregon. Originally from Colorado, he earned a bachelor’s degree in Mining Engineering from the Colorado School of Mines. After a fun but short career blasting rocks in the tunnel construction industry, he began working on a Master’s degree in Geology at the University of Arkansas. There, he worked as a USGS student hydrologic technician measuring streamflow and working on an aquifer recharge modeling project while concurrently completing his degree, which focused on mercury contamination in Arkansas surface waters. Upon completion of his master’s degree, he then took a position with the USGS in Klamath Falls, Oregon as a hydrologist, initially spending much of his time in the field collecting water quality data on Upper Klamath Lake. He eventually began managing projects for various water quality and sediment transport projects in the Klamath, Coast Fork, and upper Willamette Basins in Oregon. Liam’s work includes using multivariate and surrogate regression models to estimate constituent concentrations and loads, water quality monitoring, and occasional mercury projects. When not obsessively tracking storm events to plan for sampling, Liam is an Oregon cliché: a musician, steelhead-obsessed fly fisherman, skier and mountain biker.

The USGS, in cooperation with the Army Corps of Engineers, has conducted dissolved oxygen and suspended sediment monitoring downstream of Fall Creek Lake for the last 5 years during operational drawdowns that are intended to safely pass endangered juvenile salmonids through the dam regulating outlets. The drawdown operations involve lowering the lake elevation to streambed, resulting in a run-of-river scenario through the dam that transports large quantities of sediment downstream. These sediments are ultimately deposited in off-channel habitats or transported through the system at high streamflows. Approximately 50,000 tons of sediment were transported from the lake during the drawdown over the course of 5 days in December 2012, the first year of monitoring. Sediment loads from 2013 – 2016 were variable, but much lower than the first year of monitoring. Dissolved oxygen data from the November 2015 drawdown showed an observed minimum value of approximately 0.7 milligrams per liter, concurrent with a maximum turbidity value that exceeded the limits of the sensor. This low dissolved oxygen event was short in duration, suggesting a rapid chemical oxygen demand expressed at the monitoring site approximately 1 mile below the dam. In a Lagrangian frame of reference, however, the low concentrations at the sensor represented hypoxic conditions in a parcel of water that could potentially persist downstream of the monitoring site. The quantity of suspended sediment transported downstream during the drawdowns appears to be controlled by a number of factors, including hydrologic regime during drawdowns, meteorological conditions, and sediment supply from the reservoir. Identifying trends in suspended sediment transport and dissolved oxygen during these operations provides important information for reservoir managers as these operations continue, and can help inform similar operational changes being considered at other project sites.
Use of deep drawdowns for downstream juvenile Chinook Salmon passage at Fall Creek Reservoir, Willamette Basin, Oregon

Mr. Greg Taylor

Greg Taylor has been employed as a fisheries biologist in the Willamette Basin for 18 years. He worked for the Oregon Department of Fish and Wildlife for 3 years conducting investigations on bull trout in the McKenzie and Middle Fork Willamette Basins. For the last 15 years Greg has been employed by the U.S. Army Corps of Engineers as a Supervisory Fisheries Biologist for the Willamette and Rogue Projects. He is responsible for operation and maintenance of fish facilities, serves as a technical advisor on fisheries issues, and implementation of the Willamette Project Biological Opinion.

The U. S. Army Corps of Engineers (USACE) completed construction of Fall Creek Dam in the fall of 1965. The Dam included upstream and downstream fish passage facilities. An evaluation of the fish passage facilities conducted by the Fish Commission of Oregon (1966-70) determined the emigrant passage facilities were ineffective, but noted large numbers of juvenile salmonids migrated from the reservoir using the regulating outlet (Smith and Korn 1970). From 1968-77 the reservoir elevation was lowered to streambed to facilitate fish passage and survival. This resulted in annual returns of spring Chinook from 1,000 - 4,500 fish. Changes in reservoir evacuation schedule beginning in 1977 are implicated with the smolt mortality and adult return problems observed at Fall Creek since 1980 (Downey 1992). Downey (1992) showed a 30% improvement in survival for juvenile outmigrants under low flow and low head conditions. In 2007, the USACE lowered Fall Creek Reservoir from elevation 728 ft. (minimum conservation pool) to elevation 714 ft. to complete required maintenance on the intake structure. This operation was repeated in 2008-09. In 2010, the reservoir was lowered to 690 ft. to improve passage survival for outmigrating fish. In 2011-16, the USACE lowered Fall Creek Reservoir to elevation 680 ft. which resulted in a complete drawdown to streambed. This presentation summarizes data collected on adult returns and juvenile downstream passage associated with reservoir operation and drawdown.
Session A5 - Downstream Passage II

Examining responses of reservoir conditions and food webs following deep drawdowns for downstream Chinook Salmon passage at Fall Creek Reservoir, Willamette Basin, Oregon

Christina Murphy

Christina Murphy is currently a PhD candidate in Oregon State University’s Fisheries and Wildlife Program. She was a fisheries student with the US Army Corps of Engineers as a high school and early college student before researching abroad. She completed her Masters in Spain, where she focused on identifying the effects of hydrological alterations on fishes. Her PhD studies were inspired by management changes implemented to improve downstream passage through dams. In her research on Pacific Northwest reservoirs and changes in timing and magnitude of drawdown, she is evaluating physical and chemical conditions, phytoplankton, zooplankton, benthic insects, a diverse fish assemblage, and habitat availability in order to inform dam and reservoir management decisions.

To improve downstream passage of juvenile Chinook Salmon through dams, USACE has begun to implement operational measures including modified drawdowns of reservoirs for short periods during late fall/early winter. We began examining the physical, chemical and biological responses to repeated, streambed drawdown of Fall Creek Reservoir in 2013. We also are studying similar limnological and food web parameters in two additional reference reservoirs (without the streambed drawdown). We hypothesized that the modified drawdown would lead to export of sediment, nutrients and taxa downstream (i.e., native and introduced fishes) that could trigger potential cascading effects on the reservoir’s food web and productivity the following seasons, including effects on rearing juvenile Chinook Salmon during the summer months. During the summers following streambed drawdown, we found differences in light among reservoirs, consistent with sediment resuspension. Though nutrient exports increased during the streambed drawdown, we did not observe significant differences to subsequent in-reservoir nutrient availability. We also did not observe major changes to primary productivity. However, carbon and nitrogen stable isotope ratios indicated that traditionally piscivorous Largemouth Bass and Rainbow Trout were surprisingly feeding as zooplanktivores in Fall Creek Reservoir. This could have potential implications for availability of zooplankton prey at key periods for Chinook Salmon growth in the reservoirs. We also note shifting fish community composition in Fall Creek Reservoir following repeated deep drawdowns. As operational measures to improve downstream passage through dams are implemented, it will be important to consider lasting effects on in-reservoir conditions.
Session A5 - Downstream Passage II

Floating Trash Boom Design for the Cowlitz Falls Dam Fish Collector

Mr. Troy Lyons

Troy Lyons has expertise in design of hydraulic structures, physical modeling, river hydraulics, and computational hydraulics. He holds a B.S. and M.S. degree in Civil and Environmental Engineering from the University of Iowa. He has spent his career at IIHR focused on applied research of hydraulic structures using both physical and numerical modeling techniques. For the last six years, he has been the Director of Engineering Services at IIHR – Hydroscience & Engineering, one of the nation’s premier and oldest fluids-related research and engineering laboratories. Mr. Lyons’s work appears in journals such as the Journal of Hydraulic Engineering and the Journal of Hydraulic Research. He is a registered Professional Engineer in the State of Iowa.

Cowlitz Falls Dam is a hydroelectric dam on the Cowlitz River in Washington State, USA operated by Lewis County Public Utility District. As part of regulatory requirements associated with its FERC (Federal Energy Regulatory Commission) license at downstream projects, Tacoma Power was required to improve upon the fish passage survival rate for downstream migrating juvenile salmonids on the river system. Ultimately, they elected to build a shore-based fish collector at the dam that was constructed in 2016 and is scheduled to be operational for the 2017 fish passage season. The Cowlitz River carries a significant debris load and experiences significant water level fluctuations, creating several challenges for operation of the fish collector. One of the key components of the project was the design and evaluation of a floating trash boom located upstream of the forebay to collect and divert river debris such that it could be collected before reaching the fish collector. The trash boom spans the width of the river and consists of a series of 4 foot deep by 20-foot long floating panels with pinned connections, secured with cables to anchor blocks on each shoreline, to create a near-parabolic shape. Two methods were used to estimate the potential loading on the debris boom. The first was the method published by the USACE in 1996 (Design of Ice Booms, CRTD No. 9601) and the second was by modelling the trash boom and a portion of the river with a three-dimensional hydrodynamic numerical model using ANSYS Fluent. Both methods incorporated loads on the trash boom due to drag from the current, impact and drag forces of debris/ice, and gravity forces. Several scenarios were evaluated for various river flow rates and debris conditions. In addition, the same methods were applied to estimate hydrodynamic loads on a behavioural guidance structure (BGS) used to guide fish to the fish collector entrance. This presentation describes and compares each method, the results, and their suitability to this design and others.
Session A6 - Hydro Power & Conservation: The Icelandic Master Plan

*Hydro power plants in Iceland and their impact on freshwater fishes*

Ingi Rúnar Jónsson

Ingi Rúnar is senior fish biologist at the Icelandic Marine and Freshwater Research Institute. He has been working at the institute since 1994. His main research has been on salmonids (Atlantic salmon, Arctic charr and brown trout), including assessment on stock size, exploitation, ecology, migration pattern and life-history.

Icelandic rivers have been classified into the following categories: glacier-fed rivers, direct run-off rivers and spring fed rivers. These river types have very different characters i.e. temperature, flow regime and turbidity. Most of the rivers, having the largest volumetric flow rate, are totally or partly of glacial origin. The natural flow regime of a glacial river is highly variable, both annually and diurnally, usually being turbid during the summer months. Some of the largest hydro power plants in Iceland are utilizing water from glacier-fed rivers. In Iceland there are five species of freshwater fish. The three salmonid species Atlantic salmon (Salmo salar), Arctic charr (Salvelinus alpinus) and brown trout (Salmo trutta), along with threespine stickleback (Gasterosteus aculeatus) and European eel (Anguilla anguilla). The salmon is anadromous, but both resident and anadromous forms of the charr and the trout exists. Hydro power plants and their reservoirs alter the flow regime at downstream reaches and in some cases the glacial water characteristics are also partly or completely removed. This decreases the turbidity of the downstream sections, which can affect fish stocks, production, migration and exploitation. In some cases the dams close the fish migration routes; for example in river Blanda in Northwest Iceland where the migration route for anadromous fish to the highlands has been closed off. There are also examples of increased turbidity of lakes and rivers, when water with higher turbidity is diverted to them. The power plants and their reservoirs usually cause a change in the river turbidity, having effects on primary production and the ecology of fish stocks. In the talk we will discuss the impact of hydro power plants on fish stock in Icelandic rivers, focusing mainly on glacial river systems.
Session A6 - Hydro Power & Conservation: The Icelandic Master Plan

*Integrated biological, geological and cultural diversity of river basins with hydroelectric potential*

Dr. Thorleifur Eiríksson

Biologist from University of Iceland with emphasis on ecology, Ph.D. from Stockholm University in behavioral ecology. Specialist at Hólar University College, scientist and director of Westfjords Natural History Institute supervising several environmental projects, Specialist at Icelandic Museum of Natural History working on the Icelandic Master Plan for Nature Protection and Energy Utilization and scientist and project manager at RORUM environmental research and consultation

A method to estimate the integrated natural value of river basins, based on the evaluations of geological, biological and cultural diversity of the environment, will be presented. The method can also be used to evaluate the expected impact of hydroelectric exploitation of the same river basin and thus estimate the expected loss of natural value caused by harnessing. The majority of Icelandic hydropower potential lies within glacial rivers. Geomorphological division of the river courses into alternating segments of erosion and deposition was used as a basis to categorize the river basin to evaluate its integrated diversity based on geological, biological and archeological analysis. This division proofed to correspond well with distinct ecological systems along the river course as well as the river banks and adjacent areas, and is thus well suited for the evaluation of diversity relative to a particular area. Thus, this approach appears to harmonize quite well with natural habitats within the river and in the adjacent areas, and it fits particularly well to the low species diversity of freshwater fish in Iceland. We will show results combined according to predesigned formulas to give an assessed natural value for each river course as well as the estimated loss by harnessing.
Session A6 - Hydro Power & Conservation: The Icelandic Master Plan

The use of aquatic organisms in ecosystem evaluation and how they are affected by potential hydro power development

Prof. Gísli Már Gíslason

Born in Reykjavik, Iceland 18 February 1950, educated at the University of Iceland, Department of Biology, BS degree 1973, Diploma in Biology 1974 and the University of Newcastle upon Tyne, England, Department of Zoology, Ph.D. February 1978. I have been a teacher at the University of Iceland from 1977, first as a lecturer, then senior lecturer and from 1988 a full professor of limnology. I served as a head of the Biology Department 1980-1983, and Vice-Dean and later the Dean of the Faculty of Science of the University of Iceland 1999-2001. During this time I have served on serval committees and boards, including on the board of Nordic Society Oikos (chairman several times) and the Oikos Editorial Office (chairman for many years). I was a Councillor in the Government’s Nature Conservation Council 1987-2000, on the Icelandic delegations to the Ramsar Convention and the International Whaling Commission. During the past 18 years I have been an expert in the Nature evaluation working group in the 1st, 2nd and 3rd phases of Master Plan for Nature Protection and Energy Utilization.

In the Icelandic Master Plan developed for evaluation of the impact of hydro power and geothermal utilization aquatic organisms played a major role, with other physical and ecological parameters of the water catchment area (i.e. geology, groundwater systems, vegetation, birds and anthropogenic remains). With hydroelectric development, whole river catchments are changed, reservoirs constructed, hydrological continuity disrupted, and often valuable land for other land uses is inundated and river discharge regimes are altered. In most cases, this affects fisheries, farming, recreational uses and nature conservation value. In this study we will give examples on how aquatic organisms, especially invertebrates and fish were examined in the Master Plan. The evaluation took into consideration their inter- and intraspecific diversity, density and uniqueness, i.e. occurrence of rare species or populations. For the final evaluations, these variables were used in ranking the areas for nature conservation values.
Session A6 - Hydro Power & Conservation: The Icelandic Master Plan

The concept of the Icelandic Master Plan for Nature Protection and Energy Utilization and an integrated process based ecosystem approach to evaluating river basins

Dr. Skúli Skúlason

Skúli is a professor of ecology and evolution and his research has been primarily concerned with the ecology and evolution of diversity of freshwater fishes, primarily Arctic char and threespine stickleback. He has also participated in work regarding management and conservation of marine and freshwater fishes, e.g. in 2014-2017 as a leader of an expert group for the evaluation of natural and cultural monuments for the Icelandic Master Plan for Nature Protection and Energy Utilization.

The Ministry for the Environment and Natural Resources in Iceland has been responsible for the creation of a Master Plan for Nature Protection and Energy Utilization since 1999, and a legislation in this regard was passed by the Icelandic Parliament (Althingi) in 2013. The Master Plan is based on a multi-criteria evaluation of the diverse values involved and the likely impact of proposed power plant developments in the highly diverse river and geothermal systems on the island. For proposed hydro power plant projects whole river basins are evaluated. For natural (i.e. geological and hydrological systems, landscapes and wilderness, ecosystems, plant and animal species and populations) and cultural values (i.e. archeological remains), estimations of diversity, rarity, size/fragmentation, international responsibility and information quality are made. The results are used to categorize areas (river basins) and potential impacts of power plant operations into the following management classes: 1) for conservation, 2) for ‘on hold’ (e.g. because knowledge is lacking or other less detrimental ways of utilization being considered) and 3) for utilization. Conservation class means that areas should be permanently protected from energy developments. To become operational the Master Plan proposals have to be accepted by the Icelandic Parliament. In this talk we will explain how this is performed, and in particular how an integrated ecosystem and process based approach is used to evaluate diversity, e.g. of migratory and resident populations of Atlantic salmon (Salmo salar), Arctic char (Salvelinus alpinus), brown trout (Salmo trutta), threespine stickleback and eel (Anguilla anguilla) as examples, but these species constitute the fish fauna of Icelandic freshwaters.
Session A6 - Hydro Power & Conservation: The Icelandic Master Plan

Role of river basin geology and geological processes in relation to potential hydro power developments in a volcanic environment

Dr. Thor Thordarson

"Thorvaldur Thordarson Chair in Petrology and Volcanology at Faculty of Earth Sciences, University of Iceland. Thordarson’s expertise in hot spot (Iceland, Hawaii) and arc volcanism (New Zealand) is coupled with research on ancient volcanic systems and mineral exploration (Australia, Finland). He has been involved in wide-ranging research on volcanism and volcanic hazards, including volcano monitoring and surveillance in Iceland and New Zealand and industry-linked research on magmatic ore deposits. Thordarson has studied Icelandic volcanoes for >25 years and has been instrumental in research on the physical volcanoology of effusive and explosive eruptions including their environmental and climatic effects. Thordarson is the world’s leading expert on the 1783-84 Laki eruption with >600 citations to the 23 papers that he has published on different aspects of the eruption (petrochemistry, volcanoology, environmental, climatic and societal impacts). Current research is centered on historic and Holocene volcanism, with particular emphasis on explosive eruptions at active central volcanoes in Iceland (including Eyjafjallajökull volcano). He has been a member of the Icelandic and British Government Scientific Advisory Committees on Icelandic volcanic ash emergencies and currently serves in the professional specialist group 1 in the Master Plan for Nature Protection and Energy Utilization. Thordarson has more than 140 publications, including 3 books, concerning various aspects of physical volcanoology and volcano-climate interactions that have received >6000 citations. He has supervised 28 Postgraduate students in the period and 21 already graduated.

The Ministry for the Environment and Natural Resources in Iceland has been responsible for the creation of a Master Plan for Nature Protection and Energy Utilization since 2001, and a legislation in this regard was established in 2013. Among other things, the Master Plan provides guidance for assessing the probable impact of proposed hydroelectric power plant schemes in Iceland. The nature of the migratory and resident fish habitats in any one river system is strongly influence by the surrounding geology, i.e. the type of bedrock and surface deposit cover, groundwater flow as well as the overall hydraulics of the drainage basin. When considering proposals for hydroelectric power plant developments the Master Plan evaluation includes assessment on the “value” of the geology and geological processes within a river drainage system from an ecological, socio-economical, educational and environmental point of view. When the value is established through assessment via these four categories, the impact of the proposed plant is assessed by carefully evaluating its potential influence in relation to the four above mentioned categories. We will demonstrate this evaluation process with examples from three different river systems in south and north Iceland, with special emphasis on the migratory and resident fish habitats.
Session A7: Downstream Passage III

Successful downstream passage of juvenile salmonids at a run-of-river hydro project in the Pacific Northwest

Mr. Nick Ackerman

Nick Ackerman has been a biologist for Portland General Electric working on the beautiful Clackamas River in Estacada Oregon for the past 10 years. His main focus at work is designing and implementing upstream and downstream passage evaluations for salmon, steelhead, and Pacific lamprey at PGE's Clackamas Hydro Project. When not at work Nick spends his time coaching his three kids in youth sports, running them around the county to their various activities, and working on his property.

Portland General Electric (PGE) operates a three dam run-of-river hydropower project (Project) on the Clackamas River in Northwest Oregon (FERC 2195). The Project is over 100 years old with dams ranging in hydraulic height from 14-43 meters. As part of the operating License received in 2010 PGE committed to significant upgrades to the Project’s fish passage infrastructure. Though improvements were made to upstream and downstream passage facilities, Project operations, and instream flows; this presentation will focus on the downstream passage system and associated population benefits to local endangered salmon and steelhead populations. Important new components of the downstream passage system include two surface collectors, a spillway exclusion net, an extension of a bypass pipeline system, and a new downstream migrant sampling facility. Design elements of these modifications will be briefly discussed though emphasis will be placed on monitoring results. These changes have improved collection efficiency, overall survival of juveniles through the Project, and subsequent returns of adults to the Project. In the first spring with the last of the facility upgrades in place, overall survival through the Project of coho and steelhead smolts in 2016 was approximately 95% across the entire season. Improvements in adult returns will be covered in a subsequent presentation.
Session A7: Downstream Passage III

Population level response to 21st century fish passage infrastructure in the upper Clackamas River basin

Garth Wyatt

Garth Wyatt-Fish Biologist for Portland General Electric Garth is a native Oregonian and grew up in high desert of Central Oregon. He has been a fish biologist at West Side Hydro on the Clackamas River, OR for the last 10 years and in that time the project has gone from having fish passage to one of the top preforming fish passage programs in the region. Garth received his BS in Fisheries Science at Oregon State University and specializes in fish passage solutions around hydro-projects. Prior to joining PGE Garth worked for the Confederated Tribes of Warm Springs, the Oregon Department of Fish and Wildlife, and Oregon Department of Environmental Quality. Garth is an avid fisherman and enjoys all things Salmonidae.

Portland General Electric (PGE) operates a 3 dam 123-MW hydro-complex (Project) on the Clackamas River with dams ranging in physical height from 14-63 meters (FERC 2195). In 2010 PGE received a 45 year license from FERC to continue operation of the Project. In response, construction of license mandated fish facilities ensued from 2006-2015. Associated facilities either built and/or improved within the Project area relevant to this analysis are 1) new River Mill adult fish ladder, 2) 14 m3/s River Mill surface collector, 3) 28 m3/s North Fork floating surface collector, 4) 11.4 km juvenile fish bypass pipeline, 5) juvenile sampling building, 6) adult fish sorting facility 7) spillway exclusion net, 8) and a suite of habitat improvement/minimum flow increases. Unlike many other Columbia and Willamette tributary hydro-systems built in the 20th century, the Clackamas hydro system had functioning upstream and downstream fish passage infrastructure originally integrated with varying degrees of efficacy. This offered a unique opportunity to investigate the impact of 21st century fish passage infrastructure on established ESA listed populations of spring Chinook, coho, and winter steelhead. A long term (1958-present) data set from Project facilities and site specific evaluations were used to identify population level responses associated with infrastructure improvements. Topics of interest included in this presentation are: 1. Adult run timing advancements of 2-4 weeks at the 25th, 50th, and 75th percentile completion dates affecting preferred upper basin utilization. 2. Relationship between the expansion of juvenile life history strategies collected and potential increase in the age class diversity of returning adults (portfolio effect). 3. Temporal emigration trends of downstream migrants following infrastructure improvement. 4. Observed juvenile collection efficiency increases and recruits per spawner analysis relationships. 5. Relative performance increase of Clackamas spring Chinook and winter steelhead to regional conspecifics after infrastructure improvement. 6. Observed reductions in spring Chinook pre-spawn mortality. 7. Lamprey recolonization in the Faraday diversion reach.
Session A7: Downstream Passage III

*Design and Assessment of Surface Passage from Lower Granite Juvenile Bypass System Gatewells*

Jon Renholds

Jon Renholds is a Senior Hydraulic Engineer for the Hydraulics Section of the US Army Corps of Engineers Walla Walla District. He is a registered Professional Engineer with 14 years of engineering experience with the last 7 years spent at the Walla Walla District primarily with fish passage design issues. He gave 2 presentations in 2014 at this conference in Madison, WI. He has a BS in Environmental Engineering from Oregon State University and a Masters in Civil Engineering with a Hydraulic Engineering and Stream Restoration emphasis from Colorado State University. David Trachtenberg is a Fish Biologist for the Environmental Analysis Section of the US Army Corps of Engineers Walla Walla District. He has 11 years of fisheries experience with the last 7 years spent at the Walla Walla District primarily addressing fish passage design issues. He has a BS in Fish and Wildlife from Oregon State University.

A prototype fish passage weir was installed within the juvenile fish bypass system (JBS) of the US Army Corps of Engineer’s (USACE) Lower Granite Dam on the lower Snake River in 2013. At Lower Granite Dam, fish migrating downriver through the powerhouse are diverted into gatewells by large bypass screens installed in the turbine intakes. Currently fish pass from these gatewells through 10” diameter orifices into a collection channel for bypass from turbine passage. Based on the success of surface oriented spillway weirs at Lower Granite Dam and other USACE projects, it was thought a surface passage alternative such as a weir may reduce delay within the gatewell, better pass debris, and therefore reduce travel time and injury to juvenile salmonids passing the JBS. Physical modeling using a 1 to 12 scale model was conducted to determine the size, position and shape of the weir. Following hydraulic design, mechanical and structural considerations were incorporated into a construction contract for installation during the 2012-2013 JBS winter outage period. The 2-ft wide prototype weir was designed to have either a broad or sharp crest and pass approximately 15 cfs from the surface of the gatewell into the collection channel. In 2013, a biological study was conducted to assess the biological (e.g., injury and time of passage) and debris passage characteristics for existing 10” diameter orifices, the broad crested weir and a new 14” diameter orifice. In 2014, this biological study continued with comparison of the 10” diameter orifice, the sharp crested weir and a new 14” diameter lighted orifice. Biological study results of the studies indicated that the standard 14” orifice performed biologically similar or better than the 10” orifice, lighted 14” orifice, and both types of overflow weirs.
Session A8: New Technology

*Development of a computer vision system to identify sea lamprey at barrier traps and fishways*

Dr. Alex Haro

Dr. Haro’s work involves migratory fish behavior, design, engineering, and evaluation of fish passage structures, biotic and abiotic influences on fish migration, behavior of upstream and downstream migrant diadromous fishes, and ecology and management of American eels. His research focuses on restoration and sustainability of migratory (diadromous and riverine) fish populations, and supports effective conservation and enhancement of populations of fish species throughout the northeastern United States, as well as nationally and internationally.

Barrier-integrated (low-head dam) traps are deployed in streams across the Great Lakes basin to assess adult sea lamprey abundance, evaluate program success, and function as trap/sort facilities to control sea lamprey. Trap and hand-sorting methods to count or isolate sea lamprey from barrier traps suffer from deficiencies in effectiveness, fish retention, and delays in passage of non-lamprey species. A bilinear convolutional neural network (CNN) computer vision and object identification (CVOI) numerical model has shown high detection/identification efficiency for biological objects that are challenging to distinguish (e.g., bird species) and has better accuracy than other current CVOI models. A CNN CVOI software program was adapted to automatically identify adult sea lamprey in real time as they passed through a fishway counting window. With an image training set of several thousand images, the CVOI model was able to correctly identify 84% of lamprey in the counting window, and identify 90% of other fish species as “non-lamprey”. Improvement in classification accuracy can be made with additional training imagery sets. The CVOI system could be used for lamprey control; i.e., a gating mechanism (i.e., exclusion gate, electric field, etc.) within a fish passage channel that could be automatically engaged when lamprey are detected by the CVOI system to prevent their upstream passage, while other species are allowed to pass. The system could also be adapted for automated monitoring/counting of lamprey and other species at non-barriers (e.g., temporary weirs).
Session A8: New Technology

Regulatory Considerations for New Fish Passage Technologies

Ms. Alison Colotelo

Alison is a senior research scientist at Pacific Northwest National Laboratory. Her work focuses on examining the interaction between fishes and hydropower facilities. She is involved in several large studies that examine the passage proportions and survival of juvenile and adult salmonids that passed downstream through dams in the lower Snake and Columbia rivers. Alison is also involved in a number of laboratory studies that investigate the effects of rapid decompression associated with simulated turbine passage and the implantation methods of telemetry transmitters.

Innovation and technology development over the last several years has led to the development of novel approaches to moving fish around barriers. New technologies are changing the way that we think about fish passage, but are also introducing questions about the requirements for safe and effective passage. One such consideration for technology developers are the steps and information required to gain approval from regulatory agencies to deploy new technologies, particularly in bodies of water inhabited by species listed under the Endangered Species Act (ESA). Currently, the process to gain regulatory acceptance of new fish passage technologies is ill-defined and lacks clear acceptance criteria. Furthermore, private companies desiring to commercialize their fish passage technologies are tasked with the burden of overcoming ambiguous, and non-scientifically supported performance criteria of conventional technologies and not directly applicable or potentially outdated federal regulatory guidelines, policies, or ESA rules. One new fish passage technology that has gained attention in recent years is the Whooshh Fish Transport System (WFTS), developed by WhooshhTM Innovations based in Seattle, WA. Their system uses a flexible tube that works by harnessing the power of localized atmospheric pressure differentials and guides fish over barriers. While the WFTS has yet to gain approval for full scale deployment in systems with ESA-listed fish, they are working with regulatory agencies to identify the remaining questions about the technology and the pathway to full acceptance. This presentation will outline a decision tree that can be used by technology developers as a reference to better understand the regulatory process and factors to consider when seeking approval of new fish passage technologies. However, regulatory steps between agencies and even among regions of an individual agency are not standardized and thus, this decision tree should be considered more as an assistive tool than a panacea in gaining regulatory approval.
Session A8: New Technology

Review of Fish Passage Technologies at High-head Dams

Laura Robinson

Laura Robinson began work at the Northwest Power and Conservation Council in 2009, after completing her Bachelors of Science at Portland State University in Environmental Studies and Geography. Laura has been in her role of Program Liaison Coordinator with an emphasis on Native American tribes since 2011 and focuses on fish and wildlife issues associated with impacts from the hydropower dams in the Columbia River Basin. Her current work is in leading the Council initiative to investigate potential for salmon and steelhead fish passage and reintroduction above Grand Coulee Dam in Washington, as well as tribal relations for the Council, wildlife projects, predator control, and managing the Subbasin Dashboards.

In its 2014 Fish and Wildlife Program, the Northwest Power and Conservation Council included a science-based, phased approach to explore the potential of reintroducing salmon and steelhead into the blocked US waters of the Upper Columbia above Chief Joseph and Grand Coulee dams. The first phase of the three-phase strategy calls for studies and evaluations about what is known generally about fish passage at high-head dams and specifically the quality of the habitat in the Columbia River and its tributaries above the dams. Council staff conducted research to evaluate the various technologies that are available for high-head fish passage. Based on this work, a staff paper for Council and regional use was produced at the end of 2016. For this paper, Council staff evaluated information from passage studies at Chief Joseph and Grand Coulee, and at other dams where fish passage has been studied or completed. Included in the evaluation are dams in Washington and Oregon, on the border of Oregon and Idaho, and in California and Pennsylvania. In order to better understand each location, staff compiled standardized information into case studies, summarizing information gleaned from design documents, annual reports, and from personal communications with project staff. The paper explores six themes that could apply in planning and providing fish passage at high-head dams such as Chief Joseph and Grand Coulee. This presentation will focus on the findings of this research and will highlight the current technologies that are attempting innovative approaches to the challenge of passing fish above, through, and around high-head dams.
Session A8: New Technology

Whooshh Fish Passage – Results and Extrapolations from 2016 Scientific Studies

Todd Deligan

Todd Deligan brings to Whooshh Innovations extensive legal and business experience and a strong commitment to environmental sustainability. A Pacific Northwest native, Todd attended the University of Washington earning a B.A. degree in Political Science and then attended Vermont Law School where he earned J.D. and MELP (Master of Environmental Law and Policy) degrees. In 2010, Todd joined Whooshh as its first fish-centric employee. He speaks extensively on Whooshh and its role in transforming fish passage and has acted as a spokesperson for the company and its technology around the world.

Study results in 2016 confirm both biologically and from an engineering perspective that Whooshh Innovations’ fish transport system (WFTS) can transport migratory species safely, timely, efficiently, and effectively. The Yakama Nations concluded a three-year comparison study that demonstrated reproducibility of safe WFTS transport. 2016 included an additional study arm, a historic first of an 1,100 ft tube transport group (funded by the U.S. Bureau of Reclamation). The study results indicate that adult survival and egg viability were statistically equivalent between hand carry, 40 ft and 1,100 ft WFTS transport methods. These positive outcomes resulted in a Bureau of Reclamation request for a full prototype test over Cle Elum dam in 2017. A CRITFC Sockeye migration study was also conducted at the Priest Rapids dam OLAFT facility. The study directly evaluated if WFTS transport affected in-river survival and travel time. ~900 Sockeye were sampled, PIT-tagged and divided between non-WFTS (ladder passage only) and WFTS. Non-WFTS fish were returned to a raceway and the upstream ladder whereas WFTS fish were tube-transported ~100 ft exiting into the same raceway. On the last day, 54 WFTS Sockeye were transported directly over the dam into the forebay, bypassing the remaining ladder passage. PTAGIS tracked both non-WFTS and WFTS Sockeye as they traveled up the Columbia into the Okanogan and Wenatchee rivers and above Lake Osoyoos in B.C. Study analysis showed no WFTS transport impact on migration or survival. The non-WFTS and WFTS groups that continued up the ladder tracked nearly identically. In contrast, the travel times of WFTS Sockeye transported directly over the dam were significantly reduced resulting in arrival at upstream sites one or more days sooner – a statistically significant finding. The travel time and energy saving benefits of WFTS transport are compelling. Additional studies will be shared.
Session A9: Fishway Hydraulics

THE NEXT GENERATION OF POOL AND CHUTE FISHWAYS

Mr. Michael Love

Michael Love is the principal engineer of Michael Love & Associates, Inc. in Arcata, California. He has designed a wide variety of fish passage facilities since starting his company in 1999. He was a lead developer of the US Forest Service FishXing software and learning system, and a co-author of numerous publications on fish passage at road-stream crossings, including the State of California’s fish passage assessment and design manuals. He regularly leads fish passage design courses and enjoys collaborating with Humboldt State University on fish passage research and development projects.

This presentation will describe the design, evaluation, and applications of a “vortex” pool and chute (P&C) fishway. Traditional P&C fishways, as first described in Bates (1991), are pool and weir style passage facilities operating with plunging and streaming flow regimes occurring simultaneously within the pools. The fishway operates over a wider range of headwater fluctuations, conveys substantially more flow, and provides better attraction than standard pool and weir fishways. The notch in the center of the weir generates streaming, thus conveying a large proportion of the fishway’s flow along its centerline. The streaming flow generates swift and turbulent conditions ill-suited for passage, while the sloping shoulders of the weir maintains plunging conditions that provide a low-turbulence passage corridor along the pool margins. The vortex P&C fishway layout involves skewing the shoulders relative to the centerline. Vortex P&C fishways have been constructed at several locations in northern California. Observations of their hydraulics over a wide range of flows reveals that the vortex weir shape directs the flow’s momentum towards the center of the pools, reducing turbulence and velocities along the pool margins compared to the traditional layout. Nyberg et al. (2016) developed critical design parameters for a vortex P&C fishway using empirical data from a 1:15 scale model. Results include appropriate flow-dependent values for the Chezy coefficient, which can be used to calculate the streaming flow in the fishway. Additionally, updated design procedures have been developed. Traditional P&C fishways have been constructed at slopes of 10 to 14 percent. At these steep slopes, they tend to generate unsteady hydraulics in the lower pools when the overall drop exceeds 6 to 8 feet, thus limiting their application. Observations of full-scale vortex P&C fishways built at slopes less than 8 percent, along with the 1:15 scale flume model placed at 8 percent slope revealed no signs of unstable hydraulics, even when overall drop reached 11 feet. Therefore, using a lower slope for P&C fishways appears to allow their application to sites with drops exceeding 6 to 8 feet.
Session A9: Fishway Hydraulics

An Investigation of the Hydraulics in a Prototype Pool-and-Chute, Vortex Weir Fishway for Anadromous Fish Passage.

Brendan Foster

Brendan is an environmental resources engineering master's candidate at Humboldt State University and has worked on various fish passage projects throughout the Pacific Northwest since 2010.

