

FISH PASSAGE 2015



ABSTRACTS OVERVIEW

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<http://fishpassageconference.com>

Plenary Speakers

DR. ZEB HOGAN, UNIVERSITY OF NEVADA-RENO, USA

Assistant Research Professor, University of Nevada-Reno

Fish passage in an era of broken rivers: new approaches a reason for hope?

In an era of decline of large-bodied, migratory fishes, river connectivity has been shown to be increasingly important for the conservation of native biodiversity. From North America to Asia, Europe to South America, issues with river connectivity influence – for better or worse - the life cycle, and population status, of migratory fishes. In the Mekong River Basin, the world's largest fishes, including the Critically Endangered Mekong giant catfish *Pangasianodon gigas* and giant pangasius *Pangasius sanitwongsei*, face extinction because of mainstream dams on the lower Mekong. In China, populations of the Chinese sturgeon, *Acipenser sinensis*, and Chinese paddlefish, *Psephurus gladius*, have declined significantly since the construction of the Gezhouba and Three Gorges Dams. In North America, connectivity is increasingly recognized as a determining factor in the health of sturgeon and salmon populations in the Columbia and Fraser Rivers; similarly, American paddlefish, *Polyodon spathula*, and pallid sturgeon, *Scaphirhynchus albus*, are impacted by dams and habitat fragmentation. The situation is similar in New Zealand, where a combination of factors – from dams to habitat degradation to overfishing – is resulting in unprecedented population decline of species like the longfin eel *Anguilla dieffenbachii*. Identifying novel fish passage solutions that maximize environmental benefit and minimize cost is the only way to provide for needs of a rapidly growing human population while also protecting imperiled aquatic fauna. Fish passage broadly interpreted includes a wide range of solutions to increase connectivity and restore fish migrations and populations. New methods of study, technologies, decisions about dam placement and dam removal all offer potential for restoring threatened fish. On a policy level, the Convention on Migratory Species provides a

framework for management of transboundary migratory freshwater fish – a neglected biota in urgent need of study and protection.

Dr. Zeb Hogan is an assistant research professor at the University of Nevada-Reno, the United Nations



Convention on Migratory Species Councilor for Fish, and a National Geographic Society Fellow. Zeb also hosts the National Geographic Television series “Monster Fish”. Zeb received his Ph.D. in Ecology from the University of California, Davis in 2004. His research interests include freshwater fish ecology, fisheries management, and endangered species issues. Since 2006, Zeb has worked with the University of Nevada and the National Geographic Society to merge conservation science with education and action. Project outputs to date have included contributions to understanding the migratory patterns and population structures of focal fish species, designation of the Mekong giant catfish and other species as Critically Endangered on the IUCN Red List, and awareness-raising through international and local media. Zeb’s recent articles include “Engaging Recreational Fishers in Management and Conservation: Global Case Studies”, “Endangered River Fish: Factors Hindering Conservation and Restoration”, and “Size-biased extinction risk of the world’s freshwater and marine fishes”. Zeb’s research has also been featured in *Science* (2007), *Bioscience* (2005), and *American Scientist* (2004). A web series on Zeb’s research won the Science Journalism Award (online category) from the American Association of the Advancement of Science (AAAS) in 2008.

DR. MARTIN MALLEN-COOPER, FISHWAY CONSULTING SERVICES, AUSTRALIA

Principal Consultant, Fishway Consulting Services

Universal lessons from fish passage research, design and application in Australia

Australia is characterised by rivers with highly variable hydrology and freshwater fish that have a wide range of migration strategies. The size range of migrating fish is wide (20-1400 mm) and they migrate on flows from as low as 0.05 m³/s to higher than 1000 m³/s (e.g. 1-in-5 year ARI floods). In coastal rivers, both juvenile and adult fish migrate upstream while more inland rivers have migrations where adults migrate upstream to spawn and larvae drift downstream.