This paper presents the hydraulic characteristics and simulated passage efficiency of an improved pool-and-chute, vortex weir fishway designed by Michael Love & Associates. A physical 1:15 scale model was evaluated at an 8% slope over three prototype flow rates representing high, medium, and low fish passage flows. The highest velocities and turbulent kinetic energy (TKE) values were concentrated along the fishway centerline at the high and medium flow rate and the pool sides showed lower velocities and TKE. Large eddies spin laterally and longitudinally throughout each pool. The velocity vector directions at the lowest flow rate differed from the two higher flow rates altering the motion of the pool eddies. The fishway's velocities and their spatial distribution were also used to estimate passage success and fatigue level. A preliminary numerical model was created that simulates a steelhead or coho salmon ascending the fishway. This model uses observed size distributions for adult steelhead and coho obtained from Kierman et al. (2016) and Shapovalov & Taft (1954), and calculates each individually sampled fish’s passage time and percent fatigue. Two swim pathways were analyzed at both the high and medium flow rates. A thousand fish of each species were simulated ascending the fishway, and zero fish reached 100% fatigue under any scenario. Results demonstrate that ascension of the prototype fishway should not be energetically limiting for steelhead or coho salmon. The model was also used to calculate the maximum fishway length (holding the original 30-feet width constant) over which zero fish reached 100% fatigue, assuming fish did not rest and recover from fatigue within the pools between weirs. Results indicate the fishway length could increase by an additional three pools and weirs or 37.5 feet without causing any fish in the sample distribution to reach 100% fatigue. Conservative fishway design would not recommend increasing the fishway length to ensure an energetic factor of safety and account for potential behavioral or motivation delays. References: Kiernan, J.D., Osterback, A.-M. K., Kern, C.H., Kanawi, E., and Gilbert-Horvath, E. A. (2016). Results of Scott Creek Life Cycle Monitoring Station 2014-2016. Final Report Submitted to the California Department of Fish and Wildlife as Part of the Requirements of FRGP Award # P1330409. Shapovalov, Leo, and Alan C. Taft. 1954. The life histories of the steelhead rainbow trout (Salmo gairdneri gairdneri) and silver salmon (Oncorhynchus kisutch) with special reference to Waddell Creek, California, and recommendations regarding their management. Calif. Dept. Fish and Game, Fish. Bull. No. 98, 375 pp.
Session A9: Fishway Hydraulics

Effects of Froude Scaling on Turbulence in a Denil Fishway

Dr. Katey Plymesser

Dr. Plymesser hold a B.S. (Case Western Reserve University ‘01) and Ph.D. (MSU ’14) degrees in Civil Engineering. She began her academic career at Montana State University – Billings with a teaching and research tenure-track appointment. Dr. Plymesser joined the Civil Engineering Department at Montana State University in 2016. Her research is focused in ecohydraulics and fish passage with a particular fondness for the application of hydraulic and fluid dynamic models to answer research questions in natural settings. She has worked with the US Fish and Wildlife Service (USFWS) both in Bozeman and at the Region 5 Headquarters in Amherst, MA on fish passage research projects and practical applications and assessments that culminated in the creation of a passage model for American shad in Steeppass (modified Denil) fishways. Her work has been financially supported by the DOE through the Hydro Research Foundation and the USFWS. Dr. Plymesser currently teaches Engineering Mechanics, Statics and Fluid Dynamics. She has been engaging both undergraduate and graduate students in research since she began her own graduate work in 2008. Through her work with the Montana State University chapter of Engineers Without Borders she has been active in promoting student engagement and involvement.

The Ecohydraulics and Fish Passage Research group at Montana State University (MSU), which is comprised of scientists and engineers from the Fish and Wildlife Service in Region 6 and the Civil Engineering and Ecology departments at MSU, is currently assessing the effectiveness of Denil fishways in the Big Hole river watershed to improve landscape connectivity. The Big Hole watershed, located in SW Montana, is the most important remaining habitat for native riverine Arctic grayling in the lower 48 states and there are currently 63 Denil fishways installed at irrigation diversions in the drainage. Denil fishways are being installed unmodified, and with flow control modifications that limit the inflow to the fishway. It is important to this work that thorough hydraulic analyses of the simple and modified Denil fishways are conducted. These analyses are accomplished using physical models in the hydraulics lab at Montana State University and with computational fluid dynamics (CFD) models. The hydraulics lab at Montana State University is limited by the flow rate of water that can be supplied to a structure, necessitating that laboratory work for the Denil fishway be done in scaled models. While it is generally accepted that Froude number scaling of hydraulic structures well represents the velocity and depths of full-scale, it is not certain that this dimensional scaling accurately represents full-scale turbulence (intensity and length scales). We will present the results of a CFD model study that compares turbulence intensity and length scales for full and half-scaled models of the Denil fishway to better inform the use of scaled laboratory models for fish passage work.
Session A9: Fishway Hydraulics

Hydraulic and biological analysis of fish passability of a low-head stream gaging weir

Dr. Alex Haro

Dr. Haro’s work involves migratory fish behavior, design, engineering, and evaluation of fish passage structures, biotic and abiotic influences on fish migration, behavior of upstream and downstream migrant diadromous fishes, and ecology and management of American eels. His research focuses on restoration and sustainability of migratory (diadromous and riverine) fish populations, and supports effective conservation and enhancement of populations of fish species throughout the northeastern United States, as well as nationally and internationally.

Over 8000 continuous-record stream gaging stations operate nationwide to monitor surface water flow. For many of these stream gages, low-head (<1 m height) gaging weirs function to provide a stable low flow control and site conditions facilitating the computation of streamflow to help manage water resources. However, some of these gaging weirs may present a passage barrier to some fish species at lower stream flows. As river flow increases, low-head gaging weirs may become passable by some species of fish as over-weir depths increase, head drop decreases, and velocity decreases. This research estimated the “period of passability” for a low-head gaging weir using river hydrology and weir hydraulics, coupled with migratory timing and biological design criteria for the target species, American shad, alewife, and blueback herring. These estimates need to be tested and validated with controlled studies of passage of native fish assemblages over full-scale gaging weirs. New designs of gaging weirs also need to be developed to derive the “next generation” of fish-passable weirs for new gaging sites or repair/replacement of older weirs.
Session A9: Fishway Hydraulics

Can vertical slot fishways (VSF) operate with less water without compromising effectiveness?

Ms. Ana Quaresma (talk being delivered by Mr António Pinheiro)

Ana Quaresma did her degree in Civil Engineering in 1999 at Faculdade de Engenharia da Universidade do Porto (FEUP). Worked in a consulting company in hydraulics studies and concluded the MSc in Environmental Engineering in the field of Hydraulics and Water Resources in 2005 at FEUP, with the topic of Energy dissipation downstream of dams established in alluvial beds. She is currently finishing the Ph.D. at Instituto Superior Técnico (IST). The research topic is Developing pool-type fishways based on physical and numerical modeling. Before engaging in the Ph.D. she also worked in consulting companies in hydraulics and ecohydraulics studies. Domain of activity: Ecohydraulics; fishways; Numerical modeling; Fluvial hydraulics; River Restoration

Designing holistic multi-species fishways with suitable hydraulic conditions for native freshwater species with different morphological and ecological characteristics is vital for re-establishing river’s longitudinal connectivity. Accomplishing this using as less water as possible without compromising its effectiveness is very important in Mediterranean regions, where streams have extended low flow periods. According to FAO, vertical slot fishways (VSF) are the best type of technical fishway when multiple species are present and should be given preference over other technical fish passes. However, they normally require more water to operate than orifice and notch configurations. Recently, a variation on the standard VSF called the Maba multi-structure slot (MS) fish pass has been developed. This design reduces the discharge up to 40% when compared to a standard VSF. The maximum flow velocities and the mean turbulent kinetic energy are also reduced, while the free surface elevation is maintained. But, its effectiveness has not been the subject of an experiment where confounding variables could be controlled. The main goal of this study is to understand if MS fishway when compared with traditional VSF, could be seen as an effective water efficient fishway to be used in regions affected by water scarcity. To accomplish this objective, 3D computational fluid dynamics (CFD) models of two VSF configurations and a variant of the MS fishway were developed using FLOW-3D. Biological experiments, using a full-scale indoor model fishway, with two ecologically different cyprinid species were conducted in both a standard VSF and MS fishway. Results show that both VSF and MS fishway are effective for both fish species tested. The use of MS fishway in water scarcity regions allows for a correct management of water availability while maintaining fishway effectiveness. The findings of this work are important to improve fishway design guidelines suitable for cyprinids in water scarcity regions.
Session A9: Fishway Hydraulics

*The Reality of Fish Passage in Concrete Flood Channels: The Mission Creek Experience*

Mike Garello, Marcin Whitman

Mike Garello is fisheries engineer who focuses on planning, design and construction of fish passage systems. His fish passage experience ranges from reconnaissance level studies to detailed design and construction management of various types of fish passage program and facilities including conventional fishways, nature-like fishways, trap and haul systems, barriers, collection and monitoring facilities, surface collectors and bypass systems. Marcin Whitman started his career in Naval Architecture and Marine Engineering, but soon felt he could make a more meaningful contribution working on the interface between fisheries and engineering. He started the engineering department for the Southwest Region of NMFS where he worked for nearly 10 years with some international consulting interspersed. Since mid-1998 he has been the coastal engineer for CDFW, specializing in salmonid fish passage but often finding himself drawn into issues of fluvial geomorphology.

Two sections of an urban concrete flood channel, totaling nearly 1 mile in length, were modified to facilitate passage of the Federally endangered Southern California Steelhead (ocean-running) trout at a cost for design and implementation of $5.5 million. Such efforts have been tried before with limited success. This site in Santa Barbara, California experiences a Mediterranean climate, with natural channel processes dominated by episodic surface flow and sediment transport during the winter months, followed by dry, warm summers with minimal flow. The natural channel of Mission Creek has been highly altered and constrained by flood management and urban development. While detailed CFD and physical modeling informed the design, the project team realized modeling could never capture the complexity of real sediment and debris loading, let alone assess fish behavioral response to the modified channel. As similar efforts are either being planned or are underway in other similarly modified stream channels, results of this pioneering approach is of great interest. Therefore, a monitoring program was instituted as part of the project. Low flow hydraulic measurements were taken in the first two rainy seasons and results were in good agreement with the modeling. Due to the extended drought, opportunities for measuring high flows, in particular flows that mobilize the bed upstream of the modified reach, did not occur until the winter of 2016-2017. Comparison of field performance with models over the range of design flows will be presented. Post modeling refinements to the design, maintenance implications, biological (fish passage) response and construction techniques will also be discussed.
Session B1: Fishway Design & Efficiency I

Evidence of a fishway restoring river connectivity in the Neotropical Region

Mr. Hugo Marques

Hugo Marques is a biologist, M.Sc. in Aquatic Biology and currently Ph.D. candidate in Biology (Zoology) at São Paulo State University, researching long-term effects of impoundments on fish in Neotropical reservoirs. He has been working on fish ecology and fisheries management and conservation since 2008. He also has experience with fish passage monitoring and worked in two large fishways: Porto Primavera dam, Paraná River (2009 – 2013), and Belo Monte dam, Xingú River, Amazon Basin (2015 – 2016). He has interested in the following areas: fish ecology, biodiversity/conservation, fisheries management, fish passage/migration, and telemetry.

Habitat fragmentation is one of the main impacts of river damming and fishways could be an important management tool to mitigate it, restoring river connectivity. The Porto Primavera dam is located in the upper Paraná River basin, Southeast Brazil, built on an alluvial floodplain with important tributaries serving as nursery sites both upstream and downstream. Its reservoir was filled in December/1998 and the pool-weir-orifice fishway was opened in October/2001. We test the hypothesis that the fishway increases the river connectivity using beta diversity as an indicator, once lower values of this metrics indicate higher similarity among fish assemblages. Quarterly sampling with gillnets was performed upstream and downstream of the dam before fishway opening, from February/1999 to May/2001 and from February 2003 to May/2005, with fishway operating (10 samples per period/site). The numeric abundance data was indexed by catch per unit effort (number of individuals per 1000 m2 gillnet, set for 24 h). First, we verify the correlation of fish assemblages between sites applying two Mantel tests (downstream versus upstream before and one equivalent after the fishway) using the distance matrices generated by the Bray-Curtis index. Then we calculate the beta diversity partitioned using Sorensen index, between downstream and upstream for each sampling to compare the beta diversity values before and after the fishway, by the Asymptotic Wilcoxon-Mann-Whitney Test. The mantel tests showed no correlation between the upstream and downstream assemblages before the fishway but correlated after (r=0.322, p=0.03). The beta diversity presented lower values after (median 0.47) than before (median 0.57) (Z=-2.08, p=0.04), evidencing the increase of similarity between downstream and upstream the dam with the fishway. Although fishways remain an incipient and controversial theme for Neotropical fishes, mainly in demographic and genetic aspects, the Porto Primavera fishway is probably effective for the aspect of connectivity restoration.
Session B1: Fishway Design & Efficiency I

Fishway design in the temperate Southern Hemisphere

Dr. Martin Wilkes

Martin has worked in the energy industry, local government and environmental consultancy for 25 years, taking part in and leading projects relating to waterways and other public infrastructure. After graduating from University of Worcester in 2009, Martin went on to complete an MSc in River Environmental Management at the University of Birmingham. He returned to Worcester the following year to undertake a PhD. His doctoral thesis implemented a hydrodynamic view of rivers at multiple scales in order to develop new ways of assessing habitat quality for Atlantic salmon (Salmo salar) and modelling the impacts of hydropower development on threatened fish communities in South America. With his background in highly regulated industries, Martin has an excellent awareness of legislative issues and has put this to good effect in providing guidance to EU member states on compliance with the Water Framework Directive and the Habitats Directive.

The export of fishway technology from the temperate Northern Hemisphere to other parts of the world has resulted in little success. This is because typical target species in the north (e.g. salmonids) have very different characteristics to species of other systems. This is particularly true in the temperate Southern Hemisphere, which has been severely neglected in previous syntheses of fish passage research. This region encompasses SE Australia, New Zealand and Chile. Fish communities of the temperate south are characterised by diverse and flexible life-histories and high levels of diadromy. Furthermore, the generally small body sizes and correspondingly relatively weak swimming abilities of native species in the region makes fishway design challenging. Our study aimed to define a set of criteria for better design of fish passage facilities in the region. We conducted a rapid evidence assessment to gather available data on fishway design criteria for species native to the temperate south. We included factors relating to both upstream and downstream movement. Our initial conceptual model was informed by international fishway research and tested using studies specifically focusing on local species. We found that almost all areas of fishway design were poorly supported by empirical evidence. Particular deficiencies were found in the areas of fishway attraction (upstream) and mitigation of fish mortality through hydropower turbines and other potentially damaging infrastructure. This scarcity of empirical evidence necessitated an approach that could incorporate expert knowledge and numerical modelling results. Bayesian Networks were selected as they are capable of integrating these data sources and they give easily interpretable, probabilistic answers. By combining carefully elicited expert opinion with the available data on species habitat suitability, swimming abilities and turbine blade strike models, our model can predict the efficiency of alternative mitigation measures for fish passage at hydropower dams and other barriers.
The Piracema Channel of ITAIPU, Paraná, Brazil: engineering lessons and proposed improvements to the transposition of Neotropical fish

Ms. Caroline Henn

Biologist - State Univesity of Western Paraná, 2007, with specialization degree in Biotechnology - State University of Maringá, 2016. Works in ITAIPU, in the Reservoir Division, since 2008, monitoring fisheries, ichthyoplankton and the fish transposition system of ITAIPU, Piracema Channel.

The Piracema Channel is characterized as a nature-like fish passage, being the longest of the world in this genre; it has been under operation since 2002 and bypass ITAIPU dam, in the Brazilian side of the hydroelectric power plant. Thirteen years of monitoring of fish movements evidenced two main structures that require improvements: the Water Intake and the Discharge Channel. In the Water intake, the sills of the floodgates are only 2.6m below the normal reservoir level (220.5 a.s.l.), leading to the channel to drain completely when the reservoir level drops – what happened many times in the last years. The Discharge Channel presents a 5m width section and a slope reaching 6.25% in some points. This configuration creates, under normal operation flow (12 m3/s), hard conditions for native species to swim upstream due to the turbulence and water velocity, surpassing the desired upper limit of 3m/s. Therefore, a project for rebuilding these structures is now under discussion. The proposed new Water intake should replace the 5 existent floodgates for a set of sequential floating ones, distributed inside a double concrete channel, 230m long. This arrangement should make it possible to keep the water flowing into the Channel even if the reservoir level drops up to 214m a.s.l. For the Discharge Channel, a second parallel channel should be built, thus diverting the water flow. The main tasks arising from these proposals are: 1- to avoid the same hydrodynamic problems in the new channel parallel to the Drainage Channel, once the topography around presents slopes of 8.33% in some points; and 2 – to create conditions for the upstream migration of catfish species, which swim near the bottom of the watercourses, once the floating floodgates in the new Water Intake will create water columns as high as 6.5m.
Session B1: Fishway Design & Efficiency I

Knowledge update on shad upstream migration fishway design and efficiency

Mr. FRANCOIS GROUX

Mr. François Groux obtained is Master’s degree from the French National Water and Environment Engineering School. He began his career in France in 2009, where he developed his hydrology and fluvial hydraulic expertise by working on many projects involving fishways. In 2012, Mr. Groux moved to Canada and joined the firm WSP, where he continued to gain experience regarding the design of hydraulic structures and the supervision of their construction, mainly for projects involving the construction/rehabilitation of dams and fishways, as well as the restoration of aquatic habitats. During these projects, he used various construction methods, regularly combining civil and ecological engineering. Thanks to his initial training in biology, combined with his subsequent training in hydraulics as well as his professional experience, he can effectively work on multidisciplinary projects involving hydraulics, civil engineering and the environment.

At the end of the 19th century, Allis shad (Alosa alosa) populations started declining in a vast majority of European watercourses, and even completely disappeared in several rivers (Elbe, Rhine, Meuse, Tamise, Seine, etc.). In Europe, Allis shad is presently in a vulnerable position throughout its distribution area. This may partly be explained by the presence of dams on the watercourses, which prevent all, or part of the population from reaching habitats more suitable for the reproduction of adults and the growth of juveniles. Thus, fishway efficiency regarding the upstream migration of shad is a very important issue for the management and restoration of the Allis shad populations in Europe. However, the information regarding the impact of the dams on European Shad, its behaviour at the obstacles and in fishways remains fragmented. A significant amount of information is nonetheless available regarding American shad (Alosa sapidissima), a close relative to European shad, with similar behaviour and biological characteristics. Along the U.S. East Coast, major efforts have been put forth to restore the American Shad populations (reduction of fishing, construction of fishways, restocking, etc.). This study begins by summarizing the efficiency of various fishways used in France and Europe for the Allis shad, as well as in U.S. for the American Shad. The knowledge gained in these regions is then used to identify and update the criteria currently employed for designing European shad fishways. Several recommendations for minimising the impact of obstacles and maximising the efficiency of fishways are suggested.
Session B2: Fishway Design & Efficiency II

Fish Passage Concerns with Rebuilt Jetty at Main Fishway Entrance at Little Goose Lock and Dam

Mr. Sean Milligan

Sean C. Milligan is the Chief of the Hydraulics Section at the Walla Walla District of the U.S. Army Corps of Engineers. He has Bachelor’s and Master’s degrees in Civil Engineering from the University of Idaho and is a registered Professional Engineer in the State of Washington. He has been working in the fields of hydraulics and fish passage engineering for 25 years.

Little Goose Lock and Dam, owned and operated by the Walla Walla District of the U.S. Army Corps of Engineers, is the third dam on the lower Snake River upstream of the confluence with the Columbia River, at River Mile 70.3. One feature of the adult fishway at Little Goose is a rock jetty that was designed to provide good adult fish attraction conditions at the main fishway entrance on the north side of the spillway. The jetty is also an important feature to ensure good downstream egress conditions for juvenile fish passing over the spillway. This rock jetty failed in 1971, only one year after initial commissioning. It was rebuilt, but continued to sustain some erosion over succeeding years, until it failed again in 2011 during an unusually large spill event. There has also been significant streambed erosion in this area near the north fishway entrance and jetty, downstream of the stilling basin. The Walla Walla District plans to rebuild the jetty using steel sheetpile coffer cells instead of restoring the rock embankment. Hydraulic conditions in the tailrace area near the north spillway fishway entrance and the proposed modified jetty were evaluated using a 1:55 scale physical hydraulic model at the Engineering Research and Development Center laboratory in Vicksburg, MS to ensure that the new design does not compromise adult fish attraction conditions to the entrance and will re-establish favorable juvenile fish egress conditions. This presentation will discuss original hydraulic modeling of the rock jetty and fishway entrance for original design, jetty performance history, and recent physical hydraulic modeling to evaluate the modified jetty design.
Session B2: Fishway Design & Efficiency II

*Cloister to improve fish passage for bottom-swimming fish and weak swimmers*

Ms Keiko Muraoka

Born in Yamaguchi Prefecture, Japan in 1963, I commenced work as a researcher at the Public Works Research Institute in 1983, just after graduation from Tokuyama Technical College. I started research on fish passage in 1993 to develop a new fish ladder for multiple fish species, including anadromous sculpin, which is a bottom swimming fish that runs up rivers as a small juvenile. After six years of experimental study, a new design of fish ladder was proposed. However, this design was unable to improve the existing facilities economically. To observe the swimming physiology of fish during fish passage, ultra-high-speed cameras were installed in our experimental study in 2009. This method revealed the reason why the weak swimmers failed to run up the artificial facilities. Both bottom swimming fish and free swimmers with small bodies lose their swimming balance at the boundary of flow, and are not able to maintain their swimming motion. In addition, submerged flow is effective for easy migration of these weak swimmers over the weirs of fish ladders, though approaching flow is also important in other aspects. Finally, we were able to provide a versatile method to improve fish passage for bottom swimming fish and weak swimmers.

Most artificial fish passages have been developed for strong swimmers, such as salmonids. Although these passages are designed to also accommodate weak swimmers, such as larval migrators, they create insufficient flow for the free migration of various species, especially bottom-swimming fishes such as sculpin. Our study show that it is possible to optimize the upstream movement of sculpin by restricting head-raising movements using design components such as small eaves. We propose a cloister in existing fish passage which compose an eave under it. A cloister also decreases the velocity under such eaves, which makes it effective at facilitating the free movement of weak swimmers. The scale of the cloister will depend on the body height of the targeted weak swimmer. However, by adopting an inclined ceiling, it may be suitable for fishes of different sizes. Small eaves with internal angles of 10°, 15°, 20°, 25°, and 40° were installed respectively at the corners of an experiment pipe, and the sculpin behavior in the flow was observed by using ultra-high speed cameras. When there was no cloister in the pipe, sculpin could not remain in a flow with a velocity exceeding 0.5 m/s. A cloister with an internal angle of ≤25° was effective in restricting head-raising movements and allowed the upstream movement of sculpin at a flow velocity greater than 0.5m/s. A 15° cloister allowed the active upstream movement of sculpin at a flow velocity of 1.2 m/s. Furthermore, using a roughness internal surface for the cloister decreased velocity under the eaves and increased the number of sculpins remaining in it. Cloister could be installed not only in fish passages, but also in existing facilities such as channels, the slant faces of artificial facilities and under the gates of dams.
Session B2: Fishway Design & Efficiency II

Numerical investigation of the influence of a guide wall in a fish-friendly weir

Ms. Stephanie Müller

Ms. Müller is a Master student at University of Magdeburg "Otto von Guericke " (course of study: Sustainable Energy Systems) and a scientific Assistant at the Laboratory of Fluid Dynamics and Technical Flows. Her research interests focus on vortex power plants with low ecological impact.

Numerical investigations of the flow in the fish-friendly weir, a small-scale vortex power plant intended to replace common fish ladders while financing its installation by delivering electrical power, are being carried out. This study, based on multi-million cell grid multiphase unsteady simulations running on a high-performance cluster, aims to present a method to evaluate numerically the impact of a design change on the device’s compliance with fish passage requirements.

According to literature, positioning a guide wall at the inlet of the weir can influence the vortex structure and position; this was identified as an opportunity to reduce cross-axis forces on the turbine leading to accelerated wear,[1,2] and to improve the installation’s compliance with German regulations. It was observed that a guide wall in the vortex pool leads to decreased vortex core depths, modified free surface geometry, decreased head drops, reduced losses at constant volume flow, and to decreased hydraulic efficiency if the rotational speed is not suitably adapted to the modified flow conditions. Furthermore, benefits such as the prevention of air entrainment, the reduction of the velocities and the power density in the vortex pool led to an improvement of the migration circumstances.

Based on the simulated flow properties (average velocity, velocity fluctuations, vorticity, energy dissipation...), the broader project objective is to provide quantitative information allowing fish biologists to decide to which extent and under which conditions such a vortex power plant may be used as a fish migration corridor.
Session B2: Fishway Design & Efficiency II

Design and Development of Fish Passage Facilities Installed for Shortnose Sturgeon and Other Migratory Fish Species at a Northeast Hydropower Project

Mr. Jesse Waldrip

Jesse Waldrip has a background in civil engineering and structural design. He serves as the Fish Passage Team Leader at Kleinschmidt Associates and has 14 years of experience in the planning and design of fish passage facilities. His experiences include working with biologists, engineers, and regulators on all phases of fish passage projects from feasibility studies and alternatives analysis, through conceptual and final design, into bidding and construction support, and finally monitoring and effectiveness testing.

Fish passage facilities installed at hydroelectric dams in the Northeast U.S. often need to accommodate multiple species with diverse life histories, behaviors, and swimming abilities. At the Holyoke Dam on the Connecticut River in Massachusetts, the redevelopment of downstream fish passage facilities was undertaken through an iterative process that relied on laboratory testing with the primary species of concern, computational fluid dynamics (CFD) modeling, and collaboration among the project owner, fish passage consultants, and state and federal resource agencies. Shortnose sturgeon, a federally-listed endangered species, was the primary focus for the redevelopment of the downstream passage facilities. However, safe passage of other migratory fishes was also an important factor. Laboratory testing provided data on entrainment and bypass efficiency for various bar rack and bypass configurations and bypass entrance velocities. The CFD modeling provided information used to determine whether hydraulic conditions of conceptual designs would meet established design criteria, and to optimize the final design of the selected configuration. The result of these efforts was the installation of an angled bar rack upstream of the existing turbine intakes in 2015 with bottom, mid-level, and surface bypasses located at the downstream end. A unique feature of the design was the deflection of the downstream bypass discharge up into the air, over the entrance to the existing upstream fish lift, and then down into a plunge pool. This arrangement provides a path for upstream migrants to more easily locate the existing fish lift entrance when the downstream bypasses are in operation. In 2016, 94 sturgeon were passed upstream through the fish lift at Holyoke, which is a significant increase from the previous high of 16 sturgeon lifted in 1996. Field evaluations of downstream passage effectiveness began in 2016 with American shad and American eels. Field testing with sturgeon will begin in 2017.
Session B3: Regional Evaluation of Barriers

Fish passages in international hydropower projects: challenges and opportunities

Dr. Leeanne Alonso

Leeanne E. Alonso is a Biodiversity Consultant to the International Finance Corporation (IFC), the private lending arm of the World Bank, where she advises private sector companies on how to minimize the impacts of their development projects on the natural environment. She works primarily on hydropower projects in Asia and Africa, including Pakistan, Nepal, Mali, Cameroon and Republic of Congo. Leeanne also does independent biodiversity consulting, focusing on biodiversity data collection and capacity building for the private sector to sustainably design and manage projects. Leeanne has a PhD in Biology from Harvard University and over 25 years of experience working in the biodiversity conservation field around the world, particularly in the tropics. As the Director of Global Wildlife Conservation’s Global Biodiversity Exploration Program from 2012-2015 and the Rapid Assessment Program (RAP) at Conservation International from 1998-2011, Leeanne has coordinated and led more than 45 biodiversity field surveys throughout the tropics. While her background is in terrestrial ecology (in particular, ants), Leeanne is keen to learn more about fish passages and fish monitoring techniques so that she can guide IFC hydropower clients toward better management of their impacts on aquatic ecosystems.

Large-scale hydropower projects (HPPs) are being built in developing countries throughout Africa and Asia to fulfill the dire need of electricity for their people. Developers of these projects seek maximum power generation for minimum cost. Many of these HPPs are in areas of high or endangered biodiversity and have impacts on migratory fish species. Challenges to incorporating fish passages into these HPPs include the high numbers and range of life histories of the migratory fish species, high head dams (100+ m), inaccessible locations, lack of hydrological and biological data, weak government requirements, and lack of scientific/technical capacity. For example, Nepal’s environmental legislation requires HPPs to build a fish ladder or a hatchery. However, the fish ladders are often built poorly and very few are monitored, thus little data are available to evaluate whether they are working in Nepal. Projects funded by major development banks, including the International Finance Corporation (IFC), require projects to meet high environmental and social standards, thus providing opportunities for enhancing mitigation options for fish by designing and building effective fish passages. Examples will be provided from HPPs in Nepal, Pakistan, Mali, Cameroon, and Republic of Congo to present the challenges and engage the fish passage professional community to help develop realistic solutions for these countries.
Session B3: Regional Evaluation of Barriers

SNIFFER with ICE: a taster of barrier assessment issues

Dr. James Barry

Research scientist investigating connectivity issues for anadromous fishes as part of the EU funded AMBER project (Adaptive Management of Barriers in European Rivers). As part of the AMBER project Inland Fisheries Ireland is investigating the effect of barriers on the migration of Annex II Habitats Directive fish species (lamprey, shad, salmon), with studies incorporating telemetry, barrier assessment and barrier mitigation.

Man-made barriers have harnessed river energy to benefit society. They have also led to fragmentation of rivers with restriction of fish migration. Fragmentation is relevant to the Water Framework (connectivity) and Habitats (Annex II fish) Directives of the EU. Programmes of Measures (POMS) addressing fragmentation require an assessment of causes and appropriate mitigations. Inland Fisheries Ireland uses the UK-developed SNIFFER (WFD III) assessment method at structures where mitigation measures are proposed (n=40). Passability scores are based on data describing the swimming and leaping abilities of different fish species at each ‘transversal’ or possible passage route across any barrier. SNIFFER is an objective protocol but final scores are heavily influenced by assessor opinion. The French ICE protocol covers a larger number of fish species/life stages than SNIFFER. ICE removes the requirement for both velocity readings and expert opinion. Both protocols utilise a similar passability scoring system (0 = total barrier, 0.3=high impact, 0.6= low impact, 1=no barrier). Comparison of outcomes was made in paired comparisons for 88 transversals recorded at 40 complex barriers. Scores were found to be 45.5% in agreement in the case of adult Atlantic salmon. Differences in outcome arose from key differences in protocols for the threshold swimming capabilities and minimum water depth required for fish to overcome an obstacle. Inland Fisheries Ireland also uses a rapid assessment method for catchment-wide barrier assessment using a desk protocol (historical maps and aerial imagery) to locate potential barriers followed by site-based data collection. Potential barriers on the River Barrow catchment (catchment area 3100 km2) were identified (n = 2948). The dimensional data collected in the rapid method can be input to the ICE decision matrix to derive ICE passability assessments. This allows comparison of the ‘expert opinion’ rapid assessment with the objective ICE assessment of fish passability.
Session B3: Regional Evaluation of Barriers

*FISH PASSAGES FROM PAST TO FUTURE IN TURKEY*

Ms. Aysen Pervin

I, Aysen Pervin GUNGOR, was born in Turkey in 1962 and graduated from University of Ankara in 1988 as an Agricultural Engineer in degree MSc. Than I have started to work in The Ministry of Forestry and Water Affairs, General Directorate of State Hydraulic Works. I have works in Planning Department, Operation and Maintenance Department, Compensation Department, Foreign Affairs and Private Office in different positions as an engineer. I have worked as a head of Quality Assurance Department between 2008 and 2010 and I have worked as a head of Drought Management Department between 2012 and 2013 in the Ministry of Forestry and Water Affairs, General Directorate of Water Affairs. Now I have been working at Hydropolitic Academy Association for one year from 2015 as a project manager.

Today, besides the benefits provided by the construction of water structures such as dams, hydroelectric power plants and regulators, the natural flow structure and vital balance of the water are disturbed due to such interventions in the ecological system. One of the negativities related to these deteriorations is the decrease in populations of fish species migrating upstream-downstream and even the depletion of some species. For this reason, it is proposed that all obstacles affecting the life of fish in a river where water structure is constructed are determined as a solution that can be overcome and, if necessary, forming fish passages. In Turkey, the most well-known species of migratory fish are the sea-trout, stream-trout, sturgeon and eel which are protected by international agreements or have a national protection status. There are approximately 75 years of history of fish passage studies in our country. The first fish passage is the pool type fish passage built on the Seyhan Regulator. There are 35 fish passages of 173 regulators built until 2002. They are all pool type and orifice type fish passages. The rapid increase in the river-type HES power plant projects, which were recently carried out by the private sector in Turkey, has led to increasing problems related to fish migration. In the regulators that are under the scope of the HEPP projects which are under construction since 2002, there are fish passages which are not functional due to various design, projecting and construction errors. This situation causes serious damage both to the economy of the country and the ecological environment. In addition, the current legal arrangements in our country create a gap in this regard. For this reason, in order to direct the fish passage projects planned to be constructed in rivers and to raise awareness about the importance of this issue, a 2 year R & D project has been carried out in 2 rivers (Solaklı and Yanbolu) in the Black Sea Region where fish passages are intensively applied. In this paper, we will talk about findings and interesting applications applied as fish passages and share the results and experiences from the R & D project carried out.
Session B3: Regional Evaluation of Barriers

RECONNECTING EUROPE’s RIVERS: CHALLENGES & OPPORTUNITIES FOR THE AMBER PROJECT

Prof. Carlos Garcia de Leaniz

Carlos holds a Chair in Aquatic BioSciences at Swansea University (UK), where he teaches on Conservation of Aquatic Resources and leads the Centre for Sustainable Aquatic Research (CSAR) at the Department of BioSciences. His background is on fish biology, with expertise on Behavioural Ecology, Conservation, Invasion Biology, and Aquaculture. He has more than 35 years experience working with salmonids as model systems to understand how organisms adapt and respond to change. Carlos pioneered the removal of weirs and dams in the salmon rivers of N. Spain, more than 20 years ago, and currently leads AMBER, a large EU-funded project that aims to apply principles of adaptive management to restore stream connectivity across Europe.

Europe has the most fragmented river landscape in the world. All of Europe’s major rivers are poorly connected and their headwaters remain inaccessible to migratory fish. Only three large rivers, all in NW Russia, remain fully connected to the sea. Loss of connectivity constitutes the biggest problem for achieving good ecological status under the Water Framework Directive (WFD). Yet, surprisingly little is known about the extent of stream of fragmentation at the European scale, which makes restoration difficult. AMBER (Adaptive Management of Barriers in European Barriers) is a new Pan-European project funded under the EC Horizon 2020 programme that aims to restore stream connectivity by applying principles of adaptive management. The project involves 20 partners from 11 countries, and represents all major stakeholders, from government to NGOs, and from academia to industry. One of the biggest challenges for the restoration of connectivity lies in the fact that the number of barriers is unknown because different countries use different definitions of ‘barrier’, and coverage and spatial scales differ widely. A two-century old industrial legacy has resulted in a myriad of old dams and weirs, many of which are abandoned, but whose precise number and location are unknown. The best estimate (based on extrapolation of regional data) suggests that there may be c. 1 million stream barriers in Europe, possibly more. Thus, AMBER’s first task is the compilation of an Atlas of barriers using a common methodology. Current predictions of climate change predict that river flows in large parts of Southern Europe, those already under water stress, may decrease by up to 20% by 2050. This, coupled with the need to increase hydro-production, means that the impacts of many barriers will worsen. Given that resources available for barrier mitigation will never be enough, AMBER will provide prioritisation tools to guide barrier mitigation efforts, as well as decision support tools to enable water managers and fisheries officers to maximize the benefits of water abstraction while minimizing impacts on migratory fish. Although much is known about improving fish passage, most of it relates to salmonids which is rather unfortunate as these tend to be the strongest swimmers. AMBER will examine the passage of weak swimmers, including neglected taxa such as macro-invertebrates. The availability of new technologies, such as eDNA and meta-barcoding, coupled with drones for quick surveying, and developments in predictive modelling based on presence-absence data, means that it is possible for the first time to derive global metrics of connectivity for multiple fish species and across taxa. To this end, the input of volunteers seems invaluable and AMBER has developed a comprehensive citizen science programme to facilitate the identification of barriers and the restoration of connectivity.
Session B3: Regional Evaluation of Barriers

Struggles for Flood Resiliency and Aquatic Organism Passage in Rhode Island: What Happened When Science Met a Dam’s Neighbors – A Rhode Island Case Study and Lessons Learned for Future Dam Removals

Ms. Rachael Weiter

Rachael Weiter is a Water Resources Engineer with Fuss & O’Neill, Inc., and as such is engaged in projects to evaluate fish passage and dam removal projects; design and construct fish passage structures; mitigate streambank erosion, investigate and repair dam and canal structures; and assess watersheds for opportunities to improve overall watershed health, including aquatic connectivity, flood resiliency, and water quality. Rachael completed her M.S. in Civil Engineering with a Specialization in Fish Passage Engineering at the University of Massachusetts Amherst, where she conducted research on the prioritization of stream crossings for removal within large stream networks, focusing on the benefit to aquatic organism passage and ecological connectivity.

Hurricanes Irene and Sandy were a wake-up call to many New England residents about the need for improved flood resiliency and emergency preparedness. Some flood risk reduction benefits have been achieved and are planned for those people who live and work along the Pawcatuck River in Connecticut and Rhode Island through a number of previous and upcoming dam removal and river restoration projects led by the Wood-Pawcatuck Watershed Association (WPWA) and The Nature Conservancy (TNC). These efforts were funded and designed to increase resiliency to flooding by reducing both the anticipated severity of flood impacts and the risk of catastrophic failure for these structures, thereby also reducing the potential threat to downstream roads, bridges, structures, properties, and human life within their inundation areas; while also improving aquatic organism passage and aquatic connectivity within this system and restoring free flowing river habitat. Recent assessments within the Wood-Pawcatuck Rivers Watershed have resulted in recommendations for the removal of additional targeted dams to further increase flood resiliency and enhance aquatic organism passage. There is opposition to some dam removal projects, even those in areas with a known history of flooding in residential areas that would significantly benefit from dam removal. As dam owners and communities search for ways to reduce flood risks along their rivers and streams by removing dams that are no longer serving their original purpose, it is important to engage landowners and stakeholders early when considering all options to remove, modify or repair these dams. Understanding the wishes and concerns of those living and working on these waterbodies, and effectively providing them opportunities to understand the alternatives available and to provide their input allows project proponents to make well-informed decisions and gives the best opportunity for maximizing reduction of future flood impacts, while retaining elements important to those most affected where possible.
Session B3: Regional Evaluation of Barriers

Denmark’s largest fauna passage and the integrated conflicts between stakeholders

Mr. Peter Adamsen

The specialty of Mr. Adamsen is consultancy in connection with nature restoration projects comprising detailed design, construction management and supervision. His portfolio comprises both large and small projects with the removal of barriers in stream and rivers, stream and river restoration; and establishing wetlands along streams and rivers. Mr. Adamsen has over many years acted as project manager within nature restoration. The projects have included initial conceptual design and feasibility studies and detailed design for construction works. Mr. Adamsen has special knowledge within connectivity in streams and rivers and with the fish's requirements in connection with fauna passage. In 2011 Mr. Adamsen was awarded First prize in the EFCA (The European Federation of Engineering Consultancy Associations) Young Professionals’ Competition on grounds of his ability to propose innovative solutions for nature restoration projects, particularly in connection with fauna passages at barriers/obstructions in rivers.

A large number of old hydro-power plants and water mills in our rivers and streams are outdated and no longer in operation. This arise the question: “What will be the best way to secure the connectivity in the rivers and streams.” During the lifetime of hydro-power plants, another type of habitat and nature has been established replacing the free-flowing river and its riparian areas. Often these hydro-power dams and watermill ponds have become vital elements for leisure time activity in the local communities. So whether to make a dam removal, a technical fish passage or a nature-like fish passage becomes an issue for a large number of stakeholders with different views. For the municipalities of Silkeborg, Randers, Viborg and Favrskov, Ramboll has carried out a feasibility study and plan for the future course of the River Gudenå at the 100 year old hydro-power scheme Tange. The plan consists of five proposals for redirection of the river to ensure a good fauna and fish passage for, amongst others, salmon and trout at the hydropower plant. The existing passage for fish is not working effectively for upstream passage and especially not for the downstream passage because the juvenile fish will have to navigate through 10 km of stagnant water where the predation from other fish and birds is very high. The five proposals vary between short and long passages but they all end up with the same conclusion: To establish a good fauna passage, the hydropower plant must be turned into a museum, as there is not enough water in the river to both sustain the hydropower plant and a functional fauna passage. The presentation will focus on the ecological aspects of the different fauna passages suggested in River Gudenå and on the master plan’s use in the political and stakeholder process.
Session B4: International Case Studies

The Dam Effects on the Distributions of Fish Assemblages and Water Quality on Yeşilirmak River (Turkey) using Principle Component Analysis

Dr. Bülent VEREP

Dr. Bülent VEREP is a researcher in the faculty of Fisheries and Aquatic Sciences. He graduated from marine science faculty of the department of fisheries technology engineering in 1992. And he had the degree of Master Science (1995) and Ph.D. (2000) from Institute of Natural and Applied Science of Karadeniz Technical University in Turkey. He has been working as a researcher and lecturer at Fisheries faculty and aquatic sciences, RTE University, for about 19 years in fishery ecology and water quality issues.

There are multiple effects of hydrological habitat changing like dams on river ecosystems. Transforming the river into a lake, dams interrupt the continuity of river flow to downstream, affecting the water quality with biodiversity and behavior of the species in the river stretch below the dam. An environmental filter through which only the species exhibiting strategies adapted to the new environment. In order to pass through environmental filter fish must adapted to, or they must able to change their diet and feeding strategy according to the nature of food present and hydrological movements in the new environment. Otherwise, they have to migrate to appropriate medium if they find on the river. A similar situation arises when two different dams (Suat Ugurlu and Hasan Ugurlu Dam Reservoirs) are built on the river in Yeşilirmak river basin. The aim of this study is the determination of dam effects on the fish populations distribution and the water quality of Yeşilirmak River (Turkey) using Principle Component Analysis. In this study, an assessment water quality varieties between lotic and lentic habitats on Yeşilirmak River (Turkey) will be presented. Seasonal samples were taken from April 2008 to July 2009 at 9 sampling sites in the stations of riverine and dam lakes built on the river.

According to the results of analysis of some water quality parameters; water depth, turbidity, current speed, chlorophyll-a and nutrients of water is very significant between dam and river sections of Yeşilirmak. Existing dams have formed spatial differences between river and lake areas in the Yeşilirmak river basin in terms of fish species distribution and fish food sources. According to the results; in general, the number of fish species in river areas is higher than in dam lakes. On the other hand, water quality data indicated that river and dam lake water had water quality classes ranging from 1 to 3. It seemed that intensive agricultural, industrial and anthropogenic activities could be responsible for creating this variability in water class level. Key words: dam effects, fish assemblages, water quality, PCA
Session B4: International Case Studies

The Upper Trisuli fish Passage: A Fish Ladder in the Upper Part of a Fish Migration Section of a Snow Feed River in Nepal

Mr. Ashok Baniya

Mr. Ashok Baniya did MSc. from Norwegian University of Science and Technology, Norway in 2013 and has specializing in Geography within Natural Resource Management Stream. Currently, Mr. Baniya is working with Nepal Water and Energy Development Company (NWEDC) as a Senior Environmental Manager which is developing Upper Trisuli-1 216 MW Hydro project with investment from Korean consortium, and IFC. Major outputs till date include facilitating fishery research, cumulative impact assessment for UT-1 project, setting socio-economic baseline and facilitating study on fish passage options, and eFlow management. He has an intensive working experience in the field of bio-diversity conservation, and sustainable development. Mr. Baniya has more than 16 years experiences of working in Conservation and Sustainable Development field which include among others, sustainable hydroprojects, conservation of wetlands, habitat management, NRM based green enterprises, and clean energy program.

The 216 MW run-of-river hydro power plant is located in upstream of the Trishuli River in Nepal (UT-1 HEP), and the developer is the Nepal Water & Energy Development Company Private Limited (NWEDC). As a part of the process to ensure compliance of the Upper Trishuli-1 Hydropower Project (UT-1HEP) with Nepal national regulations and the IFC’s Performance Standard 6: Biodiversity Conservation and Sustainable Management of Living Resource. A 30 m high weir is likely to create impassible barrier for upstream migration of migratory fish species. In this context, UT-1 is required to include some type of fish passage in the design of the UT-1HEP to enable passage of the two migratory snow trout species: Schizothorax richardsonii (the dominant species as per baseline studies) and Schizothorax prograstus both listed in vulnerable category of IUCN list. Both the pool type fish ladder with overflowing water combined with submersed orifices, and the vertical slot fish ladder is being designed as to Asala (shizotorax richardsonii) is a strong fish with good jumping and swimming characteristics with taking into account that low water temperature restricts the possibility of upstream migration. More importantly, with design modification in existing weir structure by letting the excess water flow trough flap gates at the left side of the dam close to the left bank as possible, spillway in ogee formed construction with a smooth concrete surface and with no obstacles, not steeper than 1:0.8 is in place. Also downstream the dam having a deep pool with volume and depth making the entrance for fish far less harmful aiming is to obtain a low grade of fish kill and injury of fish is under consideration.
Atlantic salmon kelt overwintering behaviour and spring migration rates in the Mactaquac Reservoir and Saint John River

Mrs. Amanda Babin

Amanda Babin is completing her doctorate as part of the Mactaquac Aquatic Ecosystem Study (MAES) being conducted by the Canadian Rivers Institute (CRI). She uses acoustic telemetry to understand migrations of Atlantic salmon smolts, adults, and kelts as they move through the Mactaquac Reservoir, the 100 km headpond of the Mactaquac Generating Station. Migration rates in the headpond could be suppressed due to reduced water currents, leading to migratory delay.

"Atlantic salmon (Salmo salar) adults migrate greater than 400 km up the Saint John River (SJR) to spawn. Fish may survive migration and spawning, spending winter in the river before returning to the ocean in spring. Adults which survive to migrate in spring are called kelts. Impeding this lifestage could be detrimental for the recovery of the population.

The SJR is impounded by three dams on the mainstem: Tobique Narrows, Beechwood, and Mactaquac Generating Stations (MGS). The reservoirs of water held have low water current which can disrupt the environmental cue for direction of migration. Fish may experience delays on their migration caused by reduced currents, dead-end tributaries, and dam passage. I will present research on kelt migration through the Mactaquac reservoir.

Post-spawned adults were acoustically tagged in November-December of 2014 (n=25) and 2015 (n=20), with 10 tags in each year including depth and temperature sensors. Fish were tracked by passive receivers (31 and 64, respectively) located throughout the SJR.

Winter mortality was between 25-40%. Fish had higher migration success rates when they entered the reservoir in the spring rather than the winter (67-80% vs. 0-40%, respectively). Kelts generally moved slower through the reservoir than downriver (mean ± SE: 19 ± 7 vs. 32 ± 6 km/d, and 6 ± 1 vs. 23 ± 6 km/d, respectively).

Results indicate that the MGS reservoir and dam cause some migratory delay of kelts, potentially impacting survival and spawning success."
Session B4: International Case Studies

Fish Passage Mitigation Toolbox

Mr Kelly Hughes

Kelly is an appointed member of the New Zealand Fish Passage Advisory Group. The NZFPAG is a selection of engineers, ecologists from both government and NGO organizations advising on new-build and mitigation for structures in waterways. As head of ATS Environmental, Kelly works with assessment and implementation of structures impacting on the passage of fish. Kelly also oversees the design and development of new and innovative solutions to aid in the reconnection of waterways. Improving water quality in eutrophic lakes is also a passion with some ground-breaking concepts under trial.

Over the past fifteen or so years a number of low-cost solutions have been developed in New Zealand to greatly improve the passage of mainly diadromous fish passed manmade structures in waterways. The challenge has been to meet the requirements of both ecology and engineering with minimal compromise. Perched or overhung culverts, tide-gates, velocity and/or low flow barriers are now able to be addressed with relative ease. Creating aquatic habitat within structures is now also an option and goes some way toward recovering habitat lost through urbanization. The aim of this presentation is to show the range of solutions that go much of the way towards removing the common excuses use to deflect initiatives to improve the passage or migration of a range of aquatic species.
Session B5: Ecological Consequences of Barriers

High stakes steeplechase in a changing climate: predicting travel time and prespawn mortality in spring/summer Chinook salmon in the Columbia-Snake hydrosystem and Salmon River Basin

Chris Caudill

Chris Caudill is an Assistant Professor of fish ecology in the Department of Fish and Wildlife Sciences at the University of Idaho. He and his colleagues primarily study behavior, migration and life history of anadromous fishes in the Columbia Basin.

Dams and adult salmon passage behavior have been intensively studied, yet the relationships between migration experience in regulated rivers and subsequent survival to reproduction remain unclear. We are combining behavior-based and energetic models, environment data, and future climate predictions to: 1) estimate 24 reach-specific travel times over the 1,155 km adult migration of threatened South Fork Salmon River Chinook salmon; 2) evaluate time and energy budgets in regulated, unregulated, and prespawn holding habitats; and 3) predict the probability of mortality caused by energetic depletion in relation to migration timing and thermal conditions. We characterized behavior of 2,350 fish at tailraces, fishways, and reservoirs of eight dams, and in a ~460-km unregulated section below spawning grounds. In a novel application, we used mixture models to describe the shifting proportion of “fast” versus “slow” migrants at dams. For total travel times that ranged from 23-109 d, The model successfully captured variability in total migration times to within 3% of observed times at the 5-95th quantiles (range = 23-109 d), and within 8% for individual reaches (range of times = 2-71 h). We are linking simulated travel times and thermal histories with a bioenergetic model to estimate energy content under thermal regimes representing recent average conditions, extreme observed conditions within the regulated section, and predicted future temperatures (year 2040) in the holding/spawning tributary. Model results indicate earlier migrants have lower energetic content at the onset of spawning and that prespawn mortality via energetic depletion will likely narrow the “window” of viable migration timing and conditions with climate warming. The integrated modeling approach estimates dam passage costs in relation to the entire adult energy budget for a long-distance migratory fish and is applicable for climate scenario modeling and/or to systems where slowed migration at dams may have delayed effects on fish survival or reproduction.
Session B5: Ecological Consequences of Barriers

Endangered Salmon and the Birds Who Love (to Eat) Them

Dr. Quinn Payton

Dr. Quinn Payton is a statistician and naturalist who earned his PhD from Oregon State University in 2015. He has extensive experience collaborating with wildlife biologists, geographers, oceanographers, and other environmental researchers. He has a broad range of specialties including nonparametric spatial and temporal analysis, hierarchical Bayesian analysis, spatially balanced survey design, autoregressive density dependence modelling, and sophisticated graphical presentation. In addition to his knowledge of a wide range statistical topics he is also an adept naturalist studying ethnobotany and wildlife tracking.

In the study of endangered salmonid (Oncorhynchus spp.) survival, accurate assessment of the causes of mortality at different temporal and spatial scales is paramount to prioritizing fish recovery plans. To address this need, we developed a novel hierarchical Bayesian model which allowed us to make simultaneous inference on fish survival and cause-specific mortality during passage throughout the Federal Columbia River Power System, USA. The model relaxes the assumptions inherent to standard mark-recapture models that requires precise knowledge of when or where tagged animals die following release, yet allows for spatially- and temporally-explicit rates, resulting in a more comprehensive understanding of specific threats to fish survival. We applied this model to a large group (n= 6,485) of juvenile steelhead (O. mykiss) that were tagged with passive integrated transponder (PIT) tags and released into the Columbia River. Subsequent recapture events of live fish at PIT-antennas and dead recapture events at multiple piscivorous waterbird colonies were used to increase the precision and accuracy of survival estimates compared with standard mark-recapture estimation techniques. Additionally, this model provided a way to estimate the impact of colonial waterbird predation on fish passage success. For instance, in estimating survival from Rock Island Dam until the last potential dam encounter at Bonneville Dam, credibility intervals from our model were 25% more precise than those produced by the standard CJS model. Furthermore, results showed 32.7% of the tagged fish succumbing to predation versus 39.9% surviving out-migration from Rock Island Dam to Bonneville Dam, indicating that predation from birds was a substantial source of mortality. This is the first comprehensive method of its kind for simultaneously estimating survival and cause-specific mortality rates based on encounter histories and dead recoveries of indeterminate time or place.
Session B5: Ecological Consequences of Barriers

Anadromous Fish Reintroduction in the Upper Columbia River Basin - An Overview

Mr. Stephen Smith

Stephen H. Smith has over 30 years experience in the Columbia River Basin working on salmon passage, production, and harvest issues. He has worked for the Bonneville Power Administration, National Marine Fisheries Service, and as a consultant for several Columbia River Basin Indian Tribes. He has been instrumental in the development and construction of the Confederated Tribes of the Colville Reservation salmon hatchery below Chief Joseph Dam; is an active member of the Hatchery Scientific Review Group; and has been a leading policy and technical advisor for Columbia Basin Tribes in the review and reconsideration of the Columbia River Treaty.

Habitat supporting annual production of millions of adult salmon and steelhead in the Columbia Basin was lost when, first Grand Coulee and then multiple dams were constructed on the upper Columbia River and its tributaries. At the time of dam construction, fish passage was deemed infeasible at high head dams. However, with recent improvements in fish survival at lower, run-of-river dams and new adult and juvenile fish passage technologies applicable to high head dams, anadromous fish reintroductions may now be viable. Native American tribes and Canadian First Nations are spearheading an effort to assess the viability of reintroductions; their joint paper on a comprehensive reintroduction outlines a concept for restoring anadromous fish populations above six projects in the U.S. and Canada. In its Columbia River Basin Fish and Wildlife Program, the Northwest Power and Conservation Council has included a phased approach to investigating and implementing fish passage at the two U.S. projects, Chief Joseph and Grand Coulee dams. The six-dam, comprehensive reintroduction is an issue being considered in modernization of the Columbia River Treaty between the U.S. and Canada. An overview is provided of the tribes’ anadromous fish reintroduction concept, Phase 1 reconnaissance work currently underway, and steps leading to potential field investigations with interim fish passage facilities (Phase 2).
Session B5: Ecological Consequences of Barriers

Using eDNA to Understand Changes in Aquatic Biodiversity Above and Below a Barrier

Dr. Brooke Penaluna

My research focuses on understanding the effects of climate change, contemporary forest harvest and disturbances on fish and both riparian and aquatic habitats, and more generally on the ecological linkages among water, land, and people. My goals are to use multiple lines of inquiry from various approaches to understand the complexities of fish and the aquatic and riparian world with implications for management and policy planning.

As aquatic biodiversity declines worldwide with many species already threatened, extirpated, or extinct, there is an urgent need for a rapid, accurate, and standard assessment of several aquatic species from multiple taxa. Many aquatic organisms are influenced by habitat modification and fragmentation due to barriers. However, traditional assessments of biodiversity above and below barriers require numerous surveys that are logistically and financially costly and require expert taxon-specific identification. Here, we use environmental DNA (eDNA) metabarcoding and taxon-specific targets to understand whether we can detect changes in fish, amphibians, aquatic invertebrates, and pathogens along a stream continuum, especially above and below a barrier. Preliminary results suggest utility for eDNA in identifying species from multiple taxa and tracking changes in aquatic biodiversity across a stream continuum above and below a barrier. Multiple primer sets focusing on different subsets of taxa are necessary to sample an aquatic assemblage in a reasonably comprehensive way. By using multiple genes, we find complementary views of species and improved differentiation among similar species because several gene sources offer multiple opportunities for genetic variation. Our work broadens the scope of eDNA research by informing conservation and management decisions for a wide range of taxonomic groups, including endangered, rare, and cryptic species. Ultimately, this will allow for data-driven prioritization of conservation actions for all aquatic species.
Session B6: Prioritization

Salmon Superhighway: Fish, Habitat, and Community Connections at a Landscape Scale

Dr. James Capurso

James Capurso has worked as a professional Fisheries Biologist for the USDA Forest Service for more than 30 years in Idaho, Washington, and Oregon. He has experience at the National, Regional, Forest, and District levels of the agency. He is currently serving as the Regional Fisheries Biologist for the Pacific Northwest Region of the Forest Service that includes Oregon and Washington. As a Fisheries Program Manager, he emphasizes the protection and restoration of native fish and their habitat, including protecting and restoring migratory life history components of fish populations. The Regional Fisheries Program has strong professional ties with Regional Engineers and Hydrologists to support an emphasis on aquatic organism passage (AOP), including maintaining an AOP design assistance team and providing training and resources to the Forests for AOP project design, planning, and implementation. With a Ph.D. in Water Resources Management, Policy, and Law, Capurso has an interest in water resource policy and law, particularly relative to the restoration and protection of instream flows.

The Salmon SuperHighway (SSH) partnership was formed to prioritize passage at multiple scales, concentrate restoration resources, and develop and use a passage barrier database to prioritize and present a portfolio of opportunities. Program managers from several federal and state agencies and NGOs gathered to apply these concepts to a common priority subbasin in the Pacific Northwest, the Tillamook and Nestucca River Drainages of the Oregon Coast. Drainage selection parameters included high quality habitat, fish species diversity, landownership mix, and an existing active restoration partnership community. Passage databases were combined and enhanced to develop a passage portfolio that set passage priorities at a landscape scale while incorporating biology and treatment costs. A model (O’Hanley 2011) was used to prioritize projects and define a point of diminishing returns. 270 anthropogenic barriers were identified but the treatment of 63 barriers would return access to 95% of the blocked fish habitat. Considered a demonstration project, the SSH includes monitoring to facilitate learning and future application elsewhere. A special emphasis was placed on the human dimension of the watersheds with coordination at all levels of the partnership, facilitating ownership from key community members, and enhancing fundraising and marketing capabilities. For more information: http://www.salmonsuperhwy.org/
Session B6: Prioritization

*Strategic Culvert Replacement: a catalyst for Habitat Enhancement, Community Development and Improving Socio-Ecological Resiliency*

Scott Bailey

Scott is currently a Project Manager for the Tillamook Estuaries Partnership in Garibaldi, Oregon. His work there primarily includes developing and implementing habitat restoration projects and completing project effectiveness monitoring. He also helps with other TEP programs including its environmental education work. Scott earned a B.S in Biology from Idaho State University and a M.S. in Wildlife and Fisheries Sciences from the University of Arizona. He has over 30 years of professional experience, including work with State, Federal and Tribal resource management agencies; academic institutions; private consulting firms and environmental NGOs in Oregon, Idaho, Arizona, New Mexico, California, Nevada and Utah.

Strategic culvert replacement can be a catalyst for habitat enhancement, community development and improving socio-ecological resiliency. I will present published principles for building resilience and sustaining ecosystem services in social-ecological systems and identify how strategic culvert replacement is consistent with these principles. I will briefly introduce the Salmon SuperHwy project (a collaborative, landscape-scale effort to replace barrier culverts in the Tillamook and Nestucca basins on Oregon’s North Coast) and focus on Patterson Creek - a small, direct-to-bay tributary to Tillamook Bay – as a case study. The headwaters of this small watershed are on state-owned land and its lower reaches flow through the small town of Bay City. Despite having eight passage barrier culverts, the basin continues to support small runs of several anadromous fishes, including federally threatened Oregon Coast coho. However, over two miles of suitable stream habitats are currently unavailable for anadromous fish use due to the existing barriers. In addition to impeding aquatic organism passage, the culverts in this basin are susceptible to plugging and catastrophic failure, which threatens public health and safety. The condition and configuration of these crossings also adversely affects the ability of the community and the stream ecosystem to respond to, and recover from, disturbances. I will report on baseline studies conducted to facilitate replacement of all barrier culverts in the watershed and on work to identify in-stream and riparian enhancement and education/outreach opportunities to complement culvert replacement and increase conservation benefits in the basin and beyond.
Session B6: Prioritization

Watershed-based Planning to Enhance Flood Resiliency and Ecosystem Benefits in New England and New York

Ms. Rachael Weiter

Rachael Weiter is a Water Resources Engineer with Fuss & O’Neill, Inc., and as such is engaged in projects to evaluate fish passage and dam removal projects; design and construct fish passage structures; mitigate streambank erosion, investigate and repair dam and canal structures; and assess watersheds for opportunities to improve overall watershed health, including aquatic connectivity, flood resiliency, and water quality. Rachael completed her M.S. in Civil Engineering with a Specialization in Fish Passage Engineering at the University of Massachusetts Amherst, where she conducted research on the prioritization of stream crossings for removal within large stream networks, focusing on the benefit to aquatic organism passage and ecological connectivity.

In watersheds that have historically been impacted by flooding or that were severely impacted by Hurricanes Irene or Sandy, and with the observed uptick in frequency and severity of flooding that is anticipated to continue due to climate change in the northeastern U.S., many communities in New England and New York are taking steps to address flood risk and improve ecological connectivity through watershed-based planning. Fuss & O’Neill, working with local and regional partner organizations, is leading three major watershed-based flood resiliency planning projects, in the Wood-Pawcatuck Watershed in Connecticut and Rhode Island; in the Deerfield River Watershed in Massachusetts, and in the Saw Kill Watershed in Upstate New York. The project team is conducting a comprehensive assessment of each watershed and developing holistic watershed plans that may be used by the watershed communities to target projects that will enhance flood resiliency and ecological resources through the use of natural system solutions and environmental land use planning where appropriate. Efforts include field assessments of dams and road stream crossings, stream geomorphic assessments, assessment of natural green infrastructure including wetlands and forests, as well as hydrologic and hydraulic analysis and risk and prioritization analysis. This presentation will discuss commonalities and differences between these projects as well as lessons learned.
Session B6: Prioritization

Measuring performance of nature based solutions to demonstrate multiple benefits for fish and people

Alison Bowden

My work focuses on developing and implementing innovative science and policy tools to protect and restore rivers and estuaries, as well as linking freshwater and marine conservation for migratory fish. I work on a wide range of policy issues including transportation, environmental permitting, water resource management and fisheries management. I'm a member of the NOAA River Herring Technical Expert Working Group, ASMFC Shad and River Herring Advisory Panel, and Taunton River Wild and Scenic Stewardship Council.

Ninety-six percent of the total U.S population lives in a county that has experienced a federally declared, weather-related disaster in the last several years. One of the biggest threats to our coasts and rivers is development in flood-prone areas combined with efforts to protect these developments with seawalls, dikes, dams or levees to control water. These structures are often built in streams and wetlands where they destroy valuable habitat and block natural processes. These ‘hardened’ structures can put a chokehold on rivers by constraining their flows. Often overlooked is the role that nature itself can play instead of, or alongside seawalls or dams and levees. We are safer when rivers have more room during floods so floodwaters can disperse and slow down across their floodplains. Along our coasts, natural features like sand dunes, wetlands, and oyster reefs reduce wave heights and moderate storm surges in addition to providing fish habitat. Most investments in ‘grey infrastructure’ solutions for disaster risk reduction focus on single purpose – dams, levees and seawalls are meant to hold back water or prevent land erosion. Natural features or ‘nature-based infrastructure,’ such as oyster reefs, floodplains, coastal wetlands, etc. can also perform these functions yet do so in a way that provides multiple additional benefits. To build the case for nature based approaches, it is essential to engage communities about their goals and evaluate the social, economic and environmental outcomes of natural infrastructure projects. This talk will explore how measuring outcomes can improve our understanding of how to site, build and monitor these approaches, and by using a more standardized set of performance measures across projects we can gain a broader perspective on success of projects at multiple scales to protect and restore fish populations while meeting other social and economic goals.
Session B6: Prioritization

Using Prioritization Tools to Advance River Restoration On-the-Ground

Amy Singler

Amy works in a shared position for American Rivers and The Nature Conservancy’s Connecticut River Program managing dam removal projects and directing policy and partner building to improve river restoration in New England. She also leads national culvert and stream crossing policy and implementation efforts. Amy has also worked for the Massachusetts state rivers program where she was a project manager and outreach coordinator, working statewide to promote river protection and implementation of restoration projects. Amy has a B.S. Ecology and Evolutionary Biology from the University of Rochester and a M.S. in Water Resources Management from the University of Wisconsin, Madison.

Fish Passage 2017 Amy Singler, American Rivers and The Nature Conservancy. Dam Removal is arguably the most effective tool we have for restoring and reconnecting river habitat for fisheries. While some of the more than 80,000 dams in the United States provide important water supply, flood control and recreation functions, most no longer serve the original purpose for which they were built. In the last decade an increasing number of dam owners are choosing to remove rather than repair and maintain their dam. We know that dam removal will benefit river habitat, improve water quality, and increase connectivity, and in many cases also make our communities better adapted for changing stream flows. As resource managers and practitioners we want to ensure that our effort is directed to projects that will have the most improvement for aquatic habitat connectivity given our restoration dollars. In the last several years a number of different tools have been developed to prioritize dams for removal and help with project decision making. In many cases tools that appear to have similar goals, give different results, causing some confusion as to which tool to use and how to identify projects. Using examples from the northeast, this presentation will: 1.) discuss how to get past the debate over prioritization outputs; 2.) demonstrate how these tools have been used successfully to identify new projects and build partnerships; 3.) showcase the success of these types of tools for river restoration.
Session B6: Prioritization

*Enhanced Aquatic Connectivity in the Great Lakes through Regional Collaboration*

Ms. Lisa Walter

Lisa Walter is the Commission's Strategic Coordinator for the Upper Midwest and Great Lakes Landscape Conservation Cooperative's Aquatic Habitat Connectivity Collaborative. The Collaborative works to harness the capacities, expertise, and abilities of a diverse set of partners in support of common conservation outcomes for aquatic connectivity in the Great Lakes basin.

In the Great Lakes region, barriers fragment riverine habitat and impede movement of aquatic organisms within riverine systems and between the Great Lakes and tributaries, reducing genetic diversity, and impeding energy transport and nutrient flow. However, some barriers provide system benefits by: assisting with the control of sea lamprey and other detrimental invasive species, thereby protecting threatened, endangered, or vulnerable native species; preventing upstream contaminant spread; and, decreasing pathogen spread. There is increasing interest to remove or bypass barriers including dams and road stream crossings to reconnect aquatic habitats that are public trust resources regulated and managed by various governments and private owners. As such, agencies are reviewing an increasing number of proposals to remove or modify barriers, and funders have expressed difficulty in deciding which projects to fund. A suite of decision support tools intended to facilitate prioritization of connectivity restoration projects have been developed, and pairing them with agreed-upon restoration priorities to advance coordination, focus, and awareness of larger-scale impacts is vital to their relevancy. The Great Lakes Aquatic Habitat Connectivity Collaborative brings together federal, provincial, state, and tribal agencies, non-government organizations, researchers, and funders to establish agreed-upon connectivity targets, identify, and address limiting factors related to regional connectivity decision making in the Great Lakes.
Session B7: Culvert & Tide Gate Passage

Fish Passage Culvert Designs and Retrofits – Case Studies from the Pacific Northwest

Mr. Adam Zucker

Adam Zucker is a registered water resources engineer and certified water rights examiner with 19 years of experience working out of Environmental Science Associate’s Portland office. Adam has B.S. in Environmental Engineering and Agricultural & Life Sciences from Cornell University. He has extensive management experience and expertise in stream restoration design, bridge hydraulics, and hydraulic and hydrologic modeling. One of his primary professional focuses includes the design and retrofitting of culverts throughout the Northwest in order to provide fish passage. He is intimately familiar with fish passage design guidelines for Washington Department of Fish and Wildlife (WDFW), Oregon Department of Fish and Wildlife (ODFW), and National Marine Fisheries Service (NMFS) and routinely works with the staff from these agencies to develop appropriate fish passage approaches. Adam combines his technical experience in civil and environmental engineering with his background in fluvial geomorphology to identify the most effective solutions for water resource projects throughout the Pacific Northwest.

A primary factor in the precipitous decline of salmon and steelhead in the Columbia River basin (CRB) has been barriers to fish passage and, more specifically, culvert barriers. According to fish barrier inventories performed by the Pacific Northwest Forest Service districts, up to 80 percent of culvert crossings fail to provide fish passage at all life stages of endangered fish species. Currently, the preferred method for fish passage is to simulate the geomorphology of the stream through the culvert. Engineers and municipalities have to balance the stream simulation design while balancing multiple design criteria and constraints, including restricted right-of-way; limited resources; and existing infrastructure. Designing within the confines of these constraints while meeting fish passage criteria, requires creative and innovative approaches to fish passage design. This presentation will highlight lessons learned from the design, construction, and post-project monitoring of recently completed culvert projects. Design constraints and challenges addressed will cover: • Retaining sediment in steep culverts • Reducing scour potential in bottomless culverts • Working in urban systems • Addressing perched inlets • Incorporating design elements to be consistent with the characteristics of the site This presentation hopes to share these case studies in an effort to benefit other municipalities, stewards, designers, regulators, and construction teams with the mutual goal of restoring our native salmon and steelhead species.
Session B7: Culvert & Tide Gate Passage

*Drop height and water velocity as determinants of successful culvert entry and passage for Coastal Cutthroat Trout*

Mr. Peter Drobný

Peter Drobný is a fish biologist with a strong focus on salmonids with over 5 years’ professional experience. He received his undergraduate degree in Biology with a concentration in Evolution, Ecology, and Conservation from California State University, Sacramento in 2012. During and following his degree he worked as a Scientific Aide for California Department of Fish and Wildlife conducting angler surveys in the Sacramento, Mokelumne, Calaveras, American, and Feather Rivers. He also used hook and line sampling for acoustic tagging and tracking of steelhead in the lower American River, CA. Prior to graduate school, Peter spent 3 months working on the Southwestern Alberta Grizzly Bear Monitoring Project in Canada. He received his Master’s degree in Natural Resources with an emphasis in Fisheries from Humboldt State University, California in spring 2016 through the California Cooperative Fish and Wildlife Research Unit. In his MS thesis and since starting with West Fork Environmental in August 2016, Peter has been involved in a variety of fish movement, passage, distribution, and survival studies with a variety of roles including study design, data collection, analysis, and reporting.

An experimental culvert test bed facility located at the Washington Department of Fish and Wildlife Skookumchuck Fish Hatchery was used to test the ability of fish to enter and pass through a 6-foot round corrugated metal culvert. The effects of water velocity, drop height, fish fork length, and preceding unsuccessful entry attempts were evaluated to assess successful culvert entry, forward progress into the culvert and successful passage through the culvert. Wild Coastal Cutthroat Trout captured from tributaries of the Skookumchuck River were PIT tagged for use in our experiments. Passage of fish through the test culvert was measured using PIT tag antennas at the entrance, mid-way into the pipe and at the exit. Additionally an antenna was located extending over the holding pool so that fish were detected attempting to enter the culvert. Fish that did not make an attempt were excluded from the study (13.2% of total). Binomial generalized linear models were used to determine the odds of a fish successfully landing in the culvert, establishing forward progress in the culvert and passing through the entire 40 foot length of the culvert. Odds of successful culvert entry, given an attempt was made, increased as fork length increased and declined as drop height and velocity increased. Odds of successfully passing mid-way through the culvert, given a fish successfully entered the culvert, declined as preceding unsuccessful entry attempts increased. Odds of successfully passing through the culvert, given successful passage to the mid-way point, increased as fork length increased and declined as preceding unsuccessful entry attempts increased. Odds of successfully passing through the culvert, given an attempt was made, increased as fork length increased and declined as drop height, velocity, and preceding unsuccessful entry attempts increased. Empirical studies testing fish passage, such as this one, can inform current culvert assessment protocols.
Session B7: Culvert & Tide Gate Passage

Fish Passage at Intertidal Obstructions

Mr. Padraic Smith

Name: Padraic Smith P.E. Job title: Environmental Engineer Current employer: Washington State Department of Fish and Wildlife, Habitat Program, Restoration Division Location: Olympia, WA Experience related to Fish Passage: Pad has worked professionally in the water resources industry for nearly 25 years. Pad has a strong background in hydraulics and hydrology, geomorphology of riverine and marine systems, as well as many years of experience with fish passage related issues. Currently, he is employed as a fish passage and habitat restoration engineer at the Washington State Department of Fish and Wildlife. Pad has co-authored and contributed to many of the Washington State Aquatic Habitat Guidelines publications that are often referred to as standards for design within aquatic ecosystems well beyond the boundaries of Washington State. He has designed and implemented a broad range of habitat restoration projects focusing on fish passage, habitat connectivity, side channel and groundwater channel development, large woody material, estuary restoration, tidal connectivity, and nearshore projects to protect threatened and endangered species of salmonids in throughout Washington State. Pad is currently pursuing projects to assess fish use and passage in tidal and estuarine areas as well as geomorphic impacts to fish passage through long culverts.