The development of fish passage to meet these challenging conditions has led to refining “ecological windows of operation” to optimise migration at key flows; separating ecological and hydrological functions in fishway design, leading to dual function and twin fishways; and increased use of physical modelling for low-level weirs to meet the diverse attraction conditions.

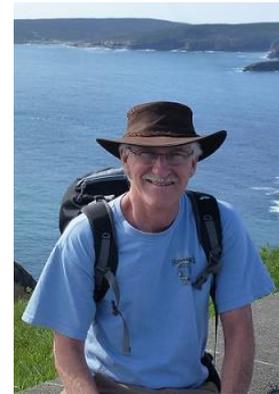
These developments have been underpinned by research on migration, fishway design, and some are supported by long term monitoring. One key finding was that turbulence was having a greater influence on passage of small fish at low water velocities; this has led to a wide range of baffle shapes in the vertical-slot design so that turbulence and fishway attraction flow vary with river flow and the migratory fish assemblage at the site.

New designs of nature-like fishways, technical/rock hybrid designs and trapezoidal weirs have also developed that not only have low turbulence but also have lower maintenance and improved hydraulic consistency. Downstream passage has influenced gate and spillway design but diversion of fish (adults and larvae) into irrigation areas remains a challenge.

From this diverse experience universal lessons for fish passage are discussed. These include the need to deeply understand the river’s hydrology and its fish

assemblage, making fish passage an integral part of dam or weir design, being transparent about risk, letting function determine design, prioritising entrance attraction, collaboration with engineers, biologists and managers at all stages of the project, targeting knowledge gaps with well-focused research and monitoring, and embedding fish passage priorities and needs in the bigger picture of environmental flows, river health and social values.

Dr. Mallen-Cooper has been a specialist fishway biologist for 30 years and has designed over 200 fishways in Australia and overseas, from fish locks and fish lifts on large dams to low-level pool-type and nature-like fishways. His approach to projects is to clarify ecological function, develop migration models and integrate fish behavior into all aspects of dam, weir and fishway design. A key aspect of this is integrating biology, hydrology and hydraulics, which has led to new approaches and applications in fishway design and improved ecological function.



In the last 10 years Dr. Mallen-Cooper has had a significant focus on broader linkages for fish passage and fish migration within catchments and between rivers and floodplains, and maximizing benefits for fish from environmental flows. Southern Hemisphere fish passage is different although the underlying principles are the same. Coping with small and large fish, upstream, downstream and lateral migrations, highly variable and often very low seasonal flows present challenges that all need to be addressed. Lessons from his experience would assist a more holistic approach to fish passage in the tropics and Northern Hemisphere.

**LAURA WILDMAN, PRINCETON HYDRO,
USA**

*Director, New England Regional Office, and
Fisheries Engineer for Princeton Hydro, LLC*

The Evolution of Dam Removal in the United States: A Perspective over the Last Quarter Century

Ms. Wildman's talk will focus on the evolution of pro-active dam removal efforts to restore rivers in the United States over the last quarter of a century. Tracing the origins of the movement from the initial discussions in the mid 1980's by tribes in the Northwest to restore the Elwha River by removing the two large dams that blocked their historic salmon runs, through numerous long and controversial dam removal campaigns on larger rivers, paralleled by hundreds of small dam removals elsewhere in the country. These efforts culminated in the eventual removal of the Elwha and Glines Canyon Dams on the Elwha River completed this year. In addition, Ms. Wildman will discuss the changing community and regulatory views regarding the removal of dams, as well as key outreach efforts that kept the momentum of this environmental movement building. She will discuss how, in only three decades, the concept of removing dams went from ludicrous to a generally well accepted method to restore rivers and reduce the long term economic burdens of dam maintenance in the United States.



Ms. Wildman is a practicing fisheries engineer who established and runs the New England Regional Office for Princeton Hydro focusing on ecological restoration consulting for aquatic systems and dam removal. Ms. Wildman received her bachelor's in Civil Engineering from the University of Vermont and her Master of Environmental Management from Yale University, and integrates both engineering

and a deep understanding of river science into her restoration work. Her expertise and passion centers on the restoration of rivers through the re-establishment of natural functions and aquatic connectivity. She is considered one of the foremost experts on barrier removal and alternative fish passage techniques and regularly lectures instructs and publishes on these topics, including assisting with the instruction of courses for the University of Wisconsin and Yale University. Ms. Wildman is President for the Bioengineering Section (BES) of the American Fisheries Society (AFS), is extremely active in her field and has a very impressive CV.

**PROF. DMITRII S. PAVLOV, A.N.
SEVERTSOV INSTITUTE OF ECOLOGY &
EVOLUTION, RUSSIA**

*Director of the Institute and Head of
Laboratory of Fish Behavior, Russian Academy
Of Sciences*

Down-stream migration of young fish in regulated rivers: patterns and mechanisms

Down-stream migration (DSM), the first phase of life in many fish species, occurs not only in natural, but also in regulated water systems. We studied DSM in more than 40 regulated water systems. Regulation of rivers affects species and age composition (mean age of migrants increases), abundance, diel and seasonal patterns of DSM (reservoirs retard DSM). Fish migrate downstream from reservoirs with deep water intake round a year. More than a billion of fish can leave a large reservoir per year; many of them are killed or injured. Pelagic fish usually prevail among migrants. Three levels of mechanisms controlling DSM were distinguished. Mechanisms of the first level, behavioral and morphological adaptations, are prerequisites of DSM; second – trigger DSM by switching off positive rheoreaction; third – shape spatial distribution of migrants through physical and biological impacts.

Parameters of DSM from water reservoirs depend on overlapping of the spatio-temporal pattern of water flow with the pattern of fish distribution among ecological

zones (littoral, sub-littoral, epipelagial, bathipelagial, and bathial). Interaction between the ecological and flow structures (IEFS) was assessed with an index of contribution of each ecological zone to DSM. Five patterns of fish distribution among ecological zones and four types of IEFS were described. IEFS integrates influence of various environmental conditions on such characteristics of DSM as taxonomic, age and size structure of migrating fish; seasonal and diel variability of DSM, share of migrants in a population. Abrupt change of hydrostatic pressure is one of the most important factors which control mortality of fish passing through turbines. Different strategies of conservation should be used for migrants and resident fish. Safe pass through dams is one of the obligatory measures of conservation for long-distance migrants (anadromous, semi-anadromous, potamodromous). Prevention of DSM is an adequate measure for residents. The most efficient protective measure for fish at large and medium-sized hydropower plants is based on ecological approach including spatial and temporal (seasonal and diel) regulation of the water abstraction.



Dmitrii Pavlov graduated from the Moscow State University, Dept. of Ichthyology, in 1960 where currently he is a Head of the Department. His main study area covers fish

behavior and ecology, and the behavior of fishes including orientation, locomotion, and migrations in the water flow. He has been studying patterns and mechanisms of downstream migrations in the field and in laboratory experiments since 1962. His field studies, with the main focus on down-stream migration through dams have been carried out in many rivers of Europe, Asia, Africa, and South America. Field programs were complemented with experimental studies on behavior, morphology, physiology, and biochemical traits of migrants. Dmitrii Pavlov has written several books and many papers on down-stream migration of young fish, control of their behavior in the water flow, and the protection of migrating fish in regulated rivers. Dmitrii Pavlov is a member of the Russian Academy of Sciences, and the Lithuanian Academy

of Sciences. Drs. Victor Mikheev and Vasilii Kostin, co-authors of the plenary talk for FP2015, have been working together with Dmitrii Pavlov in the field of fish behavior and ecology since 1981.

Dr Mikheev will present on Prof Pavlov's behalf.