Fish Passage at Intertidal Obstructions: Washington State has an active fish passage barrier correction program, with millions of dollars spent annually on fish passage barrier remediation. Tidal water crossing structures, including culverts, bridges, tidegates and control structures pose a unique problem for assessment and design for fish passage and estuarine habitat connectivity. Current fish passage criteria was developed primarily to allow adult salmon access to upstream spawning habitat and is based on adult fish swimming capabilities during the flow range expected during the period of migration. The hydrology of freshwater systems includes flooding periods that are infrequent and unpredictable. Tidal hydrology, on the other hand, is very predictable, frequent and persistent. Except during periods of peak flooding, the magnitude of the bi-directional flow created by tidal hydrology at intertidal crossing structures often dominates the freshwater contribution. Although tidal events may naturally prohibit migration at some periods of the tide, obstructions can further reduce migration periods, particularly for juvenile salmon, due to increased velocities from undersized culverts or water crossing structures. Little is known about to what extent fish behavioral ecology is modified or how to assess the duration and extent of negative effects to fish migration during the tidal cycles. In an effort to begin the process of developing barrier assessment and fish passage design guidelines, Washington State has partnered with NOAA to perform a literature review of documents relevant to fish behavior and use of intertidal areas and the impacts of intertidal obstructions This presentation will provide an overview of the current procedures being utilized at the Washington State Department of Fish and Wildlife as well as issues relating to the assessment of intertidal culverts for fish passage. Data collected at numerous intertidal obstruction sites throughout Washington State and potential impacts to fish passage and habitat will be presented.
Session B8: Telemetry I

Tracking Adult Chinook Salmon Passage in the White River, Washington

Mr. Phil Hilgert

Mr. Hilgert is an aquatic scientist with more than 35 years of experience with salmon and water control projects. In addition to managing upstream and downstream fish passage projects, he has served on eight Technical Advisory Committees evaluating salmon and steelhead fish passage feasibility.

Mud Mountain Dam (MMD) is a 432 ft-high flood control dam on the White River in Washington State completed by the U.S. Army Corps of Engineers in 1948. In 1949, an adult fish trap and transport facility was added to an existing low head diversion located 6 miles downstream of MMD. The downstream diversion structure had been constructed in 1912 to divert river flow to an off-channel reservoir and hydropower project. All fish entering the trap are enumerated and transported upstream for release above MMD, unless otherwise removed by fisheries managers. We evaluated the survival of ESA-listed spring Chinook and bull trout trapped, transported and released above MMD, and described the timing and extent of their migrations between June and October 2014 in the upper White River and its tributaries. Biologists implanted radio tags surgically in 37 bull trout, and esophageally into 185 Chinook salmon and released the fish above MMD. Mobile tracking surveys and eleven fixed telemetry receiver stations were used to track fish movement throughout the basin. Seventeen of the 185 Chinook were subsequently detected downstream from MMD and were considered fallbacks. Eleven of these 17 Chinook were detected near the diversion dam, one of which re-entered the trap and was again transported above MMD. Overall, 99% of tagged Chinook were subsequently located and tracked. Those that migrated above MMD were found to use both mainstem and tributary habitats in equal numbers. Nine bull trout were tracked moving below MMD, however, no bull trout were detected in the river below the diversion dam after release. The results of this study provided the Corps with a better understanding of fallback rates through MMD and the overall survival rate and spawning distribution of transported Chinook salmon and bull trout in the White River watershed.
Session B8: Telemetry I

Evaluation of Two Acoustic Telemetry Signal Types on Fish Passage Studies

Mr. Tracey Steig

Tracey Steig is the General Manager for HTI-Vemco USA, Inc. Tracey has a Bachelor of Science and Master of Science degrees in Civil Engineering from the University of Washington. He has conducted hundreds hydroacoustic and acoustic tag studies worldwide since 1982. Prior to becoming General Manager, Tracey was the Project Engineer for the acoustic tag fish passage studies conducted at Rocky Reach and Rock Island dams on the mid-Columbia River for over a decade.

Acoustic telemetry methods are routinely used in fish passage studies to estimate the survival, behavior and distributions of tagged fish. The ability to reliably and consistently detect and identify the acoustic tags are intrinsic to the calculation of these metrics. This ability to detect tags is often evaluated by estimating the maximum detection ranges of the acoustic tags. There are many factors that affect the acoustic tag detection ranges including (but not limited to) the following: 1) the acoustic tag signal type; 2) the acoustic tag transmit power level; 3) the acoustic tag transmit pulse width; 4) the acoustic tag frequency; 5) the signal absorption as a function of frequency; and 6) the environment acoustic background noise levels, which can vary over time. This presentation will evaluate two commonly utilized tag signal types. The primary comparison will be of the detection ranges for each of the signal types. The factors that affect detection range will be compared for acoustically quiet and noisy environments. The minimum number of detections for each tag type will be investigated, and its effect on the detection ranges to provide a baseline detectability. Then the tag velocity will be evaluated to provide an overall tag detectability. All of the presented results will be used to show the implications associated with number and placement of receivers and data collection parameters required to provide adequate detectability and ultimately on the results of acoustic telemetry studies.
Session B8: Telemetry I

*Going beyond visible light: monitoring adult fish passage in turbid conditions with technological advancements and a sense of public outreach.*

Ryan Cuthbert

Ryan Cuthbert is a fisheries biologist with 20 years of salmonid research, monitoring and restoration experience. Prior to joining FISHBIO Environmental, Ryan was a Fisheries Biologist with experience collecting and analyzing fisheries monitoring data that encompasses multiple lifestages of Central Valley salmonids. Ryan has supervised and implemented a variety of fish population and passage research projects in Bay-Delta watersheds that encompass all aspects of field sampling and data analysis, including electrofishing, seining, snorkel survey, habitat surveys, portable resistance board weirs, DIDSON/ARIS monitoring, acoustic telemetry, Vaki Riverwatcher monitoring, rotary screw trap monitoring, and mark-recapture studies. He has authored/co-authored technical reports, as well as, authored/co-authored multiple monitoring protocols. Ryan has used this extensive range of knowledge to evaluate existing and prospective salmonid life cycle monitoring programs and developed a decision matrix as tool for determining the effective and efficient method for monitoring at different locations.

The Vaki Riverwatcher infrared fish counting system (RW) has been used throughout the world to monitor fish in a variety of conditions and in various unique installations. The first RWs were installed in West Coast rivers in the early 2000s. Although most of the original RW installations are still active today, many of the following adjustments have been made to improve RW functionality and operational capacity. Remote connectivity was added to decrease data collection effort at remote installations by increasing the time period between checks. An underwater camera was also added to improve identification certainty in rivers with multiple species. Portable weirs have been used to expand the operational capacity of the RW to wider, deeper rivers with fluctuating flows. A camera tunnel was configured to improve the quality of the videos/photos. Different configurations and dimensions of the infrared scanner were also implemented to accommodate more unique installations. An air-filled chamber camera housing was configured to the RW to improve the quality of video/photos during high turbidity events. Changes were also made to the RW software to allow users to record videos/photos for downstream passages without the purchase of additional equipment. Cloud-based software (Riverwatcher Daily) was developed to help users share data more easily, as well as provide a platform for individuals interested in public relations. Finally, PIT Tag antennas are now integrated into the RW so that each PIT tag detection through the RW so that size, sex, condition, and other information can be collected. These changes have given researchers more opportunity to monitor larger rivers with multiple species under unique environmental conditions, and in unique installation configurations.
Session B8: Telemetry I

Estimating salmon escapement across the Snake River basin: a novel approach using PIT tags

Dr. Kevin See

Kevin is currently a biometrician working on threatened and endangered salmon stocks in the interior Columbia. Recent research has encompassed a wide variety of analyses focused on evaluating the effects of habitat restoration on populations’ productivity in the Northwest. Other focuses have included informing monitoring designs, state-space time-series models, marine stock assessment, and forecasting the spread of invasive species.

Estimates of salmonid adult escapement are crucial to evaluating the status of threatened populations, the success of recovery programs and the productivity of populations. In the Columbia Basin, these estimates are often made using redd counts or mark-recapture models from weir data, but these methods have limitations. Redd counts have (potentially) unknown observation error, and weirs can only be placed in certain locations. As an alternative method, we developed a branching patch-occupancy model (Royle & Dorazio, 2008) within a Bayesian framework that relies on adult salmon being PIT tagged at Lower Granite dam and subsequently re-detected by the extensive array of instream PIT tag antennas across the Snake River basin. This state-space model estimates the probability of fish moving past each detection point, as well as the probability of detection at each site and can then be used to estimate escapement at a variety of spatial scales across the entire basin. Estimates of steelhead and spring/summer Chinook from spawning years 2010 – 2015 compared favorably with independent estimates at a variety of locations, validating the model results.
Session B9: Telemetry II

Evaluation of the effectiveness of upstream fish passage facilities in the River Rhine assessed using a PIT-tagging study

Dr. Armin Peter

Studies in biology at ETH Zurich. Ph. D. in fish ecology at eawag (aquatic research) and ETH Zurich. Post-Doc at the University of British Columbia, Vancouver BC, Canada. Until 2014 senior researcher at eawag. Research focus: fish ecology, fish migration, population dynamics, river restoration, impact of hydropower on fishes. Lecturer at ETH Zurich (Swiss Federal Institute of Technology) for fish biology. Since 2015 director of Peter FishConsulting. Applied studies in fish ecology, fish migration and hydropower effects on fishes.

Swiss rivers have great deficits concerning longitudinal connectivity. Many artificial barriers impede the upstream and downstream migration of fishes, mainly at hydropower plant facilities. Hydropower plays an important role in energy production in Switzerland. However, the new Swiss Water Protection Act requires the Cantons to restore the connectivity of fragmented river habitats by installing or improving passage facilities. All hydropower plants must be remediated by 2030. Migration facilities are regularly monitored in large rivers with consecutive hydropower plants. The Rheinfelden hydropower plant is situated on the River Rhine (Switzerland/Germany) and has one technical fish pass (vertical-slot) on the left bank and one 900 m long nature-like fishway on the right. A PIT-tag study was performed to assess the effectiveness of the two migration facilities. In summer 2016, 2042 individuals (19 fish species) were PIT-tagged and released at fixed sites in the tail water. The vertical-slot fishway had only one entrance, while the nature-like fishway had three. The study aimed to investigate the use of different entrance locations, to measure the time taken for upstream migration, and to evaluate the rate of fishes turning back in the migration facilities. Attraction and passage efficiencies were also documented. Attraction efficiency of the entrance locations was good for barbel, chub and bleak. Passage efficiency was very good in the vertical-slot pass and good or very good in the nature-like fishway. The PIT-tagging study showed that the existing trapping device to count fish manually are problematic. 36–85% of the fish in the trapping device left the trap and migrated downstream. Injuries caused by the fish traps, mostly to barbel, chub, bleak and roach, were also recorded. The PIT-tagging study provided useful results for assessing passage efficiency and identified problems related to trapping and manual counting of fishes.
Session B9: Telemetry II

Predation of Atlantic salmon (Salmo salar) by the European catfish (Silurus glanis) in a Fishway: analysis by video and acoustic camera and RFID telemetry.

Dr. Eric De Oliveira

Dr Eric De Oliveira joined in EDF in 2005 as engineer-researcher in biology. He is involved in the fish passage project at hydropower plant. His research area covers migration dynamics of fishes, fish behaviours (according to passage devices) and fish passage design using telemetry methods (i.e. radio tracking, RFID, acoustic tracking) and other methods such as optical and acoustic cameras. With other department form EDF Lab., he develops new environmental monitoring system, such as remote sensing for seabed habitat or using acoustic methods to measure the passage efficiency in fish passage devices. Before joining EDF, from 1996 to 1998, he was in subantarctic island (Crozet Archipelago), in charge of the field activities of the project “Biodiversity evaluation and ecosystem transformation in a subantarctic island”. After, he did a PhD on fish stock assessment and especially using the geostatistical approaches. In 2003, he did a postdoc in IFREMER which was part of an Interreg Project. The subject of the postdoc was to develop and build methods and model to predict the distribution of seabed habitat.

Due to their strong association with human activities, freshwater ecosystems have been the recipients of numerous non-native species, with fishes being among the most frequently introduced freshwater organisms. Introductions of large-bodied predatory fishes are known to impact native fish populations and modify prey community and food web structure (Vander Zanden 1999; Eby et al. 2006; Sagouis et al. 2015). An emblematic example of an introduced megafish is the European catfish Silurus glanis that is now present in western and southern European freshwaters. The European catfish can measure over 2.7 m total length and weight 130 kg (Boulêtreau and Santoul, 2016), making it by far the largest species by length and mass in their introduced range where they are considered a ‘giant’ top predator. So this species could become new predators to adult native fish including anadromous species, which normally reach a size-refuge against native predators such as pike (Esox lucius). Near obstacles, such as dam or hydropower plant, density of predators and passage delayed of fishway are increasing which are suspected to increase artificially the predation rate by a specialization predator behavior. European catfish predation inside the fish pass has been observed directly at the Golfech Hydropower Plant in the Garonne River (Southwest France). In this study we quantify the predation on Atlantic salmon (Salmo salar) by the European catfish inside the fish ladder based on video counting windows and acoustic camera. We also analyzed predation strategy of these new predators by observation with acoustic camera and RFID telemetry. Trophic specialization of some individuals was observed and analyzed in order to identify a protection strategy for salmon in the fishway.
Session B9: Telemetry II

*Acoustic telemetry development for fish passage*

Dr. Daniel Deng

Dr. Deng is a Chief Scientist in Energy & Environment Directorate at PNNL. He is active in the development and application of experimental and numerical modeling tools for conventional hydropower and marine and hydrokinetic renewable energy systems. He directs the Bio-Acoustics & Flow Laboratory (http://bfl.pnnl.gov/) at PNNL, an accredited multi-disciplinary R&D laboratory. He was selected as one of 78 outstanding young engineers in the U.S. to participate in the National Academy of Engineering’s Annual Symposium on Frontiers of Engineering in 2012. He was awarded the PNNL Laboratory Director’s Award for Exceptional Engineering Achievement in 2015. He has co-authored more than 90 journal articles and is an editor or board member for four peer-review journals. He holds a PhD in Theoretical and Applied Mechanics from University of Illinois at Urbana-Champaign.

Acoustic telemetry has been identified as a technology to observe and assess the behavior and survival of various fish species. However, the size and/or nature of the existing transmitters limits their usefulness for studying certain fish types and sizes, introducing a potential bias to the study results. Therefore, we developed several tags, each with unique size and function. In 2014, we developed the first acoustic transmitter that can be implanted by injection instead of surgery. It is 15.00 mm in length and 3.35 mm in diameter, and weighs 216 mg in air. The tag can last > 100 days at a pulse rate interval of 3 s. Little is known about the behavior and habitat use of small juvenile (< 1 year old) sturgeon. Their small size has precluded intensive research using telemetry techniques because the transmitters commercially available are too large, have too short of a lifetime, or have an inadequate ping rate. We developed a new acoustic transmitter for juvenile sturgeon. The sturgeon tag weighs approximately 700 mg in air, is 5.0 mm in diameter and 24.2 mm in length. Its source level can be up to 163 dB re 1 µPa compared to the 156 dB for the injectable tag. It has a tag life of 365 days at a source level of 161 dB and a PRI of 15 s. We developed a self-powered acoustic transmitter (patent pending) that uses a flexible piezoelectric beam to harvest mechanical energy from the swimming motion of fish as the transmitter’s power source. It is 5.3 mm wide and 1 mm thick. Piezoelectric beams of various lengths can be used in this transmitter. It was successfully demonstrated in white sturgeon and rainbow trout in the laboratory. A field trial with juvenile white sturgeon will be conducted in the Snake and Columbia Rivers in 2017. Knowledge of juvenile eel and lamprey behavior and survival are critical for developing mitigation strategies for dam passage, including design of bypass systems at hydroelectric facilities. In 2016, we completed the design of an acoustic micro-transmitter (patent pending) that can be used to study the behavior and survival of juvenile eel and lamprey. It is 2 mm in diameter and 12 mm in length. It weighs 0.08 g in air. The prototype tag lasts 20 to 30 days at 5-s ping rate interval. Implantation protocols were developed for juvenile pacific lamprey and American eel. We will conduct a pilot-scale field trial tagging juvenile eels and lampreys in collaboration with industry partners and other agencies in 2017.
Session B9: Telemetry II

Evaluation of Juvenile Salmonid Passage and Behavior at Foster Dam Utilizing Radio Telemetry, 2015 and 2016

James Hughes

James Hughes has been a scientist in the Energy and Environment Directorate at Pacific Northwest National Laboratory since 2004. In his current role, he is responsible for developing new and maintaining existing client relationships through proposing, managing, and delivering research findings to a diverse client base. He serves as one of the primary client relationship managers for PNNL’s research activities in the Willamette River Valley. In this role, he is responsible for coordinating communication and identifying current and emerging research opportunities.

The goal of this study was to provide fish passage information for juvenile Chinook salmon and juvenile steelhead at Foster Dam (Foster) to support decisions on long-term measures and operations to improve passage conditions at the dam. Passage data for juvenile salmonids (route of passage, residence times, survival, and passage proportions) will ensure biological risks to downstream-migrating fish are minimized. Areas of particular interest for this study included passage routes at the spillway, fish weir (Spill Bay 4), and turbines. Radio tagged fish were released equally at mid- and head-of-reservoir (2 km and 4 km upstream of Foster, respectively). Radio tags were evenly distributed across 5 frequencies in a 1 Mhz band (166.500 – 167.495) and burst rates were staggered across all frequencies (4.5– 5.2 sec). Further randomization occurred between release locations, frequencies, codes, and burst rates to minimize the probability of code collision at the at the dam-face telemetry array. Direct-mounted underwater balanced loop-vee radio antennas were deployed at all spill bays and on the trash racks of the turbine penstock intakes, as well as in possible entrainment locations in the Forebay, Auxiliary, and Hatchery Water Supplies. Downstream arrays consisted of an egress, primary, and secondary array (2.5, 19, and 23 km downstream of Foster, respectively). Results from the two years of study indicated the preferred route of downstream passage for age-0 and age-1 Chinook salmon was the spillway (Spill Bays 1-3), where survival and percent passage (out of total project) were generally highest. The preferred route for steelhead passage was the fish weir (surface outlet; Spill Bay 4). Survival was also highest at this route.
Session B9: Telemetry II

Removing False Positive Detections from Telemetry Data: An Algorithmic Approach

Kevin Nebiolo

Kevin Nebiolo is a data scientist with Kleinschmidt Associates and a PhD Candidate at the University of Connecticut. Mr. Nebiolo routinely manages and analyzes large scale datasets using analytical tools in Python and R. Prior to joining Kleinschmidt, Mr. Nebiolo was a seasonal fisheries technician with the Connecticut Department of Environmental Protection, Bureau of Marine Fisheries.

For large scale telemetry projects that have the potential to generate millions of detections, false positive removal can be a very time consuming process that is prone to subjective human error. Radio telemetry receivers record four types of detections based upon their binary nature: true positives, true negatives, false positives and false negatives. True positives and true negatives are valid data points which indicate the presence or absence of a tagged fish. A false positive is a detection of a fish’s presence when it is not there and can bias descriptive statistics of passage efficiency. While false negatives can be quantified, we have been unable to quantify and readily remove false positives in a quick and efficient manner until now. Kleinschmidt Associates, with assistance from the USGS, has developed and implemented an algorithmic approach to false positive identification and removal using a Naïve Bayes Classifier. Bayes Rule is a rigorous method for interpreting evidence in the context of previous experience or knowledge. Bayes Rule cannot guarantee the correct answer, but rather provides the probability that each alternative answer (either true or false positive) is correct. Bayes theorem updates conditional probabilities (probability of a record being true positive given some data), and is particularly useful when evaluating diagnostic tests (false positives and false negatives). We successfully implemented the algorithm on a large-scale project that generated close to 20 million records of data. The multi-step process filtered out close to 3 million records. The algorithm output and training dataset provided the assurances we and stakeholders needed to have high confidence in the final dataset worthy of analysis.
Session C1: Turbine Passage I

Overview of U.S. Department of Energy Fish Passage Research

Ms. Dana McCoskey

Dana is an ecologist that has been supporting the environmental research portfolio at DOE for two years. She earned a Master of Science in environmental science and public policy from George Mason University in 2015 and a Bachelor of Science with honors in zoology from Portland State University in 2003. Dana has expertise in field research, threatened and endangered species monitoring, migration and animal movement studies, hydropower, DNA barcoding, animal monitoring technologies, and project management.

An overview of ongoing fish passage research supported by the U.S. Department of Energy’s Water Power Technologies Office will be provided in the context of ongoing environmental research in the Hydropower Program portfolio and strategic priorities. Last year, the U.S. Department of Energy released the Hydropower Vision Report, which provides a comprehensive look at the nation’s hydropower sector. The Hydropower Vision Report introduces three pillars of optimization, growth, and sustainability. The sustainability pillar is focused on ensuring that hydropower’s contributions towards meeting the nation’s energy needs are consistent with the objectives of environmental stewardship and water use management. Along these lines, the development of fish passage technologies to improve aquatic connectivity and strategies that avoid, minimize, mitigate, or manage the environmental effects of hydropower projects are essential. The Hydropower Program seeks opportunities to advance the science and applications of biologically-based turbine designs, improved fish passage systems, and other technology solutions for fish and the environment.
Session C1: Turbine Passage I

_Biologically-based Design & Evaluation of Hydro-Turbines (BioDE): A Comprehensive Multi-Year Research Effort_

Mr. Gary Johnson

Gary has been a scientist/engineer with the Pacific Northwest National Laboratory for 20 years. He earned a Masters of Science in biological oceanography from Oregon State University in 1981 and a Bachelor of Arts in mathematics and marine biology from the University of California at Berkeley in 1976. Gary’s expertise includes environmental effects of hydropower, bioengineering for fish protection at dams, Pacific Northwest estuarine and nearshore ocean ecology, scientific hydroacoustics, design of research, monitoring and evaluation programs, and facilitation of scientific work groups.

To address a major environmental concern about hydropower—the impacts of turbine passage on fishes and fish populations—our study (called BioDE) is providing advanced technologies for biologically-based design, operation, and evaluation of hydro-turbines. The overall goal is to inform advanced, fish-friendly turbine designs that are founded on biological design criteria derived from scientific, validated predictions of impacts on fish from turbine passage. The vision (endpoint) is that the hydropower community (turbine manufacturers, utilities, regulators, and natural resource managers) are routinely applying BioDE design and evaluation tools to reduce fish injury and mortality rates, decrease design and regulatory review times, and generally advance sustainable hydropower. The study has three main objectives: 1) develop, deploy, and support computational fluid dynamics modeling and analysis techniques to predict impacts on fish from turbine passage; 2) apply sensor fish and other advanced technologies to obtain direct measurements of water and fish; and 3) derive dose-response relationships using laboratory experiments to relate mortality and injury of fish to in-turbine stressors, i.e., strike, rapid decompression, and shear and use these relationships to formulate biological design criteria for hydro-turbines. Supporting tasks include species prioritization to optimize research influence, common response metrics to allow comparison of laboratory results, traits-based fish analysis to maximize inferences from tested fish results to untested fish with similar traits, and field studies with Sensor Fish and other devices. This talk will provide an overview of the BioDE study.
Session C1: Turbine Passage I

*Laboratory-Based Dose-Response Experiments to Understand How Fish are affected by Rapid Decompression and Shear*

Alison Colotelo

Alison is a senior research scientist in the Ecology Group. Her work focuses on examining the interaction between fishes and hydropower facilities. She is involved in several large studies that examine the passage proportions and survival of juvenile and adult salmonids that passed downstream through dams in the lower Snake and Columbia rivers. Alison is also involved in a number of laboratory studies that investigate the effects of rapid decompression associated with simulated turbine passage and the implantation methods of telemetry transmitters.

Engineering tools, such as computational fluid dynamics models and the Sensor Fish, are increasing our understanding of the complex hydraulic environments within turbines by measuring the physical forces (e.g., rapid decompression, shear forces, blade strike) that fish may be exposed to. This information can be coupled with the response of fish (e.g., injury, mortality) to those forces to provide relative comparisons of different turbine environments on different species (e.g., Biological Performance Assessment [BioPA] tool). Critical to linking the physical forces and overall effects on fish are dose-response experiments that include measurable doses (e.g., pressure time series, strain rate exposures, blade strike force). Laboratory-based studies are ideal for this as the doses can be controlled by type, intensity, and duration, allowing for easy comparison. Furthermore, the species, life stage, and fish size can be controlled. This presentation will summarize laboratory-based dose-response experiments that have been conducted to evaluate the effects of rapid decompression and shear on a variety of fish species. Rapid decompression may be the most common force that fish are exposed to while passing through a turbine environment as it occurs when fish move past the turbine blade. However, the magnitude can vary depending on the region of the blade the fish passes and the design and operation of the turbine. Comparatively, shear forces can occur at various locations within the turbine environment, where two masses of water, moving at different velocities, intersect. Understanding the effects of rapid decompression and shear on fish passing through turbine environments is critical to using tools such as BioPA and Sensor Fish to improve the design and operations of turbines; however, research has been limited. Future research should focus on addressing data gaps in terms of the species tested and the representativeness of doses to a variety of turbine types.
Session C1: Turbine Passage I

Simulating Turbine Blade Strike in the Laboratory to Better Assess Injury and Mortality during Turbine Passage

Dr. Mark Bevelhimer

Dr. Bevelhimer has over twenty-five years experience in aquatic ecology/fisheries biology ranging from basic research to fisheries management to environmental assessment. His work has been a combination of environmental impact analysis, field study, laboratory experimentation, and computer modeling with a heavy emphasis on quantitative and mathematical analysis.

Injury and mortality of fish during downstream passage through hydropower turbines is among the leading direct impacts of hydropower. Strike injuries range from minor (e.g., descaling or bruising) to severe (e.g., organ damage or broken bones) and can result in immediate or latent mortality. To better understand the relationships among blade strike variables and fish injury/survival, we subjected three species of fish to simulated blade strike at 8 m/s in laboratory studies with two blade thicknesses (25 and 50 mm) and at three body locations (head, midsection, and tail). Both blade width and strike location affected injury and survival rates with tail strikes generally being no different than controls. Head and midsection strikes resulted in higher mortality and injury rates, with midsection strikes generally being the highest. The narrower blade also resulted in higher mortality rates. Results from this study will be used to define biologically-based design criteria that can be used by turbine designers to improve designs and operations, e.g., increased leading edge width and strategic slowing of turbine runner velocity, which can minimize the probability and impact of blade strike.
Session C2: Turbine Passage II

Injury to adult Atlantic salmon from contact with turbine runners after swimming upstream into draft tubes: evidence from European and North American rivers

Dr. Martin O’Farrell

Martin O’Farrell, Ph.D. is a fisheries biologist based in Dublin, Ireland where he coordinates European business for Smith-Root, Inc. He previously worked for the Central Fisheries Board, Ireland on the management of Atlantic salmon and sea trout recreational fisheries. Martin has been involved in fisheries management and fish passage issues associated with the design and operation of hydroelectric and thermal electric generating stations throughout the U.K., Europe and other international locations.

In the context of hydropower and fisheries issues, an obvious concern is the survival of various fish species entrained at turbine intakes. The topic of fish species attracted to generating flows from tailraces and draft tubes and subsequently making contact with turbine runners has received much less attention. The vast majority of hydropower stations in Europe and North America operate without screening turbine draft tube outfalls. We present evidence of injury to adult Atlantic salmon from contact with turbine runners after swimming upstream into draft tubes. This evidence comes from the Netherlands (hydropower stations at Lith and Linne on the River Meuse and at Roermond on the River Roer) and from Norway (Nedre Fiskumfoss power station on the Namsen River and Nedre Leirfoss power station on the River Nidelva). In the case of the Nedre Leirfoss power station, the water outlet from the draft tube has now been modified and adult Atlantic salmon can no longer come in contact with the turbine runner. Adult Atlantic salmon, examined on these rivers after collection at fish traps and by angling, show injuries which can only have been caused by contact with a turbine runner. We hypothesize that the consistent head/snout injuries we have observed are caused by contact with turbine blades. We have estimated that up to 10% of adult Atlantic salmon may be injured in this manner on some Norwegian rivers and that these injuries may impact survival and spawning success. Such injuries have also been noted for large sturgeon and anadromous salmonids at some projects in the United States. In addition to these injuries, false attraction to tailraces and draft tubes can result in fish not locating upstream fish passes on bypass reaches.
Session C2: Turbine Passage II

Sources of injury and mortality during downstream hydropower turbine passage and spatial distribution of mitigations

Dr. Brenda Pracheil

Dr. Pracheil received her M.S. in zoology from Michigan State University in 2006 and her Ph.D. in Natural Resources from University of Nebraska-Lincoln in 2010. She then conducted postdoctoral studies at University of Wisconsin Center for Limnology from 2011-2013. She joined the staff at Oak Ridge National Laboratory as an aquatic ecologist in 2014 and has also been serving as an Associate Editor of the North American Journal of Fisheries Management since that time. Although her work generally focuses on fish movement, bioaccumulation and health, especially that impacted by hydropower or other energy production, it has spanned across ecosystems. Her published works include research on sediment chemistry, water chemistry, parasites, invasive species, threatened and endangered species, and watershed land-use. Her work combines geospatial analysis, modelling, statistics, and field and laboratory data collection techniques including telemetry, mark-recapture, stable isotope and trace-element chemistry to address research questions.

Even dams lacking passage structures are passable by fish in a downstream direction and this passage may be important to population dynamics in fragmented rivers. However, in the case of hydropower dams, one-way connectivity provided via downstream turbine passage can introduce a new and significant source of mortality. Fish may be injured or killed during turbine passage owing to forces such as blade strike, shear and/or turbulence, cavitation, and rapid pressure decreases. Determining contributions of individual forces is important for designing more environmentally friendly turbines and mitigations that minimize the effects of hydropower on fish populations. In this study, we use existing data on fish turbine passage injury and mortality and data on hydropower mitigations ordered in Federal Energy Regulatory Commission hydropower licenses, to accomplish three objectives: (1) describe injury and mortality rates by fish species and turbine type, (2) provide insight into what in-turbine forces are most responsible for mortality, and (3) spatially and qualitatively describe attempts to mitigate damages caused by downstream turbine passage. Similar to previous studies, we found that Francis turbines, the most commonly deployed hydropower turbine in the US, have the highest associated fish mortality of any turbine type. Most fish species in this database have >90% survival after 48 hours and fish <200 mm had higher survival than larger fish.
Session C2: Turbine Passage II

A Comparison of Direct Survival/Injury of Eels Passed Through Francis and Propeller Turbines

Cory Hoffman

Mr. Hoffman's specialty is in fisheries ecology and taxonomy, with experience in sampling fish communities throughout the United States. Mr. Hoffman also has experience in a variety of biological sampling including macroinvertebrate collection, aquatic habitat evaluation, stream morphology characterization, radio telemetry, and turbine passage survival. During his time at Normandeau Associates, he has worked at fish collection and passage facilities and has performed downstream fish passage survival/injury studies on anadromous and catadromous fish species. While performing these studies, he has handled and tagged juvenile clupeids and adult American Eels.

Passage survival (direct effects) and injury rates of American Eel, Anguilla rostrata and European eels, Anguilla anguilla were estimated at Francis (N=5) and propeller (N =7) type turbines via controlled releases of HI-Z Tagged eels. The turbine type, number of blades, runner rotation rate (rpm), runner diameter, and eel length affected survival and injury rates. Overall, the 48 h survival rates were higher for eels passed through the Francis turbines (93.5-98.0%; mean 95.1 %, SE = 2.0-5.5%) than the propeller turbines (73.5-93.0%, mean 80.7%; SE = 1.5-6.9%). The higher survival at the Francis turbines is counter intuitive since the Francis units had more blades (12-15) than the propeller units (4-6). For both the Francis and propeller turbines there were trends for decreased survival with an increase in rpm, number of blades, and increased survival with larger runner diameter size. The incidence of observed injuries trended lower for the eels passed through the Francis turbines (0-35.6%, mean 12.5%) than the propeller turbines (6.5-42.6%, mean 25.6%). The dominant injury types also differed for these two turbine types with bruised bodies the predominant injury observed for eels passed through the Francis turbines and severed or nearly severed bodies observed at the propeller turbines. None of the Francis-passed eels were severed. A recent study at a horizontally oriented propeller turbine (bulb turbine) indicates that blade orientation to prevailing flow maybe a factor. The highest survival (93%) and lowest injury (6.5%) rates for a propeller type were observed at this turbine. The specific physical and/or behavioral factors that provide safer passage through Francis turbines needs to be further investigated.
Session C2: Turbine Passage II

_Devvelopment of Fish-friendly Hydropower Guidelines for Lower Mekong River Fish: Turbine Characterization at Nam Song & Nam Ngum Dams using Sensor Fish_

Dr. Daniel Deng

Dr. Deng is a Chief Scientist in Energy & Environment Directorate at PNNL. He is active in the development and application of experimental and numerical modeling tools for conventional hydropower and marine and hydrokinetic renewable energy systems. He directs the Bio-Acoustics & Flow Laboratory (http://bfl.pnnl.gov/) at PNNL, an accredited multi-disciplinary R&D laboratory. He was selected as one of 78 outstanding young engineers in the U.S. to participate in the National Academy of Engineering’s Annual Symposium on Frontiers of Engineering in 2012. He was awarded the PNNL Laboratory Director’s Award for Exceptional Engineering Achievement in 2015. He has co-authored more than 90 journal articles and is an editor or board member for four peer-review journals. He holds a PhD in Theoretical and Applied Mechanics from University of Illinois at Urbana-Champaign.

The Mekong River is the second-most bio-diverse river on the plant, and as a result the Mekong River Basin is home to the world’s largest freshwater fishery. Within the Lower Mekong Basin, freshwater fish are a very important protein source for the local population. Not only do many inhabitants rely on the river for sustenance, they also rely on the river for their livelihoods. Along the mainstem Mekong and its tributaries there are plans for many dams both small and large. Of the native fish species that inhabit the waters many of the fish are small in size, large in number, and with a high species diversity. Currently there is little information available to guide construction of downstream fish-friendly hydro systems in a manner which is safe for Lower Mekong species. Sensor Fish, a small autonomous sensor device, were released at Nam Song and Nam Ngum Dam to characterize the physical conditions that fish are exposed to during turbine passage. Nam Song Dam has three horizontal Kaplan turbine units. Fifteen percent of releases experienced at least one severe event (acceleration $\geq 95G$) in the stay vane/wicket gate region of the turbine passage and 17% experienced at least one severe event in the runner region. The median nadir pressure (i.e., lowest pressure point) was 66 kPaA and the pressure change was 87 kPaA. Nam Ngum Dam has two older Francis turbine units and three newer Francis turbine units with higher generating capacity. In the older Unit 1, 60% of Sensor Fish releases experienced severe events in the stay vane/wicket gate region and 37% in the runner region. In the newer Unit 4, 32% experienced severe events in the stay vane/wicket gate region and 37% in the runner region. The median nadir pressure was 99 kPaA in Unit 1 and 126 kPaA in Unit 4, respectively. Overall, Unit 4 is better for fish passage than Unit 1 because the Unit 4 has higher nadir pressures and fewer severe acceleration events. It is also important to understand how native fish species of interest respond to the physical stressors encountered during turbine passage. To this end controlled laboratory experiments were initiated on Iridescent Sharks and Blue Gourami to investigate their susceptibility to rapid pressure change and shear flows.
Session C3: Swimming Performance

FISHWAY LOCATION, ENTRANCE AND PASSAGE FOR POTAMODROMOUS MEDITERRANEAN CYPRINIDS.

Dr. Francisco‐Javier Sanz‐Ronda

Hydraulics Professor at the Forestry Engineering School of Palencia (University of Valladolid, Spain). I have been working in fish passes designing for more than fifteen years. My research focus on fish passes ecohydraulics and evaluation. I also coordinates the scientific group GEA (Applied Ecohydraulics Group).