DR. CLAUDIO BAIGÚN, WETLANDS INTERNATIONAL, BRAZIL

Program Coordinator at Wetland International and Researcher at the Technological Institute of Chascomus

Conciliating fish ecology and river fragmentation in South American large rivers: Are fish passages appropriate tools?

South America, the most fluvial continent, is increasingly been impacted by river damming having dams construction expanded in last 50 years and fragmenting more than 3,000 km. At present, the upper Parana basin exhibits 130 dams higher than 10 m, but most of future planned dams will be located along the Amazon watershed. Although increasing attention and research efforts have been devoted to assess functioning of fish passage in South America, objectives and support for installation can differ among basins according to river ecological characteristics, conservation goals, fisheries demands, etc. A noticeable asymmetry still exists between salmonids and non-salmonids fish passages in terms of information, research funds availability, human resources, availability of technological tools, etc. Whereas South American passes have shown a wide efficacy range, efficiency appears to be rather low for most of large migratory species challenging managers and scientists for considering how fragmentation effects on migratory fish population can be mitigated. Clearly non-salmonid fishways need to be designed to accommodate different life

history traits exhibited by neotropical fishes inhabit rivers with different hydrological and geomorphological characteristics. Questions about how principles and rules derived from salmonid passages apply and what efficiency should mean and is required in South American large rivers remain still under debate as fish adaptation to cope with river fragmentation impacts may differ among basins based on hydrological and geomorphological features and dams/reservoirs characteristics. Managers and scientists face with the need to assess the feasibility of installing fish passages within a broader context that incorporate fish conservation issues according to current and predicted ecological characteristics and socio-economic scenarios at basin scale.



Dr Claudio Baigún is a fisheries biologist who earned a fisheries masters degree at Oregon State University (USA) and a PhD at the University of Buenos Aires (Argentina). Currently he has a research position at the Technological Institute

of Chascomus (CONICET) leading the Laboratory of Fisheries Ecology and holds also the position of Program Coordinator of Fish and Fisheries Program at Wetlands International (Latin America and the Caribbean Office). His study areas have covered lake ecology and fisheries, dam impacts and fish passage performances in hydroelectric and irrigation dams in Argentina and the assessment of neotropical fisheries in large rivers oriented to develop an Ecosystem Approach. During Dr. Baigún's career he has also coordinated education of fishermen and managers on good fishing practices and the need to manage artisan fisheries within a participatory governance framework. Dr. Baigún has an exceptional CV, with publications in over 50 peer-reviewed journals, contributions to over 20 book chapters, and presentations at hundreds of conferences worldwide.

DR BEATE ADAM, INSTITUTE OF APPLIED ECOLOGY, GERMANY
Institut für angewandte Ökologie

To master the art of building functional fish ways

For more than 100 years fish migrations are investigated and the impacts of migration barriers on fish populations documented. It

is tried to remove dams and weirs or at least to build alternative fish ways to restore the up- and downstream passableness of rivers to minimize the ecological barrier effects. Moreover rules were established to ensure the traceability of fish passes for upstream migrating fish and geometric and hydraulic limiting values were defined to ensure their passability for all species. So in Germany a new comprehensive guideline for the construction of fish passes and fish passible structures ways was published in 2014 and similar provisions exist in other countries too. While a sufficient knowledge how to build fish passes is available, there are still large gaps in our knowledge about proper positioning, dimensioning, hydraulic and operational requirements for fish protection and bypass systems for downstream migrating specimen.

Nevertheless the efficacy of many fish ways to ensure the up- and the downstream migration stays far behind expectations. A common reason is that existing regulations are not applied consistently and/or the guidelines only apply to new constructions or standard cases and cannot be easily transferred on upgrades of existing transversal structures. Moreover most constructive specifications are only based on technical considerations while the biological requirements of migrating fish are not sufficiently regarded.

Main reason for this situation is that observing the behavioural patterns of migrating fish under natural conditions is difficult and/or requires great technical, financial and personal efforts. Furthermore the benefits of basic biological research have been underestimated so far. Actual there are just a few research institutes that have a well trained staff and the technical and instrumental equipment for such research in Europe.

While development, planning and constructing of efficient fish ways is not trivial whereas the gaps of knowledge are big, there is still the risk that even new facilities only operate limited or do not work at all because they do not fulfil the needs of migrating fish. In addition to the biological requirements, also constructional aspects have to be taken into account, which requires an experienced hydraulic engineering.

Taken as a whole the construction of effective fish ways is accordingly a complex

multi- and trans-disciplinary task. As long as no training is offered on this field, the sophisticated construction of functioning fish ways can only be achieved through a close, constructive and confident cooperation between hydraulic engineers and fish biologist. During this talk it will be explained how this goal can be reached by referencing to examples from the practice.



Dr Beate Adams graduated in 1992 in Biology. Her dissertation investigated the damage of loach (*Barbatula barbatula*) taste buds as a quick indicator for river pollution. She is founder of the Institute of Applied

Ecology (Institut für angewandte Ökologie) and works in inter- and transdisciplinary cooperation with German universities and with hydraulic engineers to define the demands for efficient fish passes, fish protection systems and downstream migration facilities. The methodology comprises fish ecological field studies as well as ethohydraulic laboratory experiments. International engineering guidelines have benefited from her experience and her consultative work influenced the construction of Europe biggest double slot fish pass on the River Elbe at Geesthacht with its unique monitoring device. Based on knowledge of the behavioural pattern of downstream migrating silver eel she invented the early warning system “Migromat” which drives an episodic eel protecting operation mode of hydropower plants in rivers. With respect to the European animal welfare Act Dr. Adam gives lessons for the proper and gentle handling of aquatic species in the context of ecological surveys.

SESSION A1: Behavioral guidance and fishway monitoring

Upstream passage of adult salmonids: blocking off cul-de-sacs with graduated field fish barriers

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Abstract Body:

The hydrology of watercourses in the vicinity of hydropower installations is often complex and varies with cascade catchment area inflows, generating and spill regimes and statutory compensation flows in the residual basin area. Depending on discharge regimes from draft tubes, spillways, tailraces, fish passes and residual channels, ascending adult salmonids can be attracted into hydrological cul-de-sacs where their upstream migration is delayed and they may become vulnerable to predation, illegal capture and condition loss. The spawning urge of maturing adult salmonids is such that downstream movement out of such cul-de-sacs is an unnatural choice.

This paper reviews hydropower installations in Europe where graduated field fish barriers (GFFBs) have been installed to exclude ascending adult salmonids from tailrace and draft tube environments. The case histories include Rygene on the Nidelva (Norway), Vessy on the Arve (Switzerland) and Beeston on the Trent (England). The paper also reviews other hydropower installations in Europe where installation of GFFBs is being considered as an option to exclude ascending adult salmonids from draft tubes, tailraces and spillway channels. This approach is being driven by a combination of biological, economic and safety goals. Based on a review of the literature on fish

guidance using electric fields, GFFBs have been quite successful in achieving results — especially for upstream fish-guidance needs where river flows and water velocity can be leveraged with the graduated nature of the technology to yield positive results.