During the last decade the Spanish River Authorities have promoted the construction of many fish passes. However, after their installation a continuous monitoring is needed to ensure their correct performance and till the date, few of them have been evaluated. This work collects five of these study cases. All of them are pool and weir fishways located in the Duero River basin, with different configurations. Their evaluation was carried out in terms of fish location, entrance and passage. Two broadly spread Mediterranean cyprinids were selected as target species: Iberian barbel, Luciobarbus bocagei (Steindachner, 1864) and northern straight-mouth nase Pseudochondrostoma duriense (Coelho, 1985), due to their similarities with several rheophylic potamodromous barbels and nases from the same area. Passive integrated transponder (PIT)-tag and antenna system were used to study fish movements. Experiments were carried out during the spawning season. Results show that both river discharge and water temperature motivated fish upstream movements. Flow discharge next to the fishway entrance and its distance from other important flows greatly influenced on fishway location. Barbels got more success in locating the entrance than nases. Once inside the fishways, both species ascended them easily (<30 min/m) and successfully (>50%). Observed differences in passage time and success were mainly related to water drops and pool dimensions. The results highlight the importance of attraction flows and fishway design in the global efficiency of upstream fish movement and state the importance of evaluations to assess the performance of this vital structures.
Session C3: Swimming Performance

Swimming performance of sauger (Sander canadensis) in relation to fish passage

Mr. Kevin Kappenman

Principle investigator of an applied research program at the Bozeman Fish Technology Center (BFTC) in Montana. A current research focus is on co-leading a multi-agency team made up of Engineers and Ecologists in reconnecting the aquatic landscape to promote ecology. The effort has included developing a test bed facility at BFTC with tools that include a 56 ft open channel flume, complex video and hydrological modeling equipment, and enclosed swimming chambers. The laboratory tools are used to assess fish passage and swimming capability of aquatic species and ultimately improve fish and aquatic species passage capabilities. To date our team has provided information and characterized the swimming and passage abilities of Arctic grayling, westslope cutthroat trout, rainbow trout, longnose dace, sauger, and shovelnose sturgeon. The information is used to assess barriers, prioritize removals, and design fish passage ways. My current fish passage research is focused on improving conservation status of Arctic grayling; our fish passage workgroup is currently assessing the landscape connectivity benefits of Denil fishways in the Big Hole River Watershed in Montana.

A lack of information on the swimming abilities may inhibit the design of effective passage structures for sauger (Sander canadensis), a highly migratory species particularly sensitive to habitat fragmentation. Passage success, maximum ascent distances, and maximum sprint velocities of sauger were estimated in an open-channel flume over a range of water velocities (51, 78, and 92 cm/s ) and temperatures (10.0, 14.3, and 18.3° C) to assess swimming performance. Passage success was high (91%) over all test velocities, as was the maximum instantaneous burst velocity (219 cm/s). Water temperature and body size had little effect on swimming performance. Sauger transitioned from steady sustained swimming to unsteady, burst-glide or steady burst swimming at 97 cm/s. Sauger were capable of sustained sprints of 124 cm/s over 15 second duration in a swim chamber. Results suggest passage structures with water velocities less than 97 cm/s should provide high probability of successful passage of adult sauger whereas structures with water velocities exceeding 219 cm/s may be impassable.
Session C3: Swimming Performance

*Arctic Grayling and Denil Fishways: A study to determine how water depth affects passage success of Arctic grayling through Denil fishways*

Erin Ryan

Erin Ryan holds a B.S. (Montana State University, ‘13) and M.S. (Colorado State University, ‘15) in Civil Engineering, emphasizing in ecohydraulics and stream restoration. She is currently an engineering technician with the US Fish and Wildlife Service at the Bozeman Fish Technology Center. In her current position, she conducts research focused on habitat connectivity for aquatic species by evaluating the swimming capabilities of various fishes and the efficacy of passage structures. Ms. Ryan is also involved in the assessment of existing fishways or fishway concepts and the design/retrofit of hydraulic structures to meet both flow conveyance and fish passage needs throughout the western United States.

Arctic grayling (Thymallus arcticus) are a species of special concern in Montana and the last remaining fluvial population in the lower 48 states. They reside in southwest Montana, a highly agricultural area that includes farming and ranching communities in the Big Hole River and Centennial Valleys. Over 60 Denil fishways have been installed at irrigation diversions in the Big Hole River watershed, with more planned for the future, to provide aquatic connectivity for Arctic grayling and other fish species. However, there is relatively little information to guide the operation and management of the fishways, especially during water limited periods. The objective of this study was to determine the optimum water depth, or range of depths, for upstream passage of Arctic grayling through Denil fishways. Present installations in the Big Hole use either 6- or 12-ft long ladders set with a 1-ft vertical elevation drop. We performed a laboratory study that utilized an open-channel flume, both 6- and 12-ft Denil ladders, and hatchery reared Arctic grayling (TL ~ 12 inches). Our study targeted 18 depth treatments, a combination of three approach (tailwater) depths and six depths at the upstream-most Denil baffle, in each fishway and one treatment with no ladder for a total target of 37 treatments. Fish movements were monitored during 2-hour trials using overhead video cameras and passive integrated transponder (PIT) antennae - one installed at each end of the fishway. The hydraulic environment was characterized by collecting water depths, water velocities, flow and temperature. Multiple logistic regression was used to examine relationships between passage success and hydraulic variables including water depth, velocity and flow. Key results and our best statistical models will be presented, including recommendations for design and operation of the fishways to optimize passage for Arctic grayling.
Session C3: Swimming Performance

Modelling up-and downstream movements of a catadromous species through a vertical-slot fish pass

Ms Esmeralda Pereira

Esmeralda Pereira is graduated in Biology and holds an MSc in Management and Conservation of Natural Resources by the University of Évora. Esmeralda has developed her research in the bio-ecology of migratory fish species, fish pass monitoring, flow regulation and in sustainable use and management of fisheries at MARE - Marine and Environmental Science Centre. Has relevant skills in bio-telemetry, animal tracking, fish sampling and geographic information systems. Currently, Esmeralda is a PhD student funded with a PhD grant from FCT (SFRH/BD/121042/2016), at the University of Évora (advisor: Dr. Pedro Raposo de Almeida and Dr. Bernardo Quintella, PhD). Her thesis focus is: i) the importance of trophic migration of catadromous species regarding the species gains, ii) their importance to freshwater habitats, and iii) the impact of anthropogenic barriers in these dynamics.

Fish passes around the world continue to focus on the upstream migration, while downstream movements are often neglected. Even when fish passage assessments show that upstream migration has been mitigated, this passage solutions may continue to be inefficient for downstream movements, and for species such as diadromous fish, the upstream stretch can eventually become an ecological trap. In 2011, a vertical slot fish pass designed for shad (Alosa alosa L; Alosa fallax Lacepede, 1803) and sea lamprey (Petromyzon marinus L.) was installed in the Coimbra dam (River Mondego, Portugal). Species such as the potamodromous iberian barbel (Luciobarbus bocagei Steindachner, 1864) and iberian straight-mouth nase (Pseudochondrostoma polylepis Steindachner, 1864), and the catadromous thin-lipped grey mullet (Liza ramada Risso, 1827) frequently use this fish pass in both directions. Through a video recording system, it was possible to count that between 2013 and 2014, near 2 million and 1 million fish, respectively, have used this fish pass during up-and downstream migration. This device was used by seven native species with 90% of the upstream movements and more than 95% of the downstream movements performed by L. ramada. Contrarily to what is common for the majority of the fish passes constructed mainly to allow the upstream movement, this infrastructure is also highly effective for downstream migration of a particular species the thin-lipped grey mullet. Models (BRTs - Boost Regression Trees analysis) were developed to identify the environmental predictors that seem to trigger the migratory activity during both the up-and downstream movements. This study provides novel insights on the use of a fish pass efficiently used by a catadromous species on both direction, up-and downstream.
Session C3: Swimming Performance

Artificial lateral lines: Assessing fish passages sensing like a fish

Mr. Juan Francisco Fuentes-Pérez

Juan Francisco Fuentes-Pérez received the Eng. degree in Forestry and the M.Sc. degree in Conservation and Sustainable Use of Forest Systems at the University of Valladolid, Spain. After, he was working until 2014 as a researcher and hydraulic engineer in GEA-Ecohydraulics (Spain), designing more than 80 fish passes as well as researching in their non-uniform behaviour. He is currently a researcher under a Marie Curie grant in underwater robotics with the Centre for Biorobotics (Tallinn University of Technology, Estonia), researching mainly in underwater flow sensing. As result of his research activities, he has published more than 15 journal articles, designed multiple flow sensing platforms and developed two software solutions. His current research interests include fluid mechanics, ecohydraulics, underwater sensing, underwater robotics, and fishways.

Loss of longitudinal connectivity by man-made obstructions is one of the main ecological problems in regulated rivers. This issue not only affects to fish migration, but also how energy and matter flows in river ecosystems. The in situ analysis of the derived complex problems often require a multidimensional analysis where a point measurement is not enough. Artificial lateral line probe arises from this necessity, providing a new technology for understanding aquatic ecosystems. They consist of a new type of bio-inspired sensing devices for ecohydraulics flow measurement and classification. The probes are based on the highly evolved octavolateralis flow sensing capabilities of fish. This is achieved by a time-synchronized array of rapid pressure sensors installed over a probe body. The benefits of this are multiple. For instance, in contrast to point measurements, the lateral line probe provides a new source of simultaneous data in both space and time. This approach provides ecohydraulics researchers with new sources of flow information as (i) the fluid-body interactions are considered and (ii) the sampling rate is higher than any other field tool (tested up to 200 Hz), potentially measuring closer to the “fish’s perspective”. In this work, we present our conclusions from the last three years of development and research on this technology, starting for its conceptual design and finishing with our latest results in fish passage monitoring. Taking into account our results, artificial lateral line probes have proven to be a multipurpose tool, able to monitor complex aquatic ecosystem relations.
Session C3: Swimming Performance

Embryogenesis in otolith icefish Pseudochaenichthys georgianus and phylogeny of the development of the body and brain along with the perception of changes in position, speed swimming and sounds.

Mr Ryszard Traczyk

Ryszard Jacek Traczyk, M.Sc., is a Polish citizen, and is Doctoral Candidate of Environmental Ph.D. Studies, at Oceanography and Geography Department, University of Gdansk in Poland. Mr. Traczyk is studying the biology of endemic fish of the Atlantic sector of Antarctica, from the unique family Channichthyidae white-blooded fish devoid of red blood cells and acquired antifreeze proteins in the process of adaptation to life in the icy waters below the freezing point. He became member of AFS since presentation his work at meetings AFS in Portland two years ago. He participated in two Antarctic expeditions research, working in a team ichthyologists estimating fish stocks on the shelf of South Georgia and in Antarctic Zone in the vicinity of the islands Elephant and the South Orkney Islands and the team investigating the occurrence of krill in the ice edge area from King George Island to South Orkney. He was awarded the Kosciuszko Foundation in New York to study at the laboratory of blessed memory Professor Richard Radke at the Institute of Geophysics at the University of Hawaii.

The ability to sense vibration is important in perception of body position, assessment of the environment and reception of acoustic communication. Unlike visual information, the animal can sense vibrations originating from all directions simultaneously. The most basal group with some perception of position and vibration are the settled sponges. They possess crystal spicules, arranged in a net of spongin-collagen polymerized fibers, which move in response to changing pressure. Their structure determines their aggregation and growth in extracellular lymph into the net of collagen fibers. More sophisticated crystallizing spherical statolites are important in animals developing strategies for movement. Radially-symmetric jellyfish use their rounded statocytes to explore the open sea at low speeds. More highly-developed ctenophores, annelids and molluscs have greater numbers of neurons used to interpret acoustic and vestibular information. In the most derived, a brain has formed. As sensory interpretation becomes increasingly accurate, swimming strategies can be altered to improve speed. In fishes, symmetry shifts from radial to bilateral, with an elongated body. The need for further sensory adaption is determined by a species’ environment. Channichthyidae icefish inhabit the aphotic zone near the Scotia Arc Islands. Nursery and adult habitats are separated by 1000 km, as are separate populations. Deep, strong currents act as further barriers to migration. However, icefishes have low genetic differentiation, indicating high connectivity between islands. In the absence of visual cues, icefish have evolved to find passage routes between habitats by interpreting sounds created by movement of water over ocean floor topography. Their otolith shape indicates various movement strategies, including rapid horizontal swimming, vertical migration and benthic life. Extracellular stage of otolith growth is an important step in the acquisition of information on space and adaptation to environmental changes. Current work will show increase of migration possibilities during ontogeny and phylogeny under acoustic passage.
Session C4: Rock Channels & Nature-Like Fishways I

Regenerative Stream Channel Serves As A Nature-like Fish Passageway

Dr. Roman Jesien

Dr. Roman Jesien serves as the Science Coordinator for the Maryland Coastal Bays Program. The Coastal Bays Program is one of 28 estuaries within EPA's National Estuary Program. Dr. Jesien received his Ph.D. in Marine Estuarine Environmental Sciences from the University of Maryland College Park and MS in Natural Resources Management from the University of Wisconsin at Stevens Point. He has worked extensively in coastal habitat and fisheries issues throughout the East Coast.

Considering the many negative effects of dams on fish populations and an estimated 80,000 dams in the US, innovative techniques to mitigate these effects are needed. We present an approach to providing the benefits of an open stream while maintaining an historic mill pond. The Bishopville Stream Corridor Enhancement Project consists of the modification of a popular but aging mill dam to create a nature-like fish passageway in coastal Maryland. The project goal was to remove the dam while maintaining the existing pond and create fish passage using regenerative stream channel (RSC) techniques. The RSC consisted of a series of rock grade control riffles and pools that serve as a stream corridor to transition from non-tidal to tidal waters. Specifically, we removed the existing 85-ft long, 4-ft high steel coffer dam and replaced it with a series of 5 rock riffles 80-120-ft long (measured perpendicular to flow) and 35-ft wide (measured parallel to flow) in which each riffle stepped the stream elevation down in 1-foot increments. The riffle controls consisted of boulders, cobble and clean sand fill that slowed stream velocity and created resting areas for fish to navigate further upstream. The riffle structures were further stabilized with herbaceous and woody wetland species including Atlantic white cedar (Chamaecyparis thyoides) and bald cypress (Taxodium distichum). Details of the RSC and description of the construction sequence are provided. We view that this technique is applicable in situations where fish passage is needed but pond habitat should be maintained or to keep accumulated legacy sediments from mobilizing during or after construction. Since the project was completed in fall 2014, anadromous fish including alewife (Alosa pseudoharengus), white perch (Morone americana) and gizzard shad (Dorosoma cepedianum) successfully moved upstream through the project during the 2015, 2016, and 2017 spring spawning runs.
Observations of constructed roughened channel hydraulic characteristics and comparisons with self-formed channels

Mr. Joey Howard

Joey Howard is a river and fish passage engineer and principal of Cascade Stream Solutions located in Ashland, Oregon. At Cascade, he is involved in field data collection, analysis, design, plan development, construction staking, and inspection. Over the last 25 years he has specialized in the areas fish passage and screen design and habitat enhancement and restoration design. He has designed and performed construction inspection and observation services for more than 40 fish passage, protection, and habitat enhancement projects. He holds a Bachelor of Science in Civil Engineering from UC Irvine and a Masters in water resource engineering from UC Davis.

We measured morphologic and hydraulic characteristics at two constructed roughened channel fish passage structures and two self-formed channels and compared measured characteristics with morphologic and hydraulic predictive equations. Measured values were compared with National Marine Fisheries Criteria for roughened channels. Our study objectives were: 1) to identify morphologic and hydraulic similarities between constructed roughened channels and self-formed channels, 2) to identify the applicability of predictive equations to estimate morphologic and hydraulic characteristics, 3) and to identify compliance with velocity, depth, and energy dissipation factor criteria. We conducted bed and bank surveys using a total station and RTK GPS. We measured point velocities and velocity profiles using a Sontek Flowtracker with a 3-d probe. We used an unmanned aerial vehicle to obtain video and measure surface velocities computed using Large Scale Particle Imaging Velocimetry. Results highlighted the complexity in obtaining reliable data and the value of large roughness elements and bed complexity to improve fish passage opportunities.
Session C4: Rock Channels & Nature-Like Fishways I

Truckee River Fish Passage Improvement Project: Restoring 121 miles of river for spawning migration of lacustrine Lahontan Cutthroat Trout

Melissa Conte

Melissa Conte has been a Fish Biologist with the U.S. Fish and Wildlife Service’s Lahontan National Fish Hatchery Complex, located in Reno, NV for 6 years. She serves as a crew leader for the Complex's fish passage program and as such gets to travel the state of Nevada and the Eastern Sierra Nevada assessing fish passage barriers. She also works on numerous other projects on the Truckee River and in winter and fall can be found helping with spawning activities at Lahontan National Fish Hatchery. Melissa graduated in 2005 with a Bachelor of Science degree in Fisheries Biology from Mansfield University of Pennsylvania. In her spare time she likes to fish Pyramid Lake, kayak and hike the numerous trails around Reno/Tahoe.

The Truckee River originates at the outlet of Lake Tahoe and runs 121 miles through Eastern California and Western Nevada before terminating at Pyramid Lake. Pyramid Lake is home to two federally listed fish, the endangered cui-ui sucker (Chasmistes cujus), and the threatened Lahontan cutthroat trout (Oncorhynchus clarki henshawi). Historically, Lahontan cutthroat trout (LCT) were able to migrate the entire river from Pyramid to Lake Tahoe but barriers to migration stopped this in the 1930’s causing extirpation of the species. In 2006, the U.S. Fish and Wildlife Service’s Lahontan National Fish Hatchery Complex (LNFHC) began stocking Pilot Peak Strain LCT, known through genetic analysis to be the same Pyramid Lake LCT strain thought to be extinct, back into Pyramid Lake. In 2014, the LNFHC documented the first LCT spawn in the Truckee River since 1940 and then in 2015 documented the first successful recruitment of LCT since extirpation. Genetic testing confirmed that it was the Pilot Peak strain LCT that spawned. Of the 46 diversion dams along the Truckee River, 7 are major migration barriers to LCT and 2 are major barriers to cui ui. In 2016, U.S. Fish and Wildlife Service (USFWS) Region 8 and the LNFHC was chosen for the National Fish Passage Programs (NFPP) National Aquatic Conservation Initiative (NACI) for the Truckee River Fish Passage Improvement Project (TRFPPIP) which seeks to re-establish the historic migration route of this native fish. The TRFPPIP has already addressed 3 of the major barriers and with the NACI funding will be able to address the remaining 4 connectivity issues/barriers that remain with a unique design utilizing roller compacted concrete (RCC) dams with rock weirs.
Session C4: Rock Channels & Nature-Like Fishways I

*Nature-like Fish Passage in the Gulf of Maine: Case Studies in the Design and Implementation of Nature-like Fishways for Northeastern Diadromous Fishes*

Mr. Joseph McLean, PE

Joe McLean is a consulting Civil Engineer and Team Leader in the Civil and Infrastructure Engineering Practice Group at Wright-Pierce. A graduate of the Tufts University College of Engineering, Mr. McLean has over fifteen years of design and construction management experience on a wide array of multi-disciplinary civil engineering projects across New England. At Wright-Pierce, Mr. McLean leads an engineering team focused on infrastructure associated with habitat and water resources restoration projects, which includes developing fish passage strategies, culvert/bridge replacements, and barrier removals in both freshwater and tidal ecosystems. Notable project work includes being the lead engineer and construction manager for the removal of the Veazie Dam (completed in 2015), which was part of the landmark Penobscot River Restoration Project in the Gulf of Maine.

The desire to utilize nature-like fish passage solutions, as opposed to traditional structural fishways, is an increasing trend in the Northeast and particularly in Maine. Nature-like fishways offer a variety of perceived advantages over their traditional concrete counterparts, including reduced operation/maintenance, improved hydraulic complexity, and a more natural aesthetic. While there are a number of common design elements, nature-like fishway style and implementation are quite unique to waterbody and location. In May of 2016, NOAA, USGS, and USFWS issued a technical memorandum entitled “Federal Interagency Nature-like Fishway Guidelines for Atlantic Coast Diadromous Fishes” which defined a common set of design standards. However, the use of nature-like fishway design tools and application of standards requires the consideration of principles beyond traditional civil engineering design, including stream geomorphology and the behavior of individual fish species. This presentation will be a technical review of four (4) recently designed and constructed nature-like fishways in the State of Maine, including two (2) step-pool and two (2) roughened channel design styles. Critical engineering design elements of each fishway will be outlined, along with pertinent technical details that informed the selection of the specific fishway style and aesthetic. This includes a walk through the logistics of constructing the fishways, as well as a review of the individual barriers, unique site challenges, and project goals at each location.
Session C5: Rock Channels & Nature-Like Fishways II

Manton Mill Pond Dam - Nature-like Fishway Bypass, Johnston, RI

Ms. Amy Hunt

Ms. Hunt is a professional engineer in 6 states with 16 years of experience with a background in environmental engineering including disciplines such as streambank restoration, fish passage, dam repair and removals, saltmarsh and wetland restoration, coastal engineering, shoreline and water resources engineering and restoration. She received her Bachelor of Science degree in Environmental Engineering from Roger Williams University in 2001. She works in the Warwick, RI office of EA Engineering, Science, and Technology Inc. PBC and currently serves as a Senior Engineer and Project Manager for natural resources projects throughout the Northeast, Mid-Atlantic and Great Lakes region.

This project was one in a series that provided fish passage past dams along the entire 16 mile length of the Woonasquatucket River to restore fish passage from Narragansett Bay to Georgiaville Pond. The Manton Mill Pond Dam was the most upstream, and the most recently addressed, of five dams that posed a restriction to fish passage to Manton Mill Pond. The other four dams, downstream of the Manton Mill Pond Dam, had been previously removed or had fish ladders constructed. The client was the Woonasquatucket River Watershed Council (WRWC). The Manton fishway, like the other downstream ladders located on the Woonasquatucket River, is located in an urban setting. This site in particular was also located immediately downstream of an EPA Superfund Site – Centerdale Manor. The site is contaminated with dioxin and other contaminants from chemical production and drum reconditioning that took place on site from the 1940s to the 1970s. Management of dioxin contaminated sediment was a part of this project. The project was privately bid to several local natural resource contractors, but the initial bids were several thousands of dollars above the available budget. The selected contractor (not the original low-bid) was willing to work with EA and WRWC to value-engineer a revised fishway cross section to meet the available budget. The project was ultimately constructed within the available budget, without any change orders. In cooperation with NRCS and US Fish & Wildlife Services, EA developed a design for an “alternative” fishway - a blend of a concrete pool and weir and nature-like fishway. The result was an aesthetically pleasing fish passage design that will provide passage for various herring species and will also become a canvas for local artists and serve as an educational tool for the local urban community. The WRWC is an extremely active watershed group in the city of Providence, Rhode Island – focusing on education and awareness of the watershed within the local city youth programs. The WRWC has many local partnerships with artists and sponsors to provide canvases, such as the Manton fishway, where young artists can showcase their talents while bringing attention to natural resources in the watershed.
Session C5: Rock Channels & Nature-Like Fishways II

Upstream and downstream passage of migrating adult Atlantic salmon: Remedial measures improve passage performance at a hydropower dam

Dr. Daniel Nyqvist

Postdoctoral researcher in fish ecology at Karlstad University, Sweden. In my research, I study the behavior of migrating fish in relation to hydropower dams.

Lately, nature-like fishways have been promoted for upstream migrating fish, and low-sloping turbine intake racks for downstream migrating fish, but evaluations of these remedial measures are largely lacking. At Herting hydropower dam in southern Sweden, a technical fishway for upstream migrating salmonids, and a simple bypass entrance/trash gate for downstream migrating fish have been replaced by a large nature-like fishway for up and downstream migrating fish, and a low-sloping rack, guiding downstream migrating fish to the bypass entrance, has been installed. In this study, we evaluated these remedial measures for adult Atlantic salmon, spawners and kelts, in a before/after improved remedial measures radio telemetry study. Passage performance was improved for both up- and downstream migrating adult Atlantic salmon after remedial measures. Passage rate (as proportion over time) increased for fish migrating in both directions, and overall delay decreased while overall passage efficiency increased for upstream migrating fish. After the improved passage solutions, almost all tagged fish passed the dam with very little delay. Before modifications, upstream passage performance through the technical fishway was higher at higher temperatures, at day compared to night, and for males compared to females. No such effects were observed for the after-measures nature-like fishway, indicating good passage performance for both sexes under a wide range of environmental conditions. Similarly, for downstream migrating kelts, discharge positively affected passage rate before but not after the fishway modifications. Altogether, our work demonstrates the possibility of coexistence between hydropower and Atlantic salmon in a regulated river.
Session C5: Rock Channels & Nature-Like Fishways II

Development and Performance Verification of the enature® Fishpass

Prof. Dr. Helmut Mader


The newly developed enature® Fishpass, a technical enhancement of the standard Vertical Slot Fishpass (Austria patent No. 507195, pending patent application EU A 1305/2008, u.Z. 30971) offers a greatly improved environmental feature passable for all fish species and life stages of European fish regions with 30 to 40 percent lower energy dissipation rate and with 20 % lower flow velocities. Alternating multiple slot baffles and guide walls induce hydraulic contraction- and extension effects and a meandering stream course. The obtained isolated roughness over artificial surface obstacles intends energy losses and lead to a significant reduction of flow velocity in slots and pools. Since the development in 2009 more than 50 enature® Fishpasses were built in Austria, Germany, Italy and Switzerland covering the fish regions from large epipotamal rivers to small epirhithral rivers and from less than 2 m to up to 20 m of drop height. The functioning of the enature® Fishpass for up- and downstream migration was verified with video monitoring for all fish regions in the lab at 1:1 scale models and at existing enature fish passes. Qualitative and quantitative migration of fish in epi- to hyporhithral and epipotamal fish regions resulted in a final score of “full functioning”. The ascent of numerous Bullhead of all ages and Danube salmons with up to 1.23 m length and Catfish (Silurus glanis) with up to 1.35 m length proved that the enature® Fishpass is passable for weak swimming species as well as for large fish species.
Session C5: Rock Channels & Nature-Like Fishways II

Evaluation of bull trout passage behaviour at a nature-like fishway created after a partial dam removal in Forty Mile Creek, Banff, Alberta

Ms. Brittany Sullivan

I am an M.Sc. Student working with Dr. Steven Cooke's Fish Ecology and Conservation Physiology Lab at Carleton University. I began my career in fish ecology/fisheries as an undergraduate student with Dr. Cooke's lab where I collaborated with Aquatic and Terrestrial Environmental Technologies Inc., and Queen's University Biological Station to evaluate a behavioural guidance system that used a light device (programmed to emit different strobe frequencies and colours) to deter fish from man-made barriers such as water withdrawal facilities and dams. I went on to become an M.Sc. student with Dr. Cooke where I collaborated with Parks Canada in Banff National Park to evaluate the effectiveness of a nature-like fishway following the partial removal of a small-scale dam. Our focus was to understand the passage efficiency and duration of a threatened species, bull trout, through the fishway. I have also worked as a contract Biologist for Parks Canada where I participated in a number of studies related to fish habitat/occupancy and water quality in Banff National Park.

Dams represent one of the major forms of river alteration. In recent years, many of these structures are reaching the end of their lifespan, where there has been need to consider either extensive refurbishments or dam removal. The partial removal of a small-scale water supply dam in Banff National Park (Alberta, Canada) created a nature-like fishway. This provided the opportunity to investigate probability to approach, probability of passage and passage duration of a threatened species, bull trout (*Salvelinus confluentus*) through a nature-like fishway. Using radio telemetry, we determined that the probability for a fish to approach the fishway was low (37.0%), but for those that approached, their probability to pass was high, with a passage efficiency of 78.3%. Passage success was related to water depth and time of day. Fish were likely to pass at high water levels (>0.40-m) in the spring to summer months in this system. Although some passage events occurred during day-light, the probability to pass the fishway was significantly higher at night (primarily 22:00 – 24:00-hrs). Passage duration ranged from 5-min to 13-days, suggesting that this resident species could have used the fishway for a variety of purposes (e.g., foraging, cover) and not just transiting. Some individuals underwent large-scale movements 2-km upstream (N=11) or downstream (N=2) of the nature-like fishway following a successful passage event. This study provides new insights on how partial dam removal and nature-like fishways can be combined to expand the knowledge base on fishway permeability for newly restored ecosystems.
Session C6: Eel & Lamprey Passage III

Fatal attraction of freshwater flows: migration of glass eel (Anguilla Anguilla L.) from sea to inland waters

Mr. Rob Kroes

Rob Kroes is a biology teacher from the Netherlands. He graduated as aquatic ecologist at the Free University of Amsterdam in 2003. After his study, he worked as a science journalist and obtained his teacher’s degree in biology. For ten years he has been teaching general biology to pre-university students at Pascal College, Zaandam. Kroes has a strong curiosity in fish. In 2016, he received a research grant for teachers from Dutch Research Council NWO to perform a PhD study on fish migration in Dutch delta lakes. Since then, he combines his teaching activities in Zaandam with his PhD study at the University of Amsterdam (UvA). Kroes collaborates in a research project to understand the main drivers for ecosystem development and functioning in lake Markermeer, a Dutch Delta lake, together with prof. dr. Piet Verdonschot, dr. Harm van der Geest, dr. Arie Vonk and dr. Emiel van Loon from the Institute for Biodiversity and Ecosystem Dynamics (UvA-IBED). Small and weak swimming fish are the main study objects of Kroes.

In this study we focus on attraction of glass eels (Anguilla Anguilla L.) by freshwater currents. Glass eels are thought to use sea currents to travel back from hatching areas to their parents freshwater residence. After one or two years from hatching, glass eels arrive at European coasts trying to reach the freshwaters. Studies emphasize the need of freshwater flows to attract migrating fish. However, in the transition zone from salt to freshwater, the fish find themselves confronted with obstructions for further migration like sluices and water pump stations. Some of these barriers do provide a freshwater current but cannot be passed. At these locations, the migrating fish wastes energy, which can affect survival, growth or reproduction. The extent to which this phenomenon occurs remains unknown. Therefore we use capture data from a glass eel monitoring project in The Netherlands to study fatal attraction of maleficent freshwater flows. Volunteers caught glass eels with 1sqm shore-operated lift nets near barriers. All barriers produce fresh water currents and enter sea-connected canals and rivers. Samples were taken at 31 locations, two times a week from March to June. The water boards continuously monitored water discharges from all sample locations. We plotted caught glass eels and water discharge (in hours before catchment) per month for locations with passage facilities and locations without passage facilities. We will discuss results and methodological design of this study.
Session C6: Eel & Lamprey Passage III

Spatial mismatch between sea lamprey behaviour and trap location explains low success at trapping for control

Rob McLaughlin

Rob McLaughlin is an associate professor in a position jointly funded by the Great Lakes Fishery Commission and the University of Guelph. He has 20+ years of experience researching the behaviour, ecology, and management of fishes, including fish passage, control of invasive species, phenotypic divergence, and human influences on fish diversity. He is co-developing the Great Lakes Fishery Commission’s research initiative on selective fish passage.

It is widely hypothesized that understanding behaviour can improve the passage (or blocking) of migratory fishes at obstructions to movement. We tested if the behaviour of migrating adult Sea Lamprey (Petromyzon marinus) and nightly manipulation of discharge could explain lower than desired trap success at a hydro-generating station on the St. Marys River connecting lakes Huron and Superior. The Sea Lamprey is an invasive species in the Great Lakes. We quantified numbers and movement tracks of acoustic tagged Sea Lampreys migrating up to, and their space use at, the hydro-generating station. In 2011 and 2012, 78% and 68% of tagged Sea Lampreys reached the generating station, respectively. Sea Lampreys were active along the face, but more likely to occur at the bottom, and away from the traps near the surface, especially when discharge was high. Our findings suggest that low probabilities of encountering traps was due to spatial (vertical) mismatch between the space use of Sea Lamprey and the trap locations and that increasing discharge did not alter space use in ways that increase trap encounter. Understanding the behaviour of invasive species can help managers assess the efficacy of trapping and ways of improving trapping success.
Session C6: Eel & Lamprey Passage III

Passive Sorting of Invasive Sea Lamprey Using Selective Fish Passage

Nicholas Corniuk

Nicholas Corniuk is a Master's student in his second year at Eastern Michigan University. He completed his undergraduate work at Central Michigan University, and has an interest in aquatic ecology with an emphasis on invasive species. Prior to arriving at Eastern Michigan, Nicholas worked to characterize the feeding patterns of invasive grass carp in Lake Erie. His work for the past year and a half, has focused on developing a selective fish passage device to address the habitat fragmentation caused by sea lamprey barriers within the Great Lakes.

Selectivity is often considered a negative aspect of fishway design. However, when viewed in the context of invasive species management, fishway selectivity can be a useful tool. Our project investigates the use of a selective fish passage device to passively sort invasive sea lamprey (Petromyzon marinus) from native finfish in the Great Lakes. We hypothesized that this could be achieved using a narrow channel to limit the tail beat amplitude of sea lamprey relative to smaller native fish species. To increase the difficulty associated with passage, these devices were inclined and water depth within the channels was limited. Two square channels, with widths corresponding to 10% and 20% of average sea lamprey body length, and one channel with sloped sides corresponding to 20% of average body length, were tested. Two angles, and two flow treatments were also tested. The performance of sea lamprey and two native species, creek chubs and white suckers, was evaluated across 12 possible combinations. Our results indicate that channel width did not have a significant effect on passage rates for either group. However, the angle of inclination showed a strong effect on lamprey passage rates. Nearly all configurations tested at the steeper inclination, 10-degrees, prevented lamprey passage, but allowed some finfish to pass. Channel flow also showed a strong effect, increasing passage rates for both groups. While these results indicate that reducing tail beat amplitude cannot sufficiently hinder sea lamprey swimming ability, the results of our 10-degree treatments suggest that an optimal balance of device inclination and ramp flow may selectively prevent lamprey passage. The relatively mild inclination required to block lamprey is particularly encouraging, as this should allow a greater proportion of native species to successfully pass this type of device.
Session C6: Eel & Lamprey Passage III

Dynamic structure operations for sea lamprey barriers

Dr. Michael Scurlock

Michael Scurlock, Ph.D, P.E. has been working in river research and applications for nearly a decade. His primary areas of expertise include hydraulic structure design, computational fluid dynamics, river and riparian restoration, and channel morphology. He is part of the RiverRestoration.org team, where they strive to make rivers better places for the community and ecosystem.

Sea lamprey (Petromyzon marinus) are an invasive, parasitic species to the Great Lakes Fishery, which have resulted in substantial destruction to ecological and economic resources. Efforts to control sea lamprey reproduction have been concentrated in the construction and maintenance of in-stream physical barriers that block access to upstream tributary spawning grounds. Barriers operate by producing hydraulic conditions exceeding the lamprey swimming performance, either through a free-overfall jumping distance, localized burst velocities, or a length of sustained velocity. Typically, barriers are constructed to focus on one barrier hydraulic, which is typically a fixed crest free-overfall configuration. A case study is presented for the design of an adjustable hydraulic structure which produces both free-overfall and velocity blockage conditions across a wide range of flow rates within the Grand River at Grand Rapids, MI. The design of the structure increases the operational range beyond a fixed-crest or single-flume design. Free-overfall operations may produce hydraulics which simultaneously block sea lamprey and permit the passage of select jumping fish species. Structural geometry optimization for velocity-blockage configurations concentrates peak and sustained velocities without generating turbulent separation zones that may be exploited for upstream passage. Results of the case-study design hold implications for physical barrier construction across a wide range of river scales, notably when upstream flood constraints are present.
Session C6: Eel & Lamprey Passage III

Efficacy of pulsed direct current to guide migrating sea lamprey

Dr. Nicholas Johnson

I study fisheries with a focus on invasive species control and native species restoration in the Great Lakes through enhanced understanding of their sensory ecology and population demographics. I earned my B.S. degree from the University of Wisconsin – Stevens Point, and M.S. and Ph.D. degrees from Michigan State University. I became a research ecologist with USGS, Great Lakes Science Center, Hammond Bay Biological Station in 2009, serve in adjunct appointments at several universities in Michigan, and am an associate editor of the Journal of Great Lakes Research. My research is mostly in collaboration with the Great Lakes Fishery Commission where I am a member of the Sea Lamprey Trapping Task Force and Barrier Task Force.