Presenting Author Bio:
Martin O'Farrell Ph.D.
Senior Scientist

Martin is a fisheries biologist by training. He has spent most of his career working as a fisheries consultant in Ireland and several other European countries. During the early part of his fisheries career, his main focus was on the assessment and management of Atlantic salmon and migratory trout stocks supporting commercial and recreational fisheries. He then spent a decade as full-time fisheries consultant with Ireland's national electricity generator, designing and executing fisheries management programmes for Atlantic salmon and European eel of river systems fuelling hydroelectric generating stations. He has widespread international experience of fisheries management issues associated with hydroelectric development and has participated in turbine passage survival assessments for Atlantic salmon smolt in Ireland, Scotland and Russia and for American eel and steelhead smolt in the USA. He has also consulted for manufacturers of infra-red and resistivity fish counting technology. He has a background in Atlantic salmon and Arctic charr aquaculture and is very familiar with environmental impact and commercial aspects of fish farming operations. For the past 15 years Martin has owned and managed an Irish company involved in the manufacture of electric fishing equipment and electric fish barriers. He sold this business to Smith-Root Inc. in 2011 and now runs the European office of Smith-Root. He has used his training and experience as a fisheries consultant to develop business opportunities for the company in Europe. Since 2012 he has also participated in Smith-Root research and development projects throughout the United States. Martin is a valued member of the Smith-Root scientific and management teams and is now a director of Smith-Root Inc.

**Attraction and repulsion measures for
safe bypass of Atlantic salmon smolts**

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Abstract Body:

While fine mesh trash racks constitute a safe barrier for downstream migrating smolts, such racks can be expensive and technically difficult to retrofit at hydropower intakes. Alternatively, a combination of attraction and repulsion measures can successfully pass fish by the intake and into a safe corridor. At the Laudal powerplant in Norway, Atlantic salmon smolts were tagged with conventional radio tags during the migration period in four different years. A statistical model could be developed to predict how flow diversion could attract fish into a bypass channel and strobe light in front of the intake had repulsing effect during night. In order to create favorable flow diversion at the intake, manipulation of mountainous reservoirs were modelled and the economic cost related to flood spill and flow changes were calculated. Finally, an advanced computational fluid dynamics model was calibrated and applied at the intake to describe the hydraulics at different flow conditions and relate the physical variables to accurate recordings from state-of-the-art three dimensional radio tags surgically implanted in smolts. The results can be used to generate general rules for safe bypassing of salmon smolts at intakes.

Presenting Author Bio:

Hans-Petter Fjeldstad has worked with ecohydraulic topics for more than 15 years and has a PhD on Atlantic salmon fishways and migration. Fjeldstad has published and reviewed papers in a number of international journals on the topics hydraulics, fishways, fish disease, habitat modelling and fish migration. Since 2013 he has been the operating agent for the IEA Hydropower annex for fish and is presently involved in a large international research projects on salmonid fishes and challenges connected

to environmental flows and migration corridors in regulated rivers.

Efficacy of pulsed air directed passage (ADP) as a means of motivating shad to pass diversion structures

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Abstract Body:

Enabling diadromous fishes to enter, pass through and exit fish diversion structures, such as fishways, with minimal delay remains a challenge. The Conte Laboratory's Air Directed Passage (ADP) technology acts to supplement volitional behavioral cues by exploiting fish sensitivity/aversion to high energy flow fields established with a sequentially activated series of parallel air diffusers (medium bubble flexible membrane type) positioned at strategic locations along the floor of test fishways. Compressed air flow is controlled by a PLC/solenoid valve system that acts to pulse air introductions at high frequency so as to actively herd fish toward upstream water inlet structures. ADP allows for control of progression (sweep) speed, direction, energy level and frequency of repeat sweeps. Tests of ADP were conducted using actively migrating wild adult Connecticut River American shad (*Alosa sapidissima*) collected mid-May through early June 2014 (N=408). Collected fish were measured for length, sexed, and tagged externally with 23 mm half-duplex PIT tags and held overnight. Trials were performed in a laboratory flume measuring 3 m X 18 m that received Connecticut River

water at a rate of 368 l/s which provided a working depth of 137 cm. Water entered the flume via a contracted rectangular weir 91 cm in width with a delta H of 35.6 cm. The flume bulkhead supporting the weir incorporated aprons and a ramped floor to streamline flow. The floor of the flume incorporated 14 recessed rows of diffusers positioned at 1.2 m centers along its longitudinal axis. Each row relied on 17 diffusers for air release. Air flow was applied at 5 m³/min with rest periods of 1 min between the 10 successive ADP sweeps used per trial. Fish passage rates were monitored by PIT antennas interfaced to a multi-reader PIT tag recorder. ADP increased passage rate 7.7 fold over selected test periods when compared to controls, i.e., 3.83% vs 0.44% per min.