New approaches to controlling invasive sea lamprey in the Great Lakes are desired. We conceived that graduated fields of pulsed-direct current may be useful for guiding juvenile and adult sea lamprey to traps during their respective downstream and upstream migrations in Great Lakes tributaries. Since starting this line of research in 2010, we have characterized responses of out-migrating juvenile sea lamprey to pulsed direct current in a lab and found that guidance efficiencies can reach 80%, but decrease with increasing water velocity. We have also characterized responses of adult sea lamprey to pulsed direct current in the lab, semi-natural stream conditions, and completely natural management scenarios; an optimized trapping system with pulsed direct current was able to remove up to 75% of adult sea lamprey from a spawning stream. During all experiments, non-target mortality was rare and impacts to non-target migration were minimal; likely because pulsed-direct current only needed to be activated at night (7 hours of each day). This presentation will summarize lessons learned from these electrical guidance studies and potential applications of the technology as a management tool for both invasive species control and fish passage needs.
Session C6: Eel & Lamprey Passage III

Attraction and passage efficiency of a vertical-slot fish pass for sea lamprey

Dr. Bernardo Quintella

Graduates in 1999 in Marine Biology at the Faculty of Sciences of the University of Lisbon; Ph.D in the Biology and Conservation Area presented in 2007 at the University of Lisbon with a dissertation focus on the sea lamprey. At the present time is an Invited Assistant Professor at the Faculty of Sciences of the University of Lisbon and a researcher at the MARE centre. The main area of expertise is Fish Migrations, with a particular focus on diadromous movements. Fish passage problematic is one of the areas of interest, including not only the evaluation of the adequacy of a fish pass for the target species but also contributing for the design improvement of these infrastructures. In recent years it has been involved in the construction and monitoring of several fish pass devices

Fish passes specifically designed to target lamprey species are not common and most multispecific devices are often less efficient for these anguilliform swimmers. A vertical-slot fish pass recently built at Coimbra dam (River Mondego, Portugal) was designed specifically for targeting anadromous shads (allis and twaite shad) and sea lamprey (Petromyzon marinus L.). To evaluate the attraction efficiency of this fish pass for sea lamprey, continuous video recordings allowed to count every individual that used this infrastructure during four consecutive spawning seasons (2013-2016). Count data was related with a set of environmental variables, and the statistical models developed consistently identified the same group of explanatory predictors as responsible for variations in the attraction efficiency of this device. Different hydrological years (wet versus dry years) were compared and there seems to be a consistency in the main explanatory predictors independently of the hydrological characteristics of the spawning seasons. To estimate passage efficiency, a PIT antennae system was installed and a sub-sample of individuals was tagged and released downstream. Passage efficiency significantly varied along the spawning season, and highest efficiencies were recorded during the peak of the migratory movement. Abundance of sea lamprey larvae increased more than thirty times upstream the fish pass since its construction in 2011. Based on the presented results, general considerations on future monitoring procedures for evaluating fish pass efficiency are presented.
Building Barriers to Protect Southwestern Native Fish

William Stewart

Bill Stewart has been a fisheries biologist with the Bureau of Reclamation for the past year. Prior to that Bill spent 12 years with the Arizona Game and Fish Department managing their aquatics research program. In his current position he is responsible for implementing the Gila River Basin Native Fish Conservation Program designed to project rare endemic species of the southwest. As part of the native fish conservation program, Bill works closely with Reclamation engineers to identify suitable locations and design fish barriers to protect native fish populations from encroachment of non-native fish.

The Central Arizona Project (CAP) is a 333-mile long aqueduct system that transports Colorado River water to municipal, industrial, and agricultural users in the Gila River basin. The Bureau of Reclamation and Fish and Wildlife Service (FWS) entered into Endangered Species Act consultation on the project’s potential to translocate nonnative aquatic organisms that could negatively impact federally-listed native fishes in the Gila basin. A series of consultations dating back to 1994 identified measures to protect native fish, one of which consists of construction of fish barriers to segregate native from nonnative fishes. In the most recent consultation (2008), the Bureau of Reclamation committed to construction of 12 fish barriers in the Gila River basin. To date eight barriers have been constructed. Barrier design consists of a vertical concrete wall that rises 4-5 feet above a concrete apron on the channel bottom. The crest wall typically follows the configuration of the channel bottom so that a 4-5 foot drop extends across the entire channel bottom. The apron is designed to produce uniform water velocities that exceed fish swimming abilities, thereby precluding upstream passage. This presentation will share the successes and challenges associated with fish barrier design and construction in the Gila River basin of Arizona.
Session C7: Ecology and Planning for Passage

Computational agent-based model of fish swimming through Mississippi River locks and dams can be used as a tool to gain way to selectively block invasive carp passage

Dr. Anvar Gilmanov

Anvar Gilmanov Dr. Gilmanov earned a M.S. degree in Moscow State University (Russia) in 1973 and a PhD degree in Computational Fluid Dynamics in Institute of Theoretical and Applied Mechanics (Russian Academy of Sciences, Novosibirsk) in 1982. He also earned additional degree Doctor of Physical and Mathematical Sciences in Computational Fluid Dynamics in Institute of Applied Mathematics (Russian Academy of Sciences, Moscow) in 1996. Dr. Gilmanov’s research interests lie in the intersection of two fields of computational mechanics: Computational Fluid Dynamics and Computational Solid Dynamics, and his interests are concentrated on Fluid-Structure Interaction phenomena. His current research includes (a) Create a Computational Fluid Dynamics (CFD) model of Lock and Dam #5 using available computational software such as ANSYS-Fluent, Matlab; (b) Get new data from simulation of fish swimming, identify and recommend changes to gate operation to block Asian carp.

The imminent threat of invasive (Asian) carp swimming into the Upper reaches of the Mississippi River demands new and effective approaches to selectively block these species. The lock and dams located in the Mississippi River already create flow conditions that appear to slow the passage of many fishes, but this attribute has not been systematically examined. To determine the possibility that minor modifications to gate operation might create flow-fields that prevent invasive carp from passing while permitting others to do so, we developed an efficient approach using a combination of a computational fluid dynamics (CFD) model of flow through a lock and dam and an agent-based (AB) fish passage model. The CFD model can resolve the complex hydraulic patterns at fine spatio-temporal. The AB model uses empirical swimming-fatigue relationships to simulate how and where fish of different species and sizes might pass assuming they are optimally motivated to pass (a worse-case scenario). This CFD-AB model determines optimized gate operation protocols that either block (or permit fish) passage. In this talk we will present the concept of the CFD-AB model and then discuss results for Lock and Dam #5 (Winona, Minnesota), a location of critical importance because it is south of the Minnesota and St. Croix River confluences. We also present a possible enhancement of this computational approach. This work is funded by the Minnesota Environment & Natural Resources Trust Fund.
Session C7: Ecology and Planning for Passage

Linking hydroclimate and fish phenology to fish passage using ichthyographs

Dr. Ivan Arismendi

Dr. Ivan Arismendi is an aquatic ecologist that holds an Assistant Professor position at Oregon State University since 2016. He grew up in southern Chile where he obtained a degree in Fisheries Engineering and posterior Doctorate degree in Forest Sciences from Austral University in 2010. His research has been focused on aquatic ecology and climate change impacts on freshwaters.

Adaptation to environmental conditions is a cornerstone of population-level resilience. Predictions of the impacts of barriers to fish passage that focus only on point estimates of environmental conditions (e.g., flow) during a particular time period and do not consider life-stage specific behaviors may overlook the importance of species-specific adaptive capacity at individual life stages. Here, we present a framework that considers life-stage behaviors of salmonids and other aquatic species providing an ecosystem context to fish passage efforts. Our framework allows for behaviors to be considered within the context of the hydrologic regime, and can identify vulnerability of sections of the population or life stages based on phenology.
Session C8: Road Crossings and Connectivity

An Update on the Fish Passage File in British Columbia

Mr. Craig Mount

Craig is the Aquatic Habitat Geomorphologist with the BC Ministry of Environment. He obtained his M.Sc. in Physical Geography from the University of Western Ontario in 1995. He has worked in the Environmental Management field in BC since that time with experience in both consulting and varying levels of government. Craig has been on the Culvert Fish Passage Technical Working Group since its inception in 2007 and provides spatial modelling and data management expertise in addition to his main role as fluvial geomorphologist.

Fish Passage at resource road crossings continues to be large problem in British Columbia (BC), Canada. With a land mass larger than California, Oregon and Washington combined, BC has a massive legacy of roads (>550,000 km) on the landscape. Conservative estimates place the number of culverted crossings on these roads at more than 400,000 - many of which represent a barrier to fish passage. As a result, improperly designed / installed / maintained closed-bottom culverts and the resultant isolation of thousands of kilometres of fish habitat are one of the greatest threats facing the significant number of native BC fish species (anadramous and otherwise). As a follow-up to presentations given at this conference in 2011 and 2013, this presentation will provide an update on progress made by the multi-agency Fish Passage Technical Working group which is addressing this problem in BC. Accomplishments in the interim include improvements to the PSCIS database system, expanded collaboration within Provincial Ministries and Federal Fisheries, increased partnerships with First Nations and NGOs and a growth in leveraged funds spent on crossing remediations. The BC Fish Passage Program has now carried out over 17,000 assessments and while this is a small percentage of the total number of crossings on the landscape, it does give us a reasonable sample size from which to draw some meaningful observations. Updates and refinements made to the freshwater fish habitat model have also allowed for a more quantitative and qualitative assessment of the opportunities for regaining habitat in different types of watersheds. The results from this spatial analysis of crossings and the habitat they impair in a cross-section of topographically and hydrologically diverse watersheds from around the province will also be presented.
Session C8: Road Crossings and Connectivity

_Enhancing aquatic connectivity by preventing unintentional fish passage barriers_

Dr. Ian Kroll

Ian Kroll is a natural resource policy fellow in the Fish and Aquatic Conservation Branch at the U.S. Fish and Wildlife Service’s Headquarters. His position, which focuses on analyzing the policies that create or perpetuate unintentional fish barriers, is funded through the Dean John A. Knauss Marine Policy Fellowship and the National Sea Grant Program. Kroll recently finished his doctorate in Marine Sciences from the University of North Carolina at Chapel Hill. For his graduate work, Kroll developed and applied geochemical tagging techniques to assess the connectivity among the larval, juvenile and adult subpopulations of commercially important marine fisheries across estuaries. His research included studies on larval oyster dispersal among designated spawning sanctuaries and population-level effects of estuarine habitat utilization by juvenile black sea bass. As a graduate student, Kroll was awarded a three-year NOAA Fisheries Sea Grant Fellowship. He received a bachelor’s degree in biology from Vassar College in Poughkeepsie, New York.

Governmental and non-governmental (NGOs) programs that fund fish passage barrier removal and aquatic connectivity improvements have achieved broad success. Since 1999, the U.S. Fish & Wildlife Service’s (USFWS) National Fish Passage Program has reopened approximately 15,000 stream miles and 82,000 acres of wetlands to fish and other aquatic species. However, even as existing barriers are being removed, over 2.5 million dams, culverts, and other barriers remain throughout the United States. Furthermore, gaps in policy, enforcement of those policies, and lack of knowledge and awareness of effects to resources may contribute to new unintentional fish passage barriers. Unintentional barriers not only threaten several commercially, recreationally, and ecologically important species, but also jeopardize community resilience during extreme environmental events. Therefore, it is imperative to understand the root cause of barrier creation and perpetuation. The USFWS recently began an effort to document existing policies, legislation, technical issues, and knowledge gaps that may result in the construction of unintentional barriers. This nation-wide effort attempts to address fish passage issues through prevention, in conjunction with already successful restoration programs. Here, we will discuss how current permitting and funding practices can create new barriers and perpetuate existing barriers through the lens of three federal public works agencies: Federal Emergency Management Agency (FEMA), Federal Highway Administration (FHWA), and U.S. Army Corps of Engineers (USACE). We also suggest short (1-3 yr) and long (3+ yr) term management solutions and policy amendments to improve aquatic organism passage, economic gains, and flood safety.
Session C8: Road Crossings and Connectivity

Washington State Department of Transportation’s Fish Passage Program

Ms. Susan Cierebiej

Susan Cierebiej is a biologist with 24 years of experience working for the state of Washington. Susan has worked in the field of fish passage and salmonid habitat restoration for the Washington Department of Fish and Wildlife (WDFW) and presently at the Washington State Department of Transportation (WSDOT). Susan has been involved with the WSDOT fish passage program since 1996. Susan received her Bachelor of Science in Environmental Science from the Evergreen State College, Olympia, Washington.

The Washington State Department of Transportation (WSDOT) has long recognized the importance of minimizing the environmental impacts of Washington’s transportation system. As a part of that commitment to the environment, in 1991, with legislative support, WSDOT created a dedicated program to correct barriers that restrict or completely block salmon and trout access to historic spawning and rearing habitat. In that same year, WSDOT partnered with the Washington Department of Fish and Wildlife (WDFW) to assist with that effort. Through a comprehensive inventory it was determined that WSDOT highways had 3,601 fish-bearing stream crossings; of which, 55% are barriers to fish passage. Culverts can impede fish movement when surface water drops are excessive, flow velocity is too high, water depth is too low, or sharp changes in gradient are too steep for fish to navigate. This can result from improper culvert installation, deterioration, changes in basin flow conditions over time, and because human understanding of fish passage has evolved over time. The health of salmonid populations are an indicator of ecosystem integrity and a major natural resource concern in the Pacific Northwest. Salmonids are highly mobile species. Adult salmon, steelhead, sea-run cutthroat, and anadromous bull trout migrate from the sea to freshwater, accessing the streams where they were born. Juvenile salmon rear in fresh water streams, sometimes for a year or more, moving upstream and downstream, seeking food and cover, before outmigration to the sea. Resident salmonids also require unrestricted access to spawning and rearing habitat. In the early years of its fish passage program, WSDOT relied heavily on retrofitting barrier culverts to make them fish passable by adding weirs or baffles. While this was an inexpensive way to provide some fish passage to a relatively large number of sites, it has proved to be a short-term fix and does not meet the passage needs of juvenile salmonids and other aquatic species. WSDOT now primarily replaces barrier culverts using either stream simulation culverts or bridges. While bridges are preferred for facilitating habitat connectivity for both fish and wildlife, they can be much more expensive and we have found that many of the benefits of bridges can be achieved using stream simulation culverts. The stream simulation design attempts to construct a channel within the culvert that mimics the conditions in the natural channel so that if the natural channel is passable for fish, then the stream simulation culvert should be passable for fish species present as well. To date, WSDOT has completed 321 fish passage barrier corrections, allowing access to 1,759 kilometers (1,093 miles) of potential upstream habitat for fish.


Session C8: Road Crossings and Connectivity

Determining potential functional connectivity of fish species with various life history traits

Andrew Chin

Andrew Chin is a PhD candidate at the University of Toronto investigating the effects of land use and environmental change on fish communities in estuaries to the headwaters. His studies are based in New Brunswick, Canada using various datasets to address the impacts of habitat change on both habitat quality and the amount of habitat, as well as species movement.

The effect of stream fragmentation due to culverts on the functional connectivity of various fish species may be determined by their life history traits. Depending on the location of the spawning habitat, certain species encounter more obstacles to swim upstream from the estuaries to the headwaters, such as diadromous species which require both freshwater and marine habitat. By contrast, non-diadromous species will still encounter obstacles at any point in the stream network. However, the ability of many species to pass through the culverts due to the swimming strength is unknown. We used the total length of species as a morphometric approach to infer the swimming strength of four focal species with different life histories. Two focal species—non-diadromous Fourspine Stickleback (Apeltes quadracus) and diadromous Ninespine Stickleback (Pungitius pungitius)—have similar swimming strengths due to their sizes, but different life history strategies. Next, we compared two similar diadromous species with different total lengths—Alewife (Alosa pseudoharengus) and American Shad (Alosa sapidissima)—which the former is smaller than the latter. We analyzed the amount of habitat available for these species by calculating the Dendritic Connectivity Index (DCI) to assess the overall potential functional connectivity of the stream networks of three watersheds of New Brunswick (Canada) for each species to pass through culverts located by Fisheries and Oceans Canada. The DCI accounts for the life history of the diadromous and non-diadromous movement of specific species. We also determined the probability of reaching each stream segment based on the swimming strength. Future directions include completing the analyses for all 25 species found within these watersheds using the morphometric approach to account for the variability in size of juveniles and adults. Overall, our findings emphasize that a species-based approach is necessary to inform policy and management in the development of fish passage standards.
Session D1: Screens I

Improving Data Collection Methods for Hydraulic Evaluations of Fish Screens

Mr. Christopher Shupe

Christopher (Kit) Shupe, E.I.T. is a hydraulic engineer in the Hydraulic Investigations and Lab Services group at the Bureau of Reclamation's Technical Service Center in Denver, Colorado. He received his B.S. degree in civil engineering from the University of Colorado Denver. He gave an oral presentation, "St. Mary Diversion Dam Fish Passage Model Study", which he co-authored at the 2016 Fish Passage conference in Amherst, Massachusetts.

Fish screens are installed at water diversions to protect fish from entrainment into the diversion system. Reclamation is required by federal and state regulatory agencies to conduct post-construction hydraulic evaluations of all new fish screening facilities to ensure compliance with fish screen criteria. Evaluations also need to be completed if there are changes in diversion operations, screening operations, or baffle settings. Field evaluations of large fish screens require significant effort in designing an appropriate instrument mount system, collecting data, and analyzing results. There may be situations where physical (structure geometry, features, and access), hydraulic (approach velocity magnitude or uniformity), or environmental (debris loading, algal growth, and sediment accumulation) conditions make it difficult or impossible to meet criteria or produce unknown errors in data quality. The purpose of this research project was to determine if methods for collecting hydraulic data on vertical flat plate fish screens can be improved to reduce evaluation cost and increase measurement quality. Testing was performed on a full scale four-bay vertical flat plate fish screen diversion model. The following questions related to current methods for making velocity measurements on fish screens were addressed in this study. What is the effect of velocity measurement distance from the screen face on approach velocity? Are velocity measurements collected greater than 3 inches from the screen representative of near-screen conditions? What are the best measurement locations to accurately represent flow through the screen face? Can a traversing data collection system be used in place of collecting stationary data points at the screen face? What is the effect of traversing speed on approach and sweeping velocities? Are the velocity measurements affected by vibrations induced on the measurement probe? What is the effect of screen porosity on screen approach velocity uniformity?
Session D1: Screens I

A decade of steelhead smolt entainment: fish diversion patterns of irrigation dams in the Umatilla River Basin, Oregon

Will Simpson

Will Simpson has participated in research and monitoring of Pacific Northwest fish for 15 years. He is currently a Fish Ecologist for the Quantitative Ecology and Technology program at U.S. Fish and Wildlife Service’s Abernathy Fish Technology Center in Longview, WA. Will has a strong background in using and developing tools to evaluate the effect of passage barriers, hatchery supplementation, and invasive species on fish.

Few studies have quantified long term variability in entainment of anadromous salmonids at irrigation diversions at a basin level. Consequently, the factors that influence variability in entainment and how this entainment and associated fish screening technology affects salmonid populations has not been extensively evaluated. We monitored movement of hatchery steelhead smolts at three federal irrigation canals in the Umatilla River basin, OR. Passive integrated transponder (PIT) tag antenna arrays were deployed at canal headgates and screens to estimate the entainment and bypass of volitionally migrating steelhead. A subsample of approximately 5,000 hatchery steelhead smolts were tagged and released annually within natural production areas upstream of the three irrigation diversion dams over eleven years, and we examined whether the river flow at these diversions and the timing of diversion was related to the magnitude of entainment. Relationships between fish entainment and river flow were unique to each diversion, and as a result some of the largest annual entainment numbers occurred at a smaller diversion. Patterns of PIT tag detections suggest that these diversion-specific relationships are in part influenced by the morphology of diversion dams and streams near canal headgates. We estimated 24% of hatchery steelhead smolts (N=411,824) released upstream entered at least one irrigation canal during downstream migration; however, 98.5% of these fish returned to the Umatilla River using screened bypasses and few dead or stranded PIT-tagged steelhead were detected within dewatered irrigation canals. Fish screens on diversions of the Umatilla River appear very effective at preventing steelhead losses to irrigation canals, even though many steelhead were entrained into irrigation canals. The results suggest that canal monitoring efforts ideally should capture interannual variability in fish entainment and should not necessarily be limited to the largest irrigation diversions.
Session D1: Screens I

Fish screening and passage at the Harmony Diversion near Manderson, WY: Harmony can be tortuous.

Nick Scribner

Nick has been the fish passage coordinator for WY Game and Fish (WGF) since 2015. In this role he provides support and leads projects to address passage and entrainment issues across WY with peers, local government, and non-governmental groups such as Trout Unlimited. The position is rather new within the department, having been created in 2009, so we’re still figuring it out. Prior to that he was a habitat biologist at WGF for 9 years working on stream restoration projects, fish passage, riparian habitat, and upland habitat issues. He was raised on a dairy farm in NW Wisconsin and completed his bachelors at UW-River Falls and Masters at UW-Stevens Point prior to moving west to work for WGF in 2005.

Harmony Diversion is located in North Central Wyoming on the Nowood River 7.5 miles upstream from its confluence with the Big Horn River near Manderson, WY. The Nowood River supports 20 different fish species of which 17 are native and 6 are listed as sensitive in Wyoming’s State Wildlife Action Plan (SWAP). Entrainment studies conducted in the canal during 2006-2007 estimated total annual entrainment to be nearly 55,000 fish consisting of 16 different species including 4 of the 6 sensitive species. Sensitive species captured in the canal included burbot (Lota lota), sauger (Sander canadensis), flathead chub (Platygobio gracilis), and mountain sucker (Catostomus platyrhynchos). The instream diversion is also an upstream barrier to fish movement. During low water years the structure blocks the entire river channel. Work began in 2009 to identify options to reduce fish entrainment and improve passage. A preferred alternative was developed that included installation of a new headgate with fish screens, permanent concrete diversion structure, fish ladder, and sediment sluiceway. Construction of a new headgate and installation of 2 cone screens were completed in 2014. Unfortunately, the concrete diversion, fish ladder, and sluiceway plans were developed before issues related to shovelnose sturgeon (Scaphirhynchus platyrhynchos) passage, ice jams, and long-term maintenance of the adjacent highway were fully evaluated. After considering these issues, a new approach is being pursued to move the diversion upstream, abandon the newly built headgate structure, and replace it with a similar headgate and fish screens at a new site. The new structure would incorporate 5 rock weirs in the stream channel and require moving a portion of the irrigation ditch. Finding a solution to best address entrainment, passage, and maintenance all at once has been a tumultuous task at Harmony Diversion. However, the current plan provides the greatest benefit to the stream, fish populations, and landowner while favorably addressing long-term maintenance and channel stability.
Retrofit of a Flat Plate Fish Screen with an Air Burst System for Sediment Transportation

Mr. Ryan Stephen


Flat plate fish screens are located and positioned in an off-stream intake channel. The channel is located downstream of an intake structure that includes trashracks and crest gates. A bypass structure is located at the downstream end of the channel that returns the fish to the river. The crest gates were designed to control flow through the structure and prevent the sediment bed load from entering the intake structure. The original operations and maintenance plan was to manually remove sediment on an annual basis. After commissioning, the intake channel experienced greater sediment deposition than expected. Sediment build up disrupted cleaning of the fish screen and flow profiles through the screens. Onsite personnel attempted to manage the sediment from the top of the structure with hand tools and a length of pipe attached to an air compressor. Moving floors, jetting systems and air burst systems were considered as possible solutions. Due to area and space constraints, intake layout and existing equipment onsite, an air burst system was selected to help mobilize sediment downstream through the intake structure. The air burst system was designed to clear the sediment at and directly upstream of the fish screen panels to allow the screen cleaner sweep to operate properly and more effectively. Distribution headers were installed at the bottom of the screens and along the bottom of the opposite wall at the downstream end of the structure. After installation, sediment transportation was greatly improved. The screen cleaner is no longer impeded by sediment accumulation. A side effect was floating debris sinks during the burst and gets transported through the bypass instead of building up at the downstream end of the intake structure. This presentation will discuss the strengths and limitations of the air burst system, along with future testing of air burst systems.
Session D2: Screens II

Tokul Creek Fish Passage and Hatchery Intake Improvements

Mr. Steven Kingsley

Steve Kingsley is a Principal and Civil Engineer at KPFF Consulting Engineers where he has specialized for over 23 years in planning, design and construction of projects at the interface of land and water. Steve has been engaged in a broad range of project types for Fisheries and Natural Resource agencies for the past 12 years including fish passage, intake screening, hatchery renovation, and stream restoration. Steve is a licensed civil engineer in eight states including Washington, Oregon, California and Alaska.

The Tokul Creek Hatchery in Snoqualmie Washington, operated by Washington Department of Fish and Wildlife (WDFW), was established in 1901. To control water level in the creek for hatchery water supply intake, a concrete and timber weir with an integral pool and weir fish passage was constructed across the full width of the Tokul Creek in the 1950’s. Since original construction, the weir and fish passage have been damaged by flood debris and undermined by degradation of the streambed. As a result of the damage, the weir had become endangered to potential structural failure, and the structure had become a barrier to migrating fish and other aquatic organisms including Fall Chinook, Fall Chum, Coho, Pink, Summer Steelhead, winter steelhead, and cutthroat trout. Through a planning and design process begun in 2012, several alternatives for long term fish passage improvement were evaluated including roughened channel type and vertical slot and pool type. The design also included construction of a new flow control weir and screened hatchery intake in compliance with current guidelines for fish passage and screening. For this particular location, guidance from WDFW and the National Marine Fisheries Service (NMFS) as well as the unique hydrologic extremes of the watershed steered the project toward the vertical slot and pool type. Seasonal flows on Tokul Creek vary by a factor of more than 40, creating challenges to maintaining fish passage throughout the year. Successful construction of the facilities began in May 2016 and was completed in January 2017. This presentation will describe the approach used to evaluate alternatives for fish passage and intake screening improvement, the geologic and hydrologic conditions at the facility that influenced the design, and the challenges of constructing the passage and flow control weir in the creek while sustaining hatchery operations and avoiding adverse construction impacts on downstream habitat.
Session D2: Screens II

The efficiency of inclined and oriented racks at small and medium sized hydroelectric plants to prevent Atlantic salmon smolts from entering turbines

Mr Stéphane Tétard

I obtained a master's degree in Fisheries and Aquatic Sciences in 2011. Since 2013, I have been working for EDF (Electricity of France) in the National Hydraulic and Environment Laboratory. I am involved in many fishway design projects together with civil engineers. Some of these projects are associated with physical modeling in our lab to evaluate some fishway solutions. I also conduct various ecohydraulics studies mainly focused on diadromous fish with a special attention on fish behaviour using telemetry (acoustic, radiotracking, RFID) and sonar imaging.

Accurate evaluation of the functionality of all newly designed fishways is needed to ensure that river connectivity is restored. The efficiency of a protection system for fish migrating downstream: low-sloping or oriented rack with narrowly spaced streamwise bars associated to a bypass, has been assessed for Atlantic salmon smolts at four small or medium sized hydroelectric plants (HEP with maximum intake capacity between 5 and 30 m3.s-1) in southwestern France. For the evaluation of these downstream passage facilities, we used mark-detection method. Between 239 and 300 hatchery-reared salmon smolts per facility were PIT-tagged and released in 5-6 groups 100 m upstream the HEP. Their passages downstream the HEPs were monitored with RFID antennae. On average between 82.8% and 92.3 % of released smolts successfully crossed the HEP through a non-turbine route. Mean bypass passage minimum efficiency was between 80.9 and 87.5% according to studied sites and no released group of fish had a passage efficiency below 70%. Except at one site where passage times were longer, 50% of smolts passing through the bypass did it in less than 23 minutes after release and 75% of them did it in less than 2h15min. Including surviving fishes passing through the turbines, adjusted overall fish passage efficiency at studied HEPs was between 98% and 99.2%. Our findings give credence to the recommended design criteria for low-sloping and oriented racks, which are the main solutions implemented in France for small and medium sized HEPs.
Session D2: Screens II

Size Matters: Using Experience, Data, and Modeling to Scale the Farmers Screen For Large Diversion Applications

Mr. Les Perkins

Les Perkins has spent the last decade developing, refining, and creating a market for The Farmers Screen™. Les was a co-founder of FCA and a leader in the fish screening and passage industry in the Pacific Northwest. Les has been a frequent speaker at fish passage and screening as well as restoration conferences around the US and in Australia. In addition, Les has been intimately involved in the assessment of potential hydropower sites in the western United States. Les is currently the Chair of Oregon Department of Fish and Wildlife’s Fish Screening Taskforce as well as a consultant to the Australian government regarding fish screening criteria development. Les is currently the General Manager at Farmers Irrigation District in Hood River, OR.

Farmers Conservation Alliance (FCA), a 501(c)3 non-profit company dedicated to creating innovative technologies and program policies to modernize irrigated agriculture, developed the Farmers screen to reduce operational expenses and eliminate threats to fish. The Farmers screen – a federally approved, passively safe, horizontal water diversion fish protection system, is a self-cleaning fish screen, patented for both form and function, that requires no power, has no moving parts, and protects anadromous and resident fish of all lifestages, thus facilitating safe fish passage at water diversion inlet facilities. Ranging in size from 1.0 to 160 cubic feet per second (cfs), 41 water diversion screen sites throughout the Western US have been converted to the Farmers Screen technology. Recent international interest in scaling the Farmers Screen by two orders of magnitude has developed, and both physical modeling and finite element analyses are presently pending or underway in Southeastern Australia, Oregon, and England’s Lake District. Building upon the fundamental mass balance relationships associated with the Farmers screen geometry, screen function is naturally facilitated by the screen’s taper wall, weir wall, and a properly proportional footprint, thus inducing (consistently with Newton’s conservation laws of mass and momentum) a high horizontal sweeping velocity and a minimal vertical through-screen velocity. The combined velocity attributes are synergistically conducive to the screen’s self-cleaning dynamics and the assurance that fish of all life stages safely pass through the diversion without injury or mortality. With an eye to ultimately screening very large dams, the quest to first upscale the Farmers screen to a 1,000 cfs prototypical embodiment is explored.
Session D3: Dam Removal

*Dam Removal Europe: a movement needed to support practitioners and to refute myths to citizenship*

Mr. Herman Wanningen

Herman is a Dutch aquatic ecologist with more than 18 years of experience. He has worked for regional water authorities on river and lake restoration projects. In 2007 Herman started Wanningen Water Consult. He develops fish migration visions and policies and gives advice on implementing different types of fishway techniques. He gives advice on national and international fish passage and river connectivity projects such as the Iron Gate Dam in the Danube River (Romania) and a Sturgeon project in the Ebro River (Spain). He organizes conferences, network meetings. He is the founder of the World Fish Migration Network and Fish Ecology Network on LINKEDin and World Fish Migration Foundation. Herman is coordinator and co-author of the worldwide guidance “From sea to source, International guidance for the restoration of fish migration highways” which was published in 2012 (www.fromseatosource.com). In 2014 and 2016 he coordinated the World Fish Migration Day, which was celebrated in 270 locations the first year and in 450 the second year.

The removal of dams and weirs has been happening for centuries. Since the 90’s a few countries have increased this activity. USA has already removed at least 1,300 dams. What very few people know is that in Europe there have been over 3,500 barriers demolished already. In some European countries, like France, Sweden, Spain, Finland and UK dams are being removed due to: legislation, safety reasons or the need to reach a good ecological status of their rivers for the Water Frame Directive. However, administrations and practitioners experience opposition against removal because citizens’ knowledge about dam removal is limited and many are against removal for esthetic, cultural or economic reasons. In addition to this, there is the Renewable Energy Directive, which requires EU countries to fulfil at least 20% of their total energy needs with renewable energy by 2020, and amongst these renewable energy sources is hydropower. All this makes dam removal projects tremendously difficult to those who are willing to start removing outdated and unused dams, and automatically makes dam removal an uncomfortable subject to bring up for politicians. This situation is like a snake biting its own tail and it will not progress until we come to an understanding on the need for both efficient dams and removing obsolete and abandoned dams. Therefore, we need to work on more awareness and funding to actually remove old dams. This is why World Fish Migration Foundation (WFMF), World Wildlife Fund (WWF), European Rivers Network (ERN), Karlstad University (KAU), The Rivers Trust and Normandie Grand Migrateurs started a Dam Removal Europe (DRE) movement and platform in 2016 (www.damremoval.eu). DRE wants to improve citizens’ awareness about removing dams and refute wrong ideas, facilitate communication between USA and Europe, create a reference community of experts and starters who generate and share knowledge about dam removal and put dam removal on the agenda of policy makers.
Session D3: Dam Removal

Hogansburg Dam Removal: Repatriation of Tribal Lands, Fish Passage, and Collaboration

Mr. Mark Kacmarcik

Mark Kacmarcik is a geotechnical engineer working for the Corvallis, Oregon office of CH2M, Inc. Mark obtained his Bachelors degree in civil engineering from Virginia Tech in 2004 and his Master of Science degree in geotechnical engineering from Virginia Tech in 2005. Mark has more than 12 years experience in a diverse array of local to international civil engineering projects. Mark specializes in the geotechnics of dams, levees, stream restoration projects, dam removal, and mine reclamation. Mark teleworks from Wenatchee, Washington, where he spends his spare time kayaking, wilderness canoe tripping, trail running, mountain biking, and backcountry skiing. Mark also spends countless volunteer hours working on local salmon recovery projects and bicycle advocacy.

In 2016, the Saint Regis Mohawk Tribe (SRMT), as project co-licensee (FERC ID No. P-7518), decommissioned and removed the 87 year old Hogansburg Hydroelectric Dam—the first impassible barrier to fish on the St. Regis River from the St. Lawrence River in northern New York. Removal of the 281-foot long and 12-foot high Hogansburg Dam reconnected up to 555 river and stream miles of habitat for migratory fish including walleye, lake sturgeon, muskellunge, salmon and American eel. The presentation will focus on how the design, permitting, and construction of the project was undertaken to manage unique technical and environmental challenges including protection of an upstream DOT-owned bridge, management of sediment to protect downstream critical habitat, and stabilization of newly-exposed stream banks subject to high-velocities and ice floes using a hybrid approach of biostabilization and riprap. With the removal of Hogansburg Dam, SRMT is credited with the first removal of a hydroelectric dam in New York and is the first Tribe to remove a Federally-licensed dam in the United States. Success was made possible with broad support from state and Federal stakeholders and serves as a possible model for future dam removal projects involving tribes and First Nations.
Session D3: Dam Removal

Unknowns Associated with Dam Removal and Managing Risk to Fish Passage

Mr. Bill Norris, PE

Bill Norris is a professional engineer with over 25 years of water resource engineering experience. He specializes in data acquisition, hydraulic & hydrologic analyses and planning, design, and construction oversight for habitat restoration, fish passage, wetland, stream channel and large wood installation projects. His expertise with hydraulic modeling facilitates the integration of design analysis with the design process. Bill has been involved with numerous fish passage related projects on both urban and rural rivers throughout the country including the Wind River, Hemlock Dam Removal; White Salmon River, Condit Dam Removal, and Patapsco River, Bloede and Simkins Dam Removals.

Fish passage is an objective of many dam removal projects, yet there are many unknowns associated with dam removal that jeopardize meeting that objective. Designers seldom understand the former channel until it has been exhumed from impounded sediments. Following dam removal, exposed channels may include waterfalls or bedrock chutes, potentially impeding fish passage. If fish historically accessed the basin above a dam, then it is tempting to take the approach that passable conditions existed before the dam; therefore, remove the dam and the passable conditions will be restored. However, dam construction disrupts independent variables such as sediment transport and in some cases hydrology through storage or diversion. In doing so, dams disrupt pre-dam equilibrium channel conditions which forces an adjustment to the channel by dependent variables such as channel slope and bed elevations downstream. Therefore, it is important to understand the initial conditions, and to anticipate the likely geomorphic progression following dam removal when pre-dam independent variables are restored. It is equally important to plan contingency measures to influence the geomorphic progression following dam removal to achieve fish passage goals. The designer should seek understanding of these processes within the context of both the local scale and watershed scale, and consider to what degree independent variables have also changed within the watershed outside of the immediate influence of a single dam. To manage risk to fish passage associated with dam removal, possible channel conditions should be ranked by their probability and consequence on fish passage, and contingency actions should be considered. These assessments should be performed for the initial conditions following dam removal as well as for anticipated geomorphic progression. In this talk, select case studies will be discussed to demonstrate approaches to managing risk to fish passage based on anticipated and actual geomorphic evolution following dam removal.
Session D3: Dam Removal

Smolt-loss in reservoirs and the effects of removing dams in lowland rivers

Dr Niels Jepsen

Niels Jepsen has been a dedicated fish biologist since 1995. He has worked as a senior scientist at DTU Aqua since 2003. His early research focused mainly on up- and downstream migration of salmonids and eel and how artificial impoundments can greatly increase the mortality and delay of migrating fish. In the recent years he has been focusing on the effects of predation and river restoration to support salmon populations.

In many river systems, downstream migrating fish must pass various obstacles. These include natural lakes or river impoundment, water diversions, weirs and dams. The time of seaward migration is critical for juvenile salmonids and high mortality leads to reduced population size and even local extinction. As opposed to natural lakes, reservoirs are man-made obstructions where the local populations of migratory fish have not adapted to traverse lentic waters. Increased predation in reservoirs and impounded areas above dams create favourable habitats for predatory fish species that normally do not occur in faster flowing river stretches and may also delay downstream migration and thereby further increase predation. We recorded 90 % smolt mortality in two reservoirs, largely due to predation. In three additional reservoirs and two artificial wetlands in Denmark, mortality was measured by the same method (telemetry) and the mean loss for salmon and sea-trout smolts was 82 %. We found a high predation rate for smolts released immediately downstream of a power station (70 %) and suggested that predators were attracted to this area in a response to the smolt-run. Compared to the mortality for smolts in rivers, each km of reservoir/impoundment is vastly more risky for migrating smolts. The unsustainable loss rates have been found for both wild and hatchery fish and for both salmon and trout smolts. The only method to effectively solve this problem in lowland rivers has been to remove the barriers. This has been done extensively in Denmark, where app. 70 % of all important dams have been removed during the last decades. The observed effect of these measures on the population of migratory fish has been swift and in some instances overwhelming. In this presentation, 20 years of smolt-loss studies will be summarized and the effect of dam removal will be demonstrated.
Session D3: Dam Removal

Hughesville Dam Removal: A Lesson in Sediment Management

Mr. Geoffrey Goll

Geoffrey Goll is the President and a managing partner of Princeton Hydro, LLC, a water resource consulting firm with offices in New Jersey, Maryland, Pennsylvania and Connecticut with a total of 48 staff engineers and scientists. Mr. Goll obtained his Bachelors Degree in Civil Engineering from Rutgers University, College of Engineering and a Master of Engineering from the University of Wisconsin, Madison. He currently holds professional engineering licenses in seven states. He is experienced in stormwater and floodplain management, wetlands mitigation, river restoration, bridge and culvert engineering, coastal protection, and geotechnical engineering. More specifically, he has managed and overseen the removal of over 30 dams for the purpose of dam safety compliance, fish migration, floodplain reconnection, and habitat restoration.

The Hughesville Dam was constructed circa 1880 and was a timber crib and rock fill dam. The low head dam was 12 feet in total height from the top of the spillway to the bottom of the downstream apron. This was the fifth dam removed on the Musconetcong River. As part of the dam removal, Princeton Hydro completed feasibility studies and initiated designs in 2014 to decommission the spillway and restore the impoundment. To assess potential sediment impacts, vibrocoring was conducted, sediment analysis and quantification of the volume of impounded material was completed. Princeton Hydro worked with the NJDEP to assess the quality of sediment and determine its ultimate disposal. As part of the design, the 21,000 cubic yards was proposed to be hydraulically dredged to adjacent existing on-site lagoons at this now defunct paper mill plant. Geomorphic assessments and utilization of nature-based restoration techniques were utilized to design a new river channel within the former impoundment. Following the receipt of permits, Princeton Hydro provided construction administration. The unique project setting for this project included the existence of adjacent lagoons from the historic paper mill operations, made available for the project for sediment disposal. While the proximity of the lagoons was a benefit, during the course of construction, there were impacts to the hydraulic dredging process, which provided insights into the planning and preparation of future dredging projects, including understanding the limitations of hydraulic dredging, but appreciating its overall benefits to construction efficiency. There were lessons learned for setting sedimentation expectations of regulators and other stakeholders during construction and providing an understanding about the long term benefits of the removal of the dam. It is noted that the Secretary of the Interior, Sally Jewell, visited the site during construction, as the DOI had provided funding for this project.
Session D3: Dam Removal

Monumental Legacy: Rogue River Basin Dam Removals

Mr. Scott Wright

Scott Wright, P.E. has over 24 years of private and public sector water resources experience and has been the engineer of record and project manager for numerous stream, river, and wetland restoration projects. His focus areas include dam removal, fish passage, large-scale in-stream structures, and river structures. Scott served as the project manager for the design-build team that removed the Gold Ray Dam and Gold Hill Dam on the Rogue River. Scott’s comprehensive knowledge of construction techniques, permitting, and water resources design provide exceptional solutions to complex problems with multiple stakeholders. Scott was awarded the “Spirit of the Oregon Plan” from the Oregon Watershed and Enhancement Board for his steadfast dedication to watershed restoration. Scott is a principal partner at River Design Group, Inc., a river restoration firm with offices in Oregon and Montana. His work includes projects throughout the Pacific Northwest and Intermountain West. Scott has been an instructor at Oregon State University and a guest lecturer for river mechanics and restoration classes at Oregon State University, Washington State University and Portland State University.

In less than 10 years, three mainstem dams have been removed from the Rogue River and three significant tributary dams have been removed. This historical achievement in Southern Oregon opened up over 157 miles of mainstem river habitat to unhindered fish passage and freed the way to hundreds of more miles of tributary habitat. This effort was undertaken in response to the Endangered Species Act (ESA) with the goal of recovering Southern Oregon/Northern California coho salmon and their designated critical habitat while removing relic dams. In 2008 the mainstem Gold Hill Dam was removed from the Rogue River along with Elk Creek Dam, a major tributary and Army Corps of Engineers dam that was supposed to be over 200 ft high. In 2009, the Savage Rapids Dam was removed from the Rogue River followed up by the Gold Ray Dam in 2010. Removal of these four dams set the stage for more work in the tributaries. In 2015, a comprehensive effort to remove two statewide top 10 fish passage barriers culminated with the removal of the Fielder Dam and Wimer Dam on Evans Creek, a major tributary to the Rogue River. Many common threads have emerged from these six dam removals in the Rogue Basin. The presentation will focus on several lessons learned that are transferable to other dam removal projects. Monitoring information and results will also be provided showing the long-term benefits of dam removal.
Session D4: Eel & Lamprey Passage I

The Eel Passage Research Center at Age Five – What Have We Learned

Dr. Paul Jacobson

Paul T. Jacobson is a Senior Technical Leader at the Electric Power Research Institute (EPRI). He manages research related to ocean energy and environmental aspects of hydropower. Dr. Jacobson’s research activities at EPRI encompass assessment of technologies and resource potential related to marine and hydrokinetic power generation, and assessment and mitigation of effects of electricity generation on aquatic ecosystems. His professional work over the past 25 years has focused on environmental assessment in aquatic ecosystems, most often related to electric power generation and especially hydropower. Prior to joining EPRI in 2009, he worked in the environmental consulting arena, most recently for 13 years as the founder and principal scientist of Langhei Ecology, LLC. For 17 years Dr. Jacobson was a faculty member of the Johns Hopkins University, Krieger School of Arts and Sciences, teaching graduate courses on ecological assessment and landscape ecology. He holds Ph.D. and M.S. degrees in oceanography and limnology from the University of Wisconsin-Madison, and a B.A. degree in biology from Cornell University.

American eel morphology, life history characteristics, and behavior, combined with the physical attributes of the upper St. Lawrence River and its hydropower projects, create an exceptional fish passage challenge. Ladders at Beauharnois Generating Station (Quebec) and the Moses-Saunders Power Dam (New York and Ontario) provide juveniles upstream passage at these dams; however, except for a small, experimental trap and transport program, turbine passage is the only pathway for downstream migration of adults which exposes them to risk of turbine mortality. Virtually all downstream migrants are large females thought to be important contributors to the spawning stock of this panmictic species. The species is listed as endangered by the Province of Ontario and it is a species of concern across the rest of its range. The Electric Power Research Institute formed the Eel Passage Research Center (EPRC) in 2013 to address the challenge of safe passage for outmigrating American eel at hydropower projects on the St. Lawrence River. This virtual center is a bi-national collaborative encompassing non-profit organizations; state, provincial, and federal (Canadian and U.S.) resource management agency representatives; and hydropower generating companies. With a minimum 5-year commitment and multi-million dollar funding, the EPRC is investigating and developing technologies for guiding eels to collection points for transfer around hydropower projects. As physical screening has been deemed infeasible for the St. Lawrence River hydropower projects, the research focuses on behavioral stimuli (e.g., electricity, light, flow fields, sound and vibration) to guide the fish. Five years into the effort, we’ve confirmed the intractable nature of the problem, enhanced understanding of outmigration behavior, improved knowledge of taxis in adult American eels, and developed a technical foundation for deploying and monitoring experimental eel guidance structures in the St. Lawrence River.
Session D4: Eel & Lamprey Passage I

Optimizing Climbing Substrates for Upstream Passage of Juvenile Eel

Ms. Zahra Anwar

Zahra Anwar is a recent graduate from the Civil & Environmental Department at UMass Amherst. She is part of the Fish Passage Concentration with a thesis focused on upstream passage substrate design for juvenile eel in North America. She hold undergraduate degrees in Physics and Mechanical Engineering from Mount Holyoke College and worked at OriginLab Corporation - a statistical and analysis software company prior to starting her graduate degree program.

The declining population of American Eels (Anguilla Rostrata) is due largely to migration barriers such as dams. Juvenile eel hatch as larvae in the Sargasso Sea and swim to the mainland - grow into glass eels at the coast and then swim further upstream where they become larger elvers. Conventional eel ramps use climbing substrates that are not optimized for eels based on size and climbing ability- this project determines substrate design parameters that affect efficient upstream passage. The important parameters considered in this study are 3 different ramp slopes and 5 different substrate roughness. During summer 2016, 600 fish were tested in total - 300 glass and 300 elvers. The tests were recorded and the video footage was used to extract parameters such as maximum distance climbed, time for maximum ascent, and rate of climbing. Other variables also weigh in the analysis to determine which design is optimal for eel passage. Results indicate that for glass eels substrate roughness may have more of an affect than slope does on climbing performance.
Session D4: Eel & Lamprey Passage I

A robust, permanent upstream passage system for juvenile American eels at a low-head hydropower dam, Penobscot River, Maine

Jesse Wechsler

Jesse specializes in the development and administration of research to assess the effects of hydropower projects on fish and aquatic resources. His area of expertise includes fish passage, in-stream flow studies, water quality monitoring, data analysis, technical reporting, and project management. Richard is a Senior Environmental Compliance Specialist with Brookfield Renewable. Richard is responsible for all fish way operations, monitoring studies, and compliance with applicable regulatory requirements for Brookfield's comprehensive fish passage program on the Penobscot and Union rivers in northern Maine.

Brookfield Renewable designed and built a permanent, flow-through fishway at a low-head hydropower project in northern Maine to pass juvenile American eels to upstream habitats. Scientists assessed the need for and location of an upstream eelway at the dam in the spring and summer of 2014 and 2015 during routine nighttime monitoring. Numerous juvenile eels were observed ascending wetted, roughened concrete or congregating at the base of the dam. Based on the monitoring, the fishway was positioned at a non-overflow section of the dam where the largest concentrations of eels were observed. The concrete and steel fishway is approximately 66-feet long, 4.5-feet wide, and ascends approximately 15-feet at a 20-degree slope. As compared to more traditional seasonal eel ladders, the design provides passage throughout the open water season, reduces annual maintenance, and provides a range of hydraulic conditions to attract various sizes of migratory juvenile eels. The fishway includes bristle substrates suitable for multiple age-classes of juvenile eels, protection from predators, debris protection, and attraction and conveyance water from the headpond under varying river flow conditions. Brookfield Renewable installed the new eel fishway in advance of the 2016 upstream passage season and demonstrated with a sub-sampling, catch per unit effort video-monitoring analysis that nearly 100,000 juvenile eels passed upstream.
Session D4: Eel & Lamprey Passage I

Theoretical Assessment of Downstream Passage Survival of Silver American Eel at a Small Hydropower Project

Stephen Amaral

Steve Amaral is a Principal Fisheries Biologist with Alden Research Laboratory, Inc. He has B.S. and M.S. degrees in Fisheries Biology from the University of Massachusetts and over 25 years of experience in the design and evaluation of fish passage and protection technologies developed for hydro projects and other types of water intakes.

Resource agencies have been prescribing narrow bar spacing (0.75 inch clear) and low approach velocities (< 1.5 ft/s) for downstream passage of silver American eels at hydropower projects in the U.S. These criteria can result in significant costs and lost generation. To determine the relative effectiveness of two clear bar spacings, 0.75 and 1 inch, we used a theoretical model to estimate total project survival of silver eels passing downstream at a small hydropower project with each bar spacing. Total survival was estimated using passage and survival rates associated with each available route (turbines, bypasses, and spillway) for the range of flows that occur during the eel migration season. Due to the low project head and hardiness of eels, we assumed direct mortality would be 0% for eels passing through the bypass system or over the spillway. Turbine survival was calculated using a multiple linear regression model developed from a dataset of silver eel turbine survival estimates from 54 field tests conducted at projects in North America and Europe. Indirect mortality was not included in the analysis because it does not vary with bar spacing and, therefore, would not influence the survival comparison between the two spacings. The results indicated that total survival across the entire eel migration period will be 98.9 to 99.8% for the 0.75-inch spacing and 92.0 to 98.4% for the 1-inch spacing, depending on the proportion of eels migrating downstream at different river discharges. The lower survival rates for the wider spacing are primarily due to greater entrainment (about 28%) compared to the narrower spacing (about 4%). Also, the relatively low turbine survival (52-54%) experienced by entrained eels contributes to the difference in total survival between the spacings, as this mortality is applied to a greater proportion eels with the use of 1-inch spacing.
Session D5: Eel & Lamprey Passage II

European eel conservation strategy – From passage solutions to release of imports and back again

Dr Olle Calles

Olle Calles is an associate professor in fish ecology at Karlstad University, Sweden. He has a PhD in biology form Karlstad University and a MSc in biology from Uppsala University. He has worked on fish migration and fish passage solutions at hydroelectric plants since 2001, with a special emphasis on nature-like design and downstream passage facilities. Olle has conducted multiple projects on fish passage in collaboration with hydropower companies, researchers and managers in Sweden, Italy, Latvia, Costa Rica and Greece.

Hydropower companies strive to optimize energy utilization while minimizing deteriorating effects on environmental values. The European eel is a highly threatened and iconic fish species that has a life cycle that is obstructed by dams in rivers. European hydropower companies traditionally compensate this negative effect by transporting eels past multiple obstructions. A more recent approach, however, is to allow two-way migration by providing eels with passage solutions. We present the most recent initiatives for improved eel passage, targeting both biological and design perspectives. Juvenile eel passage design in regulated rivers has been rather static during the last century, due to the historically very high numbers of juvenile eels recruiting to European rivers. The recent and drastic reduction in recruits has affected management strategies. Eel passes have largely been replaced by compensatory releases of imported juvenile eels. In an attempt to reverse this trend, our ongoing research project is studying the importance of eel passage (ramp) design and placement on the catch efficiency of natural and translocated juvenile eels. Our results show a substantial difference between ramp substrates on juvenile eel climbing success, and that substrate preference differs between naturally recruited and imported eel. Recent attempts using low-sloping racks guiding eels to bypasses have reached passage efficiencies of >90% and median delays of 24 h at small HEPs, but detailed knowledge on eel behaviour by racks and bypasses are still largely lacking. It is neither known if such solutions are applicable to large HEPs, and one major concern relates to the bar spacing of evaluated racks (15-18 mm). A large flume is now being built at the Vattenfall Ecohydraulic Centre, where we will study the importance of bar spacing for behaviour and performance of downstream migrating silver eels. The flume facility and the study design will be presented to incite discussion.
Session D5: Eel & Lamprey Passage II

Evaluation of intake rack solutions for downstream fish passage using a large scale fish flume

Dr. David Aldvén

PhD in animal ecology. Have been working with fish telemetry for the last 6 year; covering both marine and freshwater species. But have had a focus on salmonid migration and behaviour for the last 5 years. The focus at my current position at Vattenfall AB is to work with the environmental impacts of hydropower and how to restore impacted ecosystems and fish communities.

The implementation of the European water framework directive will mean that many hydropower owners will face big investments dealing with different solutions for safe up- and downstream fish passage. However which solution that is best suited for guiding downstream passing fish past the turbine intake is not entirely clear and no study have compared different solutions in a full scale situation. To deal with this problem we are testing different hydropower intake rack solutions in a fish flume which equals a 1:1 scale of a small scale hydropower intake channel or a portion of a large scale intake channel. In the experiment we are testing different variations of both inclined- and angled-racks with different rack openings. The main focus is to investigate fish passage but also production related issues such as head loss and trash/debris issues. In the first part of the experiment we are using European eel (Anguilla anguilla), looking at portion of fish that passes the rack, the time it take to pass and the amount of injury. We will also investigate hydraulic properties such as turbulence and speed profiles, as well as self-cleaning abilities, amount of passing debris and clogging of the rack. The lack of knowledge in this area highlights the importance to find a solution that is effective both in terms of fish passage and minimizes the production loss.
Session D5: Eel & Lamprey Passage II

*Analysis of silve-phase European eel population dynamics at an upper River Erne catchment site used in a trap and truck conservation measure.*

Dr Kieran (T.K) McCarthy

Dr Kieran (T.K) McCarthy has been involved in studies on Irish lakes and rivers for four decades but is now primarily involved in researching eel populations in hydropower impacted river systems. This work, which contributes to the Irish Eel Management Plan, includes annual analyses of the biomass of silver-phase eel produced in the Rivers Shannon and Erne and estimation of the spawner biomass escapement to downstream of hydropower dams. He is also researching eel parasite assemblages and use of light barriers to deflect migrating eels from hazards or to improve capture rates for conservation purposes.

Since 2009 the monitoring of silver eel production and spawner biomass escapement from the hydropower impacted River Erne (mean annual discharge 92 m3 / s) in Ireland has involved annual mark-recapture studies of downstream eel migration at an experimental fishing weir located in the lower river basin. It also involved monitoring of the eels supplied by other contract fishing crews to a hydropower mitigation trap and truck programme from other upstream conservation fishing sites. During recent years we have used one of these sites, located at the confluence of two upper basin tributaries the Upper River Erne and River Annalee, to develop alternative protocols for investigation of downstream migrating silver eel population dynamics. The most effective method we have developed involves catch depletion analyses, using sequentially located winged-coghill nets on the two tributary rivers. Our results indicate that, for small to medium sized Irish rivers, this novel fishing methodology can provide good estimates of upper catchment spawner production rates. It also facilitates analyses of the effects of environmental factors on seasonal patterns in downstream eel migration. The method is very cost-effective when undertaken at fishing sites where fishing crews are funded as part of a hydropower mitigation measure.
Session D5: Eel & Lamprey Passage II

*Effects of regulated flow on nocturnal patterns of silver-phase European eel migration upstream of an Irish hydropower plant.*

Mr Eamonn Lenihan

Eamonn Lenihan is researching the ecology and behaviour of downstream migrating silver-phase European eels approaching the forebay of the Cliff hydropower station on the River Erne. He is a 1st class honours B Sc graduate, having majored in zoology, of the National University of Ireland Galway. He has been recipient of several awards, including one for achieving the highest grade in the School of Natural Sciences during his final year project. In addition to his current project he has been involved as a research assistant on a marine fisheries project.

The annual and diel discharge patterns of the lower River Erne (Catchment area 4375km2, mean annual discharge 92m3s⁻¹) in Ireland reflect anthropogenic regulation for hydropower generation, flood control and navigation purposes. An eel management plan for the river system, established in response to the EU regulation for restoration of the European eel stock, involved closure of commercial fisheries and implementation of a silver-phase eel trap and truck programme to mitigate for adverse effects of hydropower dams. This conservation fishery has facilitated research on seaward migration of potential spawners and analysis of eel population dynamics. In the past 2016/2017 migration season, in addition to annual monitoring of spawner production by mark-recapture methods at an experimental eel weir, we have used a Didson acoustic camera to monitor patterns of eel movement upstream of Cliff hydropower dam. The results, which will be discussed, showed that within-night and between-night variation in nocturnal power generation rates strongly influenced eel migration patterns. Furthermore, it was recorded that cessation of generation was associated with upstream return movements of eels from the dam area.
Session D7: Water Quality

Design and Evaluation of Lower Granite Dam Fishway Temperature Improvement Project in 2016

Mr. Ryan Laughery

Regional Fish Passage Technical Specialist for the Northwest Division Corps of Engineers. Obtained his bachelor's degree in civil engineering from Washington State University in 2002. From 2002 to current has primarily been involved in the design and development of fish passage structures for Lower Columbia and Lower Snake River hydropower projects. For the past several years he has served as technical lead for the development of physical and numerical models for the evaluation of configurations and operations of hydropower projects to improve fish survival.

Elevated temperatures and differentials within the Lower Granite Dam fishway have historically impacted passage of adult salmonids. Snake River sockeye appear to be most susceptible, with run timings in July during strong forebay thermocline periods. A temperature control structure was installed at the fishway exit in 2016 in order to improve thermal conditions within the fish ladder and forebay near the ladder exit. Water temperature was monitored in the near-forebay and within the fish ladder between June 20 and September 20, 2016. Directional fish movement and behavior were characterized using a sonar system. Data from the Passive Integrated Transponder (PIT)-tag detections at multiple antennas within the LGR adult fish ladder were also evaluated during 2015 and 2016 to characterize temperature influence. This presentation covers the design and operation of a temperature improvement project and includes a summarized evaluation of the sonar and PIT data used to characterize fish behavior and movement in relationship to temperature.
Session D7: Water Quality

A Numerical Model to Estimate Fish Exposure to Elevated Temperature in McNary Dam

Dr. Marcela Politano

Dr. Marcela Politano is a Research Engineer at IIHR-Hydroscience & Engineering, The University of Iowa. She has expertise is numerical modeling of the hydrodynamics and water quality parameters in rivers, tailraces, reservoirs and fish passage structures. Her background includes modeling of multiphase flows, total dissolved gas, and heat and mass transfer. She has had a lead role in over thirty projects for the power industry. She regularly publishes in international journals, conferences and technical reports.

This paper describes an assessment tool that can be used to evaluate fish exposure to elevated temperature in a hydropower dam. An unsteady three-dimensional non-hydrostatic model is used to predict the hydrodynamics and thermal dynamics in the forebay and turbine intakes. In this study, a model based on the Reynolds Average Navier–Stokes equations, using a Boussinesq approach, with a standard k−ε model to solve the flow field is used. The thermal model takes into account the short and long wave radiation and heat convection at the free surface, which is function of air temperature and wind velocity. The model was validated against temperature measurements obtained by USACE for 46 stations along 6 transects in the forebay and gatewells of McNary Dam at 15 min intervals during the summer of 2004. A particle tracking technique simulates fish movement in the forebay. Two simple approaches were used to represent fish trajectories in the forebay. The first assumes than fish behave as an inert particle without any behavioral rule and the second approach considers near-surface orientated fish. The model was used to simulate an extreme event observed on July 13, 2015. Atmospheric conditions and minimum flowrate caused water temperature at 5m beneath the surface nearly 72 degrees Fahrenheit. Possible exposure to the upper incipient lethal temperature as well as duration in the zone of tolerance and resistance were computed with the model. The effect of swimming depth on possible thermal stress will be presented and discussed in the conference.
Session D7: Water Quality

Effects of an Intake Barrier Curtain to Reduce Algae Concentrations: The Iron Gate Dam Experience.

Mr. Andrew Peters

"Peters, a commercial mariner, holds his Ocean Masters License. He studied commercial net and gear design at the University of Rhode Island. He is manager of Markets and Applications for Pacific Netting Products, the world leader in design and installation of solutions for fish and aquatic species collection, passage and barrier netting with over 8 million square feet of installed product to date. Contact: Andy@pacificnettingproducts.com or 360-297-0858 office

Background:

An intake barrier curtain was installed in Iron Gate reservoir in 2015 following the test of a prototype curtain in 2014. The curtain was intended to segregate reservoir surface waters with higher blue-green algae concentrations and prevent those waters from being entrained into the Iron Gate powerhouse intake and released to the Klamath River downstream of Iron Gate dam. Monitoring conducted in late summer 2015 indicated reductions in microcystin (70 percent), Microcystis aeruginosa (82 percent), Aphanizomenon flos-aquae (97 percent), and chlorophyll-a (61 percent) occurred downstream of Iron Gate dam when compared to surface samples collected at a depth of 0.5 meter upstream of the barrier curtain.

It was hoped that isolation of the surface waters could reduce the amount of blue-green algae released from Iron Gate reservoir into the Klamath River and improve water quality conditions downstream. Recent study showed the installation of the curtain resulted in the withdrawal of deeper waters from Iron Gate reservoir and that both water temperatures and blue-green algae concentrations were reduced downstream of the curtain and in the Klamath River downstream of the dam following curtain deployment; they were also similar to deeper waters upstream of the curtain. In addition, dissolved oxygen levels downstream of the curtain reflected dissolved oxygen levels from deeper-water upstream of the curtain.

This presentation will review the method of investigation, the curtain design, materials, engineering, operations and maintenance considerations, lessons learned and study findings.

To illustrate and illuminate, we will provide tables and figures highlighting the studies conducted in 2015 indicate that the curtain’s effectiveness at isolating near-surface waters of Iron Gate reservoir upstream of the curtain, and discuss water quality samples, physical measurements, velocity profiles, and field observations of conditions in the waters of the photic zone where the majority of blue-green algae occur.

Objective and Value:

This presentation should be of interest to researchers, educators, practitioners, biologist, engineers, tribes, and regulators from around the world who are interested in methods to control water temperature in reservoirs as well as Microcystin, the toxin that is produced by cyanobacteria, commonly called blue-green algae, which grows in lakes and rivers all over the world and are known to sicken people, fish and animals."
**Session D8: Passage Behavior I**

*The making of designer fish for passage studies*

Karen Cogliati

Karen Cogliati is currently a project leader and postdoctoral research associate in the Department of Fisheries and Wildlife at Oregon State University. Dr. Cogliati earned her PhD in 2014 in Psychology, Neuroscience, and Behaviour from McMaster University, where her dissertation research focused on spatial and temporal variation in mating patterns in a fish species with alternative reproductive tactics. She earned her BSc and MSc in Biological Sciences from the University of Windsor. At Oregon State University, she manages a project that rears Chinook salmon and steelhead trout from eggs to juveniles using altered hatchery protocols to produce fish that possess phenotypic traits that emulate their wild counterparts. Additionally, Karen conducts research to investigates natural and environmental determinants of migratory life history variants in juvenile Chinook salmon and steelhead trout.

Many Pacific salmon and steelhead populations are listed under the Endangered Species Act. As a result, studies that investigate fish passage through Upper Willamette River projects have often relied on hatchery-origin fish. However, differences exist between hatchery-origin and wild fish in terms of morphology, behavior, and physiology. These differences could confound estimates of dam passage efficiencies and survival. In this ongoing project, we are using alternative rearing strategies to produce juvenile spring Chinook salmon and winter steelhead trout to be used as wild fish surrogates that reflect the migratory and fitness phenotypes of their wild counterparts. In the Willamette River, Oregon, there is considerable temporal variation in the downstream-movement life history patterns displayed by Chinook salmon Oncorhynchus tshawytscha. However, it is unclear if juvenile migratory phenotypes are determined in response to environmental stimuli or if they are established naturally much earlier in life. In providing fish for use by researchers to evaluate dam passage efficiency, our goal is to produce a downstream migrating juvenile phenotype during the requested timeframe (e.g. fall and spring migrants). We target fish sizes that reflect wild phenotypes based on the objectives of the passage studies. When delivered, all evidence suggested that our wild fish surrogates were smolting; therefore, their movement patterns have met the requirements of the studies. Our current rearing protocols includes rearing at low density, feeding a low lipid diet, including structure in rearing tanks, and using natural growth adaptive feeding strategies. We continuously evaluate the effectiveness and phenotypic accuracy of our rearing protocol to ensure that the final product is consistent with project goals.
Session D8: Passage Behavior I

SMOLT RESPONSES TO HYDRODYNAMIC CONDITIONS IN THE FOREBAY FLOW NET OF THE SLUICEWAY SURFACE FLOW OUTLET AT THE DALLES DAM

Gary Johnson

Mr. Johnson is a research scientist at the Pacific Northwest National Laboratory in Portland, Oregon. He obtained a M.S. degree in Biological Oceanography from Oregon State University in 1981 and a B.A. in Mathematics/Marine Biology from the University of California at Berkeley in 1976. Mr. Johnson's research interests include: estuarine habitat assessment and restoration, fish passage at dams, fisheries acoustics, surface flow outlets for juvenile salmon, and juvenile salmon migration patterns.

We integrated data on smolt movements and hydrodynamic conditions at the sluiceway surface flow outlet (SFO) at The Dalles Dam to determine: 1) Which hydraulic variables were most strongly associated with fish behavioral responses? 2) Of these, were there threshold levels that could be used to support SFO design guidelines? Fish movement data were collected with an acoustic camera (DIDSON). Water velocity and associated hydrodynamic data were obtained from an acoustic Doppler current profiler (ADCP, sampling simultaneously with the DIDSON) and a computational fluid dynamics model (CFD, instituted after the field work). The fundamental biological response variable -- fish swimming effort -- was computed by subtracting the water velocity vector from the observed fish movement vector. The study provided new information that has important management implications: 1) Schooling behavior was dynamic and prevalent; the implication is that SFO entrance area must be large enough to accommodate fish schools. 2) Fish behavior was dependent on distance from the SFO entrance; this supports the notion that SFO flow nets need to be expansive enough spatially for smolts to discover despite competing flow fields. 3) Passive fish behavior was observed less than 5% of the time in the SFO flow nets we studied, implying that SFO designs cannot rely only on fish following bulk flow. 4) Active swimming against the flow was the most common behavioral response; thus, SFO performance evaluations should include a metric for fish swimming effort in SFO flow fields. 5) Fish effort variables were correlated with water velocity, acceleration, and strain. Non-linear regressions indicate potential for this approach of merging fish/flow data to lead to SFO design guidelines in the future as the fish/flow dataset is further populated.
Passage behaviour of potamodromous cyprinids negotiating a small experimental weir: passage by swimming or jumping?

Mr António Pinheiro

Antonio N. Pinheiro is Full Professor of Hydraulics at Instituto Superior Técnico (IST), Universidade de Lisboa and is a member of the IST Scientific Council. He has extensive experience in teaching and researching with hydraulics of structures and ecohydraulics, with emphasis to pool-type fishways and to river restoration. He has also experience as a consultant for hydraulic and ecohydraulics structures and for environmental flows. He contributed over 100 journal and conference papers.

Alterations in fish communities have been highly documented and strongly associated with physical stressors, such as the presence of man-made obstacles. Even small weirs, that are a priori considered as permeable to fish movements, may negatively affect fish, particularly potamodromous species, by partially or totally blocking upstream movements to spawning grounds. Although recent studies have addressed the effect of hydraulic parameters on upstream movements past small weirs, little is known on how these parameters interact to induce a swimming or a jumping behaviour in negotiating such obstacles. This study aims to evaluate the passage behaviour (swimming vs. jumping) of Iberian barbel (Luciobarbus bocagei) over an experimental small broad-crested weir, considering the effect of key hydraulic parameters: plunge pool depth (D), waterfall height (H), and flow discharge (Q). A factorial design of 16 configurations, contemplating the combinations of D (10, 20, 30, 50 cm) and H (5, 10, 15, 25 cm), were initially tested with a constant discharge of 50 L.s⁻¹. The configuration with the highest passage success was then tested for three new discharges (Q=25, 75, 100 L.s⁻¹). Results showed that passage behaviour was highly dependent on the configurations DₓH tested (Freeman–Halton test, p<0.0001) and that both factors D and H, and their interaction, were significantly correlated with it (PerMANOVA, p<0.01). As for Q, there was no evidence that passage behaviour was discharge related (Freeman–Halton test, p>0.05). Barbel negotiated most configurations by swimming, except the ones with H=25 cm. Therefore, higher H proved to be preponderant in the switching of passage behaviour from swimming to jumping. These results are useful to identify potential migration obstacles, or designing fishways, for this and other medium-sized potamodromous cyprinids.
Session D8: Passage Behavior I

Does season matter? Adressing motivation of a potamodromous fish species in an experimental full-scale vertical slot fishway

Mr. Filipe Romão

My name is Filipe Romão, I am a biologist with a master’s degree in the field of natural resources management. I am currently doing my PhD in River Restoration and Management at the University of Lisbon, Portugal. My educational background and working experience have been always in the field of biology and ecology of aquatic resources, specifically regarding the integrity and biodiversity of aquatic ecosystems. My professional activity as continuously stood in the field of aquatic biology and ecology of riverine systems, precisely with the management and conservation of freshwater fish. Some of the research projects that I have collaborated as a researcher are: "Monitoring Program of the Fishway in Coimbra’s Bridge-Weir", "Habitat Restoration for Diadromous Fish in the River Mondego"; ECOFLOW – “Effects of flow regulation on fish communities of Portuguese rivers”; "National Plan of Conservation of Brook and River Lamprey". The working experience I have acquired provided me with a deeper realization of being competent in various spheres, of the ecological research of riverine systems. My aim is to evolve my knowledge in this area so I can support environmental decision making to restore fluvial ecosystems with solid and effective arguments.

Fish motivation to swim upstream in response to attracting flow is a fundamental aspect to consider in the management of fishways. Although, the majority of fishway studies is conducted during the reproductive period when fish migrate upstream to spawning grounds, uncertainty remains on whether conclusions would be biased if the same studies were to be performed outside of the migration period. To understand how season affects fish swimming motivation, characterized by the number of upstream movements and passage successes within a fishway, the present study assessed the performance of the Iberian barbel (Luciobarbus bocagei, Steindachner, 1864) through an experimental full-scale vertical slot fishway (VSF) under two different slot configurations (C1: Q=110 L.s-1 and C2: Q=81 L.s-1) during spring (the reproductive season) and early-autumn. Results revealed that, no differences exist between seasons, in the number of upstream movements and passage successes, or between slot configurations. Differences were however detected in the plasma lactate concentrations, used as a proxy of muscular fatigue after the fisway ascent, among seasons. Lactate concentrations were significantly higher in early-autumn. This suggests that for potamodromous cyprinids, the evaluation of fish passage performance in fishways does not need to be restricted to the reproductive migratory season and may be extended to early-autumn, when movements associated to exploration and shifts in home range may occur. Furthermore, lactate differences detected between seasons imply that fish incur in physiologic adjustments in different seasons. The added effort during the “off-peak” (i.e. non-reproductive) period suggests that an along-the-year adaptation of the operating regime of fishways should be evaluated in order to be compliant with the physiology of the target species.
Session D9: Passage Behavior II

Passage Performance of two Cyprinids with Different Ecological Traits in a Fishway with Distinct Vertical Slot Configurations

Mr. Filipe Romão

My name is Filipe Romão, I am a biologist with a master’s degree in the field of natural resources management. I am currently doing my PhD in River Restoration and Management at the University of Lisbon, Portugal. My educational background and working experience have been always in the field of biology and ecology of aquatic resources, specifically regarding the integrity and biodiversity of aquatic ecosystems. My professional activity as continuously stood in the field of aquatic biology and ecology of riverine systems, precisely with the management and conservation of freshwater fish. Some of the research projects that I have collaborated as a researcher are: "Monitoring Program of the Fishway in Coimbra’s Bridge-Weir"; "Habitat Restoration for Diadromous Fish in the River Mondego"; ECOFLOW – “Effects of flow regulation on fish communities of Portuguese rivers"; "National Plan of Conservation of Brook and River Lamprey". The working experience I have acquired provided me with a deeper realization of being competent in various spheres, of the ecological research of riverine systems. My aim is to evolve my knowledge in this area so I can support environmental decision making to restore fluvial ecosystems with solid and effective arguments.

Correctly designed vertical slot fishways (VSF) can restore longitudinal connectivity for cyprinids and moderate the impact of anthropogenic barriers, such as weirs and dams, that block the migratory pathways of these fish species. Until now, knowledge about VSF design stems from several studies conducted on high priority anadromous species such as salmonids, whereas cyprinids, received less attention. In Mediterranean rivers, where water limitation is a problem, effective, low discharge fishways are valuable. Attempting to contribute to fill this gap, the present study focuses on the behaviour and passage performance of two Iberian cyprinids with different ecological traits, the Iberian barbel (Luciobarbus bocagei, Steindachner, 1864) (potamodromous) and the Southern Iberian chub (Squalius pyrenaicus, Günther, 1868) (resident). This study was conducted in a full-scale experimental VSF under two different slot configurations (C1 and C2), which require dissimilar discharges for equal mean water depths in the pools (Q=110 L.s-1, for C1, and Q=81 L.s-1, for C2). Results show that, the small-bodied water-column oriented chub, performed a higher number of upstream movements in C2, while for the barbel, a large-bodied potamodromous bottom-oriented fish, the performance was comparable in both slot configurations. Overall, C2 is a more cost-effective design requiring a lower discharge to operate while serving both species, making it the best option, particularly in regions affected by water scarcity.
Session D9: Passage Behavior II

An investigation of the hydrodynamic and fish behavior characteristics of the brush-type fish passage: İyidere (Turkey) field study

Dr. Serhat KÜÇÜKALİ, Bülent VEREP, Davut TURAN, Ahmet ALP, Tanju Mutlu, Dursun Özelçi, Cüneyt Kaya

Dr. Serhat Kucukali completed his MSc and PhD degrees in Hydraulic Engineering at the Istanbul Technical University. He was a Post-doc fellow in the Civil Engineering Department of University of Queensland in Australia. He has been conducting research on environmental integration of small hydropower plants and innovative fish pass structures. He developed an Environmental Risk Index for Small Hydropower Plants. He has been working as a Professor in Cankaya University in Ankara.

This study aims to investigate the relationship between the hydrodynamics and fish behavior characteristics of brush fish passage which has been established at the existing Small Hydropower Plant (SHP) on İyidere River on the East Black Sea Coast of Turkey. İyidere River Basin is rich in biodiversity and 13 fish species have been identified in the river. For the first time, the fish migration routes and turbulence structure of the brush fish pass have been monitored and investigated simultaneously at prototype scale. The migration routes of different fish species in the brush fish pass were determined by the biotelemetry method. The Euler approach is intended to use to determine the turbulence characteristics (turbulence kinetic energy, Reynolds shear velocity, resultant and power velocity) of the brush fish pass; whereas the Lagrange approach was used to determine the different fish species migration characteristics. Under the dynamic upstream head conditions of fish pass structure throughout the year, the vertical velocity profiles of different flow regions have been obtained by using Nivus instrument; whereas the turbulence structure was revealed by measuring the three-dimensional instantaneous velocity fields using Micro acoustic Doppler velocimeter. From those velocity measurements, the distributions of Reynolds shear stress, turbulence intensity and turbulent kinetic energy were obtained. Then the fish behavior characteristics are intended to link to those hydrodynamic parameters. Also, turbulence kinetic energy has been used as a reference parameter for the migration corridors and resting areas of fishes. Thus, the analysis will be done based on a physical basis and it will contain the most important hydraulic parameters of velocity field, turbulence, and flow depth for fish passage design. Here it will be able to achieve results that can be generalized and adapted to other classical-style fish passage. The results will be analyzed as a function of hydraulics and biological variables, including upstream migration to locate fish routes and understand how fish use and process flow information. The results from this study would be useful to fish-pass designers, representative government agencies, and fish biologists. Also, the proposed study is expected to make contributions to sustainable hydropower development.
Session D9: Passage Behavior II

Fish on the move: vertical-slot fishway PIT monitoring results for two Australian native fish in the Murray-Darling Basin.

Dr. Matthew Gordos

Matthew Gordos manages the NSW Fish Passage Program on behalf of the Aquatic Habitat Rehabilitation Unit within NSW DPI Fisheries. The NSW Fish Passage Program has improved fish passage at over 500 barriers in the State, thereby facilitating fish access to over 14,000 km of additional waterway. Matthew has 10+ years of experience in the design, management, and construction of fish passage outcomes including fishways, dam removals, and road crossing remediation.

WaterNSW is the primary bulk water supplier in NSW, managing over 40 large dams and 300 weirs across the state. Since 1993, WaterNSW has been leading the largest fish passage restoration program in Australia that has resulted in 34 fishways being constructed. The Fishway Monitoring Program was initiated collaboratively between WaterNSW and the NSW Department of Primary Industries (DPI) Fisheries in 2004 to evaluate the effectiveness of newly constructed fishways in passing the full range of target species as per the agreed fishway design criteria. From 2011 – 2016, DPI Fisheries completed detailed Passive Integrated Transponder (PIT) monitoring at ten (10) WaterNSW vertical-slot fishways in the Murray-Darling Basin. The aim of this presentation is to detail fish passage outcomes at newly constructed vertical-slot fishways, with a focus on two native species, Murray Cod (Maccullochella peelii; 0.1 – 1.0 m) and Golden Perch (Macquaria ambigua; 0.1 – 0.5 m), both of which demonstrate a facultative potamodromous migration pattern. Analysis of fishway performance centered on the percentage of PIT tagged fish that approached the fishway entrance, passage efficiency once inside the fishway, ascent time, and the number of failed ascents where the fish returned downstream. PIT monitoring results will be discussed against criteria established by DPI Fisheries in consultation with WaterNSW to assess the effectiveness of vertical-slot fishways in passing facultative migrating species. Fish passage trends among sites will be discussed against vertical-slot design criteria such as fishway slope (1:20 to 1:30), pool turbulence (< 100 W/m3), and slot size which are generally conservative compared to US Pacific Northwest design standards due to the poor swimming capacities of Australian native fish. Behavioural observations such as repetitive repeat ascents will be discussed, along with comments on future PIT monitoring recommendations.
Session D9: Passage Behavior II

*Influence of the presence of sills on the behavior of brown trout (Salmo trutta) in an experimental vertical slot fishway.*

Dr. Aurélien Ballu

I obtained my Phd in fluid mechanics from the University of Poitiers. My work consisted in carrying out an experimental and numerical study of the turbulent, three-dimensional and unsteady flow in vertical slot fishway.

The European water Framework directive adopted in 2000 aims to restore the free movement of fish species. This free movement can be difficult or impossible because of the presence of dams or weirs along rivers streams. The vertical slot fishway (VSF) is one of the most used devices in France to help fish to cross permanent obstruction and thus allowing their natural migration. To reduce the discharge in the VSFs or to restore the balance of the water depth between sequential pools, sills are often introduced at the bottom of the slots. This presentation presents results of a study on the influence of sills on the behavior of trouts (salmo trutta) in an experimental five pools VSF. Video monitoring of the third pool has been done to describe the progression of fish inside the pool. The behavior of two different sizes of trouts in a VSF equipped with sills has been compared with a reference case without sills. A statistical analysis has been carried out and demonstrates that the presence of sills can affect the behavior of fish. The results show that sills should not be inserted in such device because it can reduced the biological efficiency of the VSF.
Session D9: Passage Behavior II

*Seasonal Variation of Fish Migration in Sariakandi Fish Pass*

Mr. Bijoy Kumar Ghosh

Bijoy Kumar Ghosh joins BSC General Education Cadre in 2005. He has already proved his expertise as a successful organizer. He is smart, intelligent and active in discharging his responsibilities. He is the president of 24th BSC General Education Forum. He is one of the members of American Fisheries Society, BUET Alumni Association, Rajshahi University Association and Bangladesh Zoological Society. He successfully obtained his B.Sc Honours degree in 1997 in Zoology and got first class in M.sc in Zoology in 1998 with research. Letter he completed his post graduation diploma from BUET in 2003 (Water resources Development) and obtained higher degree on Masters of Science (WRD) with research in 2007. He has received special training on Sustainable Education Management from Queens University in Ontario, Canada respectively. Mr. Ghosh now is working at Education Engineering Department, Ministry of Education as Deputy Director (Admin.). Before joining here he worked as Research Officer at the Planing & Development Wing of the Directorate of Secondary and Higher Secondary Education.

The importance of open water fish in our socio-economic regime has recently drawn the attention of the policy makers of the country. FCD/FCDI projects mainly serve the agricultural interests, but it interfere fish migration. This inevitably affects the open water fisheries sector as migratory routes. Nursing grounds of many species of fish are hampered and disturbed for these projects also. In order to permit fish migration in rivers, it is necessary to maintain conditions that help migrants reach their spawning grounds. To overcome obstacles, such as hydraulic structures, placed in the path of migrating fish, structures must be designed to assist the fish to pass them. The periodic and directed travel of fish mainly for feeding, breeding and over coming adverse climatic conditions is called migration. Fish passes are constructed to allow normal breeding migration and to ensure natural route of fish movement. The concept of a fish passes is relatively new in Bangladesh. At present, two Fish passes and two fish friendly structures are constructed. These are Fish Pass in Jamuna to Bangali River at Sariakandi in Bogra, fish Pass in Kawadighi Haor of Monu river in Moulovibazar, fish friendly structure in Lohajong river of Tangail and fish friendly structure at Morichardanra in Chapainawabganj. Fish fry, spawning and hatchling movement from Jamuna to Bangali River was the main objective of Sariakandi Fish Pass Project. The Fish Pass Project of Sariakandi is necessary for the development of the dominant fishes like catfish and small fishes. The structures will also aid in efficient development of the carp fishes. Spawning migration, mainly in carp fish, in the study area was found to begin at the 2nd week of May and continue up to the 3rd week of July. Catfish migrations began at the last week of March and continue up to the 2nd week of June.
Posters

**Novel Fishway Entrance Modifications to Improve Passage for Native Fish**

Dr. Mary Moser

Healthy riverine ecosystems require provision of passage routes at artificial barriers for a broader array of aquatic species than has historically been targeted. To address this need, major modifications were made in 2009 at a fishway entrance at Bonneville Dam (Columbia River KM 235) to improve Pacific lamprey (Entosphenus tridentatus) passage at this barrier. The fishway entrance modifications included three major elements: a variable-width entrance weir; a floor-mounted field of flow disrupters (‘bollards’) intended to reduce bulk velocity near the entrance floor; and a lamprey-specific passage structure (LPS) that terminated in a trap at forebay elevation. Pacific lamprey using the LPS were counted. In addition, passive integrated transponders and radio transmitters were used to assess lamprey passage success before and after entrance modifications were made. Fishway entrance efficiency for Pacific lamprey improved after the modifications and annual lamprey use of the LPS increased from 48 in 2010 to over 2,800 in 2014. Hence, Pacific lamprey exhibited heretofore unknown capacity for elevation gain in an LPS (31 m) and our results confirmed that lamprey-specific modifications can improve their passage from tailrace to forebay height at a large hydroelectric dam.

**Comparison of Stream Simulation to Hydraulic Design Approaches for Constructing Fish Passage Channel Segments in Central California Coastal Streams: Challenges, Opportunities, and Lots of Large Rocks**

Mr. Jeff Peters

This poster compares different fish passage restoration design approaches for two separate bridge replacement projects located on two central California coastal streams in Santa Barbara County: Arroyo Parida Creek and Salsipuedes Creek. Arroyo Parida Creek is located near the town of Carpinteria, and is crossed by State Route 192. Salsipuedes Creek is located near the town of Lompoc and is crossed by State Route 1. Both creeks are designated as critical habitat for federally endangered Southern California Coast steelhead. Two design options are presented herein—a hybrid roughened channel/step-pool complex design with a 4.7% slope on Arroyo Parida Creek and a rock ramp/roughened channel design with a 2.0% slope on Salsipuedes Creek. The design approach for Arroyo Parida Creek centers on creating a channel that best simulates the conditions found elsewhere in the creek (i.e., the reference reaches) using the stream simulation methodology. The primary goal of the stream simulation design is to provide for a high degree of channel stability by simulating the geomorphic conditions observed elsewhere—a continuous streambed that simulates natural channel width, depth, and slope. For Salsipuedes Creek, site conditions and other constraints necessitate that a hydraulic design approach be undertaken. Unlike the stream simulation design approach, the hydraulic design approach involves designing a structure for passage of targeted fish species and life stages by establishing a stable channel that is compatible with the swimming and leaping abilities of fish over a specified range of flows. For both projects, we estimated changes in hydraulic variables—such as depths, velocities, shear stress values, and energy dissipation factors—that would result from implementation of the design options and to assess whether these changes would affect fish passage conditions, stream morphological characteristics, or the quality of habitat for fish and other aquatic organisms in channel reaches upstream and downstream of the proposed design reaches. Changes were assessed for a range of flow conditions from base flow to higher magnitude, less frequently occurring events. Each project presents a unique
situation to provide fish passage at a range of flows, with associated opportunities and constraints. For Arroyo Parida Creek, a buried water main pipeline and a relatively narrow riparian corridor serve as the primary design constraints, while the presence of relatively pristine upstream reference reaches aided in the design approach. For Salsipuedes Creek, which occurs at a geologic transition within the watershed, no appropriate reference reaches were available. As such, with the aide of 2-dimensional hydraulic modeling we designed a rock ramp that would create sufficient flow depth and velocity, as well as habitat diversity, to ensure that fish passage and 100-year channel stability needs would be met. Both projects involve the use of very large boulders (D84 = 4.5 feet!), are in the latter stages of design, and are expected to be constructed within the next few years.

**USFWS Fish Passage Engineering Design Criteria**

Ms. Jessica Pica

In 2016, the Northeast Region of the U.S. Fish and Wildlife Service released it's very first fish passage criteria manual. In February of 2017, a new edition was released. This 224-page manual provides technical guidance in the form of accepted criteria, recommendations, and best practices for the design of technical fishways, nature-like fishways, dam removals, culvert replacements, and other fish protection technologies. The manual reflects the baseline recommendations being made by the Northeast Region's Fish Passage Engineering team based on current scientific literature and engineering practices. The manual will serve to enhance consistency within the Service and other federal agencies, promote transparency in a complex regulatory arena, and document current scientific and engineering methodologies used in the interdisciplinary field of fish passage and protection.

**RECONNECTING EUROPE's RIVERS: CHALLENGES & OPPORTUNITIES FOR THE AMBER PROJECT**

Prof. Carlos Garcia de Leaniz

Europe has the most fragmented river landscape in the world. All of Europe’s major rivers are poorly connected and their headwaters remain inaccessible to migratory fish. Only three large rivers, all in NW Russia, remain fully connected to the sea. Loss of connectivity constitutes the biggest problem for achieving good ecological status under the Water Framework Directive (WFD). Yet, surprisingly little is known about the extent of stream of fragmentation at the European scale, which makes restoration difficult. AMBER (Adaptive Management of Barriers in European Barriers) is a new Pan-European project funded under the EC Horizon 2020 programme that aims to restore stream connectivity by applying principles of adaptive management. The project involves 20 partners from 11 countries, and represents all major stakeholders, from government to NGOs, and from academia to industry. One of the biggest challenges for the restoration of connectivity lies in the fact that the number of barriers is unknown because different countries use different definitions of ‘barrier’, and coverage and spatial scales differ widely. A two-century old industrial legacy has resulted in a myriad of old dams and weirs, many of which are abandoned, but whose precise number and location are unknown. The best estimate (based on extrapolation of regional data) suggests that there may be c. 1 million stream barriers in Europe, possibly more. Thus, AMBER’s first task is the compilation of an Atlas of barriers using a common methodology. Current predictions of climate change predict that river flows in large parts of Southern Europe, those already under water stress, may decrease by up to 20% by 2050. This, coupled with the need to increase hydro-production, means that the impacts of many barriers will worsen. Given that resources available for barrier mitigation
will never be enough, AMBER will provide prioritisation tools to guide barrier mitigation efforts, as well as decision support tools to enable water managers and fisheries officers to maximize the benefits of water abstraction while minimizing impacts on migratory fish. Although much is known about improving fish passage, most of it relates to salmonids which is rather unfortunate as these tend to be the strongest swimmers. AMBER will examine the passage of weak swimmers, including neglected taxa such as macro-invertebrates. The availability of new technologies, such as eDNA and meta-barcoding, coupled with drones for quick surveying, and developments in predictive modelling based on presence-absence data, means that it is possible for the first time to derive global metrics of connectivity for multiple fish species and across taxa. To this end, the input of volunteers seems invaluable and AMBER has developed a comprehensive citizen science programme to facilitate the identification of barriers and the restoration of connectivity.

**Geomorphic responses to sediment releases during annual reservoir drawdowns at Fall Creek Lake**

Ms. Mackenzie Keith

The Army Corps of Engineers draws down Fall Creek Lake, Oregon to facilitate downstream passage of juvenile spring Chinook salmon through the 55-m high dam. Since 2011, the annual fall and winter drawdowns have improved fish passage, but temporarily lowering Fall Creek Lake nearly to streambed levels has increased downstream transport of predominantly fine (<2 mm) sediment to the lower gravel bed reaches of Fall Creek and the Middle Fork Willamette River. Release of reservoir sediments has uncertain consequences for downstream habitats. In this study, we evaluate linkages between reservoir operations, upstream sediment erosion, and resulting downstream responses and document reach-scale geomorphic responses to sediment released from the reservoir over 2011–17. Preliminary results suggest a ~200,000 m³ net decrease in sediment storage within the lower 2.3 km of the reservoir between Water Years (WY) 2012 and 2017. Upper reservoir storage dynamics related to drawdowns are presently unclear because of limited data coverage for the area. Downstream of Fall Creek Dam, patterns of deposition and sediment transport have changed over the period of drawdowns. Side channels along Fall Creek that filled with coarser sand during the 2012–2015 drawdowns are now accumulating silt and fine sand, and sediment accumulation there has slowed. Most off-channel aggradation measured from 2012–2015 repeat lidar has been <0.6 m, with local aggradation as great as 2 m. Deposition measured at nine sites following the WY2016 drawdown showed most aggradation on high-elevation gravel bars and low-elevation floodplains occurred about two weeks after the drawdown when flows were higher on Fall Creek (~2,000 ft³/s) and the Middle Fork (near bankfull events, 19,000 ft³/s). Rapid mobilization and re-deposition of reservoir sediments in the post-drawdown period indicates that strategically planned flow releases could be used minimize sediment impacts associated with local deposition.

**A New Paradigm – Managing Anadromous Sea Lamprey for Restoration, not Elimination**

Ms. Julianne Rosset

The Sea Lamprey (Petromyzon marinus) is considered a nuisance species where it has become landlocked due to its parasitism on important freshwater sport fish. Unfortunately, this negative reputation has carried over to anadromous (sea-run) adult Sea Lamprey, which is not parasitic during freshwater residency. While research and management for the past half century have focused on controlling landlocked populations, recent publications identify Sea Lamprey as a critical component in the freshwater food web because they are prey for a variety of aquatic and terrestrial species and
import a significant amount of marine-derived nutrients into the freshwater environment. Therefore, efforts are underway in the northeastern United States to address misconceptions about anadromous Sea Lamprey through the creation of outreach materials and development of management plans focusing on restoration and recovery of the species. Here, we focus on gains made in facilitating recolonization of historical Sea Lamprey spawning habitat by installation of fishways and removal of dams in the Connecticut River watershed, the relationship between passage timing of pre-spawning adults at a dam and initiation of nesting, and the potential of using nest counts to assess trends in abundance.

*Fish migration through the Afsluitdijk (dam) between sea and lake*

Mr. MSc. Bauke de Witte

Fish migration through the Afsluitdijk (dam) between sea and lake. Due to safety reasons, fresh water supply and creating polders for agricultural use this Lake was created in 1932 by damming part of the sea. Nowadays this dam is a barrier for migrating fish from sea to inland destinations. In this dam there are ship- and spillsluiices located. The authors started to study the functioning of these sluices in relation to fresh water quality and fish migration. They researched the effectiveness for a change in managing these sluices. In 2014 this change was researched with good success for very small young fishes. In 2015-2017 this change in handling the sluices is made operational. Together with construction of a fish passage and salt water sewage systems. In addition a Fish Migration River will be constructed through the dam. This to make fish passage more effective and to create an intermediate zone between fresh and salt water.

*Intertidal Water Crossing Structures: Summary of a Literature Review on Fish Access and Habitat Connectivity in Tidal Ecosystems*

Doris Small

Fish access improvements have consistently been identified as one of the most effective investments for protection and recovery of Pacific salmon species. Several species of Pacific salmon are dependent on estuaries and marine nearshore habitats during early life history, including federally listed Chinook and Chum salmon. Tidal action creates bidirectional impacts that complicate the practical application of existing protocols for fish passage assessment and current fish passage design criteria. The consequences of delaying or reducing access to streams and estuarine habitat during portions of the tidal cycle due to man-made structures are poorly understood. Knowledge of fish movement relative to the tidal cycle and the impacts of tidal restrictions on habitat quantity and quality represent major knowledge gaps limiting the development of technical guidance for intertidal water crossing structures. Washington Department of Fish and Wildlife partnered with NOAA Fisheries Northwest Fisheries Science Center to develop a comprehensive literature review and data gap analysis to support development of intertidal barrier assessment protocols, prioritization of removal/replacement and technical design guidelines. This poster will summarize the findings of the literature review and data gap analysis.
Fish Passage Project Monitoring at WSDOT

Mr. Damon Romero

Since 1991, the Washington State Department of Transportation (WSDOT) has worked with the Washington Department of Fish and Wildlife (WDFW) on a program to eliminate fish passage barriers along Washington's highways. To date, WSDOT has completed 301 projects, allowing access to approximately 954 miles of potential fish habitat. Tracking performance of fish passage projects over time is critical to ensuring that fish passage sites remain passable and habitat accessible to fish. In the fall of 2015 WSDOT expanded its fish passage monitoring program to incorporate guidelines agreed upon by state agencies and Tribes as part of the U.S. v. WA culvert injunction. WSDOT’s monitoring program tracks performance measures and triggers actions to address deficiencies. There are three basic intervals for inspection: Post-Construction Compliance Inspection- WSDOT fish passage projects are evaluated shortly after completion to ensure they are constructed as designed and permitted. Fish passage is evaluated using WDFW methods. Over-Winter Inspection- sites are inspected after the first full winter to evaluate the impact of higher flows on the new structure. Long-Term Evaluations- Sites are evaluated five and 10 years after construction to determine if they still provide fish passage and if the structures still conform to the design standards under which they were constructed. During the 2015/2016 seasons, 43 sites were evaluated under the new plan. All 43 were found to meet fish passage standards and were constructed according to the permitted designs. There were 11 sites that triggered additional monitoring to track specific elements of the project that were not performing as expected. Additional monitoring intervals will determine if a repair is required or if fish passage is at risk. The WSDOT program is efficient and consistent and can be emulated by any entity that is required to monitor fish passage projects by state or federal permits.

AEPS: a methodology to quickly assess pool and weir fishways

Mr. Jorge Valbuena-Castro

For last decades, water managers have built a lot of different structures all around the world trying to reduce the impacts that transversal obstacles have produce into the rivers to fish fauna movements. However, these structures, named fish passes or fishways, are usually not assessed when the construction process ends. Thus, their functionality cannot be always proved and we do not really know if they are suitable for fish. In order to solve this problem, a new methodology to assess the theoretical ascending performance of fish fauna in the most extended fishways type (pool and weir fish passes) is proposed. This methodology contributes for a quick and first assessment of these devices for three of the most relevant species in the Iberian Peninsula: brown trout, Iberian barbel and northern straight-mouth nase. Nevertheless, it has the potential to be adapted to other species. The method has been created from 2014 to 2016 into a collaboration agreement between Duero River Authority (CHD), Ecohydraulic Applied Group (GEA), Itagra Foundation (Itagra.ct) and the University of Valladolid (UVa). The methodology is structured on the study of the main stages of fish passages: Attraction, Entrance, Passage and Exit (AEPS in Spanish). These stages comprise forty-three parameters based on design, hydraulic and hydro-biological aspects according to the swimming capabilities and preferences of the target species. The selected parameters can be easily measured in the field, after or during the design phase of the project. Finally, the methodology scores each parameter and stage from 0 to 10, based on scientific studies and field experiences, giving some advices about the theoretical efficiency of the fish pass and how to improve it.
A Municipal Assistance Program for Culvert Replacement to Meet Ecological and Safety Goals

Ms Beth Lambert

Undersized or perched crossings are a significant stressor on aquatic ecosystems in Massachusetts and a threat to public safety. In 2014, Massachusetts added standards for aquatic organism passage (AOP) into the state wetland regulations. All culvert replacements are now required to meet the standards to the maximum extent practicable. Most of the Commonwealth’s 40,000 road-stream crossings are owned and managed by the 351 municipalities in the state. Municipal road managers lack the knowledge, skills, and resources to replace culverts to meet the new AOP standards, and few culvert replacement projects meet the new standards. To increase the pace and scale at which road-stream crossings are being replaced with AOP-friendly structures, the Massachusetts Division of Ecological Restoration (DER) developed a municipal assistance program targeting road managers, primarily Departments of Public Works (DPWs). The Municipal Assistance Program began with a statewide needs assessment of DPWs to identify barriers that municipalities face in replacing culverts with improved structures (results presented at Fish Passage 2016). Based upon the results of the needs assessment, DER is now combining hands-on training, development of technical resources, and financial incentives into a single Municipal Assistance Program, all designed for DPWs. First, DER began a series of hands-on DPW trainings at selected culvert replacement sites around the state. The trainings will continue annually as each culvert replacement project moves through data collection, engineering and design, permitting, and construction. Next, in 2017, DER began developing technical resources for use by DPWs such as sample Scopes of Work and a culvert selection tool. This summer, DER will pilot a Culvert Replacement Municipal Assistance Grant Program. The grant program will make approximately $750,000 available to 5-10 culvert replacement projects to assist with data collection, engineering and design, permitting, or construction. Through the Municipal Assistance Program, DER seeks to change AOP culvert installation from a rarity to the norm.

Round Butte Dam Forebay Flow Evaluation

Mr. Ian Pryor

Complex reservoir currents may influence out-migrant juvenile salmonids navigating dammed river reaches during downstream migration. The three tributary arms of Lake Billy Chinook, Oregon, (the Metolius, Deschutes, and Crooked Rivers) converge in a primary mixing zone immediately upstream of Round Butte Dam and its associated forebay. The Selective Water Withdrawal (SWW) intake structure (completed in 2009 as part of a FERC re-licensing condition) was designed to reorient surface currents within the Round Butte Dam forebay toward the intake structure to attract out-migrant salmonids into the fish entrances. Fish attraction flows are described as a “zone of influence” where flow is directed toward the SWW fish entrances at higher velocities and in a more organized field than under “background” reservoir conditions. The attraction flows vary continuously as generation changes because fish collection is tied to power generation. We deployed acoustic Doppler current profilers (ADCP), two stationary and one mobile, during the two-month (April – May, 2015) primary salmonid out-migration season to assess the influence of SWW operations on forebay flow conditions. Using a horizontal ADCP mounted to the surface intake gates (i.e., fish entrances), we determined the zone of influence has a maximum range of approximately 370 feet, at 10 feet in depth, during peak generation discharge scenarios. The zone-of-influence range directly correlates with generation discharge through the
SWW surface intake and is highly sensitive to fluctuations in discharge. Additionally, sustained wind events in the forebay vicinity have a substantial impact on the zone of influence. Westerly and southwesterly winds tend to increase the range of the zone of influence, while easterly and southeasterly winds tend to decrease the range due to the orientation of the SWW entrance gates. Wind-induced currents are most prominent within 10 feet of the surface but are detectable to 20 feet.

**Fishway Inspection: There’s an app for that**

Dr. Bjorn Lake

Proper operation and routine maintenance is a necessary component of any successful fishway. However, all too often, dam owners neglect or simply do not know how to operate or maintain their fishway. In 2013, the U.S. Department of Interior and Commerce developed guidelines for conducting fishway inspections at dams (TR-2013-1). These guidelines provide a standard protocol for engineers, biologists, operators, regulators and dam owners to inspect their fishway to diagnose problems that cause passage ineffectiveness. Over the last few years, the fishway inspection checklist appended to the guidance document has been used by stakeholders during hydroelectric and non-powered dam inspections. To date, the data collected by filling out the checklist during fishway inspections has not been compiled or managed by the Department of Commerce in a way that will easily inform regulators for compliance matters or researchers who want to better understand the relationship between operation and maintenance and fishway effectiveness. We are developing a digital, real-time, spatially organized data collection method using a publicly-available application that will collect fishway inspection data for storage in a relational database. This fishway inspection application is being tested this year in the Greater Atlantic region. Eventually we hope to expand the use to other regions and stakeholders to build a relational database that can be used to facilitate research and compliance.

**Ten years of fishway monitoring**

Ms. Ana García-Vega

Freshwater fish species are especially vulnerable to anthropogenic disturbances, such as river fragmentation, and flow and thermal alterations, as they may disrupt the necessary movement to complete their life cycle or they may reduce the available distribution areas. In this sense, to assess the effect of these impacts on fish fauna, it is vital to understand their movements and migration patterns together with the environmental or anthropogenic factors that trigger or influence them. Functional fishways, in addition to facilitate the free movement of fish through dams and weirs, can be used as structures to study upstream fish movements, as they actuate as corridors of mandatory passage. Considering this opportunity, in this work brown trout (Salmo trutta) movements are studied using a pool and weir fishway. The fishway is located at the Marin River (Oronoz-Mugaire, Navarra, Spain) and the sampling period covered from 11/11/2005 to 12/02/2016. The fishway was equipped with a trap that was revised 3 times a week, increasing the monitoring frequency to once a day during the spawning migration season. Spearman correlations between number of fish and environmental variables (river flow and water temperature) were estimated. In total, 11116 individuals were captured in the fishway. Results shows that brown trout used the fishway for upstream migrations mainly in reproductive season, being November and December the months with most upstream movements, extending in some years from October to January. Number of daily captures was positively correlated with river flow ($p = 0.1815079$, $p$-
Typically, Dr. Mulligan performed an experiment at the USGS Conte Anadromous Fish Research Laboratory. This study not only underlines the importance of fishways to ensure the connection between functional areas for fish, but also demonstrates the importance of environmental factors, underlying the susceptibility of fish migrations to alterations on flow and thermal regimes.

**LIFE+ Segura-Riverlink: a green infrastructure approach to restore the longitudinal connectivity in the Segura River (Southeast of Spain)**

Dr. Francisco-Javier Sanz-Ronda

Habitat connectivity is a central factor in shaping fish assemblages and populations, however, few tools are developed to maintain and restore this attribute at a large scale in fluvial Mediterranean systems. The Segura River, one of the most regulated rivers in Europe, is a good example of it. The LIFE+ Segura-Riverlink is a project coordinated by the Segura River Authority and co-financed by the LIFE + Program of the European Union which aims to promote and support the environmental recovery of a fluvial sector of the Segura River Basin (more than 50 km long in its main river). The main purpose is to demonstrate and validate management measures for the development of a Green Infrastructure (GI) approach into the context of Mediterranean river basins characterized by a high impact in their connectivity. The project began in 2013 and it is finishing in 2017. During this time, longitudinal connectivity has been improved removing a significant number of small artificial barriers to re-establish fish movement, and the project have also supported other best practices of riverine restoration. The restoration actions have included the removal of a small weir and the construction of effective fish passage systems, and a monitoring programme have assessed the performance of these actions with the hope of validating the GI approach to river basin management and its possible extension to the official management programmes. The project has also developed a Land Custody Network to integrate private owners in the river management and in agreeing good practices. In sum, the project’s outcomes protect local aquatic and riverine habitats, allow fish reproductive movements along an important fluvial sector, improve ecosystem services, and build a framework of scientific and social knowledge to improve river management quality and to help the implementation and enforcement of EU policy and legislation on biodiversity conservation.

**A Full-Scale Fishway Entrance Experiment Performed at the USGS Conte Anadromous Fish Research Laboratory**

Dr. Kevin Mulligan

Typically, a fishway entrance consists of a fully submerged hydraulic control (e.g. gate, weir) located at the downstream end of an open channel that leads fish to the main body of the fishway (e.g. lift, pool-and-weir). Common hydraulic controls are an overshot gate and a vertical weir. In practice, the vertical height of the gate or weir is adjusted in response to varying tailwater elevations in order to maintain favorable fish passage conditions. Changes to this hydraulic control design can influence the hydraulics (e.g. entrance jet velocity, flow pattern) and thus attraction and entry performance. A pilot study performed in 2016 with upstream-migrating, adult American Shad (Alosa sapidissima) documented the performance of a variety of hydraulic controls under a limited number of conditions. Water depth over the crest of the gate was shown to be the main driver in performance rather than gate design. Additional trials were completed in the spring of 2017 as well as a more detailed hydraulic analysis of each of the gate designs. The results of
this study provide guidance on methods to improve fishway attraction and entry rates to numerous state and federal resource agencies and the hydropower industry.

Efficiency study of fishway with sonar camera in salmon river Piteälven, Sweden

Mr. Stefan Stridsman

The efficiency of upstream fish passage in fishways is in many cases difficult to study and very few surveys has been carried out in Swedish salmon rivers. The County Administrative Board of Norrbotten performed an pilot survey 2015 in the salmon river Piteälven in the Northern Sweden. There is only one hydropower plant (Sikfors HEP) in Piteälven located 40 km from the river mouth. Salmon and sea trout ascending the river has to locate the old river bed where spill water is running into the tailrace. After detecting and forced the old riverbed up to the spill gate the fish has to detect the fishway and pass through up to spawning areas upstreams. An sonar camera (SIMSONAR) was setup 1 km downstream the outlet of the tailrace to register migrating fish, e.g. salmon and trout, and compare the number of fish passing the sonar camera with the number of fish passing the electronic fish counter (RIVERWATCHER) in the fishway. The sonar camera registered totally 3 100 fish (> 40 cm) migrating upstream and the electronic fish counter in the fishway registered 2 900 salmon and trout merged. No other fish species is migrating in such high number and size as salmon and sea trout during the study period. No other species has been registered in the fishway. The sonar camera was not in operation over the entire migration season which means that the number of passing fish was higher than those registered in the sonar camera. The delay in the cumulative number of fish registered with sonar camera compared to the fish counter in the fishway showed a delay whit maximum of five weeks. Salmon and sea trout are probably delayed both at the tailrace and spill gates. The results indicates a loss of salmon and sea trout spawners and an huge delay in time for passing the fishway.

Completion of a Multifaceted Fish Passage Improvement Project on the Russian River, Sonoma County, California

Mr. Jonathon Mann

The study and design for the Mirabel Fish Screen and Fish Ladder Replacement project on the Russian River in Sonoma County in northern California has been underway since the early 2000s with the last four years in final engineering and construction. Along the way, many challenges of the project site were investigated and designs put into place for remediation. Construction of the fish passage and other improvements was completed in October 2016. The evolution of the fish passage studies and engineering, along with the many facets of the project site and challenges of project implementation, will be provided. The project includes a new contemporary fish screen system at the existing river diversion intake and 11 foot high bladder dam. Working in concert with the new fish screen system is a bypass fishway in the form of a vertical slot fish ladder for significantly improved fish migration past the dam and an auxiliary water supply system for increased river bypass flow control and capacity. The fish ladder also includes a large public viewing gallery with seven windows for enhanced public education and a more intimate experience with fish, in addition to very robust fish passage monitoring. The expected fish passage performance and challenges of implementation will be highlighted in the poster.
Ecological effects of improving or removing tide gates: A knowledge synthesis.

Londi M. Tomaro

Historically many coastal wetlands were diked and tide gated to provide flood protection and create land suitable for agriculture and development. The ecological effects of tide gates are relatively well studied and many restoration projects have been implemented in estuaries. However, the effects of replacement (improvement) or removal of tide gates are not well understood. Existing data are often times only available through agency reports and have not been cohesively summarized. We are conducting a systematic review and synthesis of the available knowledge on the effects of removal or replacement of tide gates. This effort is intended to inform the Oregon Watershed Enhancement Board (OWEB) on the impact of former projects and to aid in future project funding decisions. To achieve this goal we used a two-pronged approach. First, we performed a comprehensive literature search and classified the papers identified through this means based on their relevance to our project. Second, we reviewed and summarized data from OWEB-funded and non OWEB-funded projects that we attained outside of our literature search. We will use the accumulated information to answer the questions: what are the effects of tide gate removal or replacement, separately, on water quality and on fish (especially salmonid) populations? Our review indicates that removal and replacement of these structures contributed in both cases to greater tidal inundation and, therefore, to the development of marsh plant communities. However, replacement of tide gates did not always improve water quality, especially when gates were not actively monitored or paired with modulators. Tide gate removal often resulted in increased use by native species including estuarine species where inundation was brackish. However, salmonid use did not always match pre-project expectations. Similarly, replacement projects did not always provide noticeable benefits to salmon. It should be noted that tide gate removal or replacement is often accompanied by other restoration activities and parsing the benefits of each part of the project can be difficult.