Presenting Author Bio:

Mr. Noreika is a Hydraulic Engineer for the S.O. Conte Anadromous Fish Research Center Engineering Fish Passage Section. He is an innovative test engineer and designer with over 20 years of extensive experience in model testing and instrumentation related to fish passage, fishway design, and field measurements. His responsibilities include model and test design, construction supervision, instrumentation applications and testing, data evaluation, reporting, and client interaction.

Effects of sluices on migrating elvers and other fish in a Dutch salt water / fresh water gradient

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Abstract Body:

Many of the formerly gradual transitions between marine and freshwater habitats have been severely altered by man-made constructions. In the Netherlands, water managers are implementing numerous measures to decrease the negative effects of these barriers on fish migration (e.g. constructing fish passages). Adjusting sluice management to restore a salt water / fresh water gradient, however, is a novel way of accommodating fish migration. To effectively apply this measure, more knowledge is required on how fish migration is influenced by sluices.

At Spaarndam (the Netherlands), a complex of pumping stations and sluices separates salt water and fresh water. Within this complex, fish can either migrate into discharge channels towards pumping stations, or migrate into sluices and continue upstream. In spring 2014, we evaluated fish migration at the Spaarndam complex to determine where fish enter (i.e. into the sluices or discharge channels), and whether fish were able to pass the complex. A total of seventeen species were observed. The vast majority of individuals were juvenile *Anguilla anguilla* (elver). A marked difference within the complex was observed: when fresh water was discharged, the vast majority of elvers migrated towards the impassable pumping stations. Migrating elvers were almost absent in sluices. This was most likely due to the lack of an attraction flow at the sluices. In contrast, other species (e.g. pike-perch, bream and perch) used the sluices for migration utilizing openings in the sluice doors.

We conclude that the attraction flow at sluices in Spaarndam is too low to attract elvers, therefore effectively creating a barrier to migration.

Although effective for other fish species (e.g. pike-perch, bream and perch), adjusting sluice management is not effective for elvers. The creation of a continuous small attraction flow, in combination with the construction of a fish passage will be more effective for elvers.

Presenting Author Bio:

Bas van den Boogaard is a aquatic ecologist working at consultant agency Bureau Waardenburg BV. His primary focus is research on fish communities in both freshwater and marine habitats. Within this field, he works on fish migration projects,

studies on fish communities in estuarine waters and environmental assessments dealing with fish communities.

Historical evolution of fish biodiversity and capture periodicity in the River Meuse (Belgium) as revealed by 15 consecutive years of fishpasses monitoring

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Abstract Body:
In the River Meuse at 323km upstream from the North Sea, the hydroelectric dam of Lixhe (rated power of 5300KW) is equipped with two fishpasses: one pool and weir fishpass (in function since 1980; 0.13m³.s⁻¹ operating flow) and one vertical slot fishpass (in function since 1998; 1m³.s⁻¹ operating flow). Both fishpasses were scientifically monitored using capture traps during 15 consecutive years (from 1999 to 2014). The objective of the study is to analyse i) the evolution of fish stock and biodiversity over 15 years and ii) the capture periodicities of fish and their variations over years. During the considered period, we observed 36 species at adult stage (88597 individuals with 75% of cyprinids) and 13 species at juvenile (0+) stage (335067 individuals with 90% of cyprinids). The comparison between both fishpasses indicated a greater use (>50%) of the new vertical slot by rheophilic species and species that have good swimming ability. Global results showed a drastic reduction in capture per year (>90%) for some species between 1999 and 2014 like *Anguilla Anguilla*, *Alburnus alburnus*,

Blicca bjoerkna, *Rutilus rutilus* and *Tinca tinca*. Whereas other species have emerged like *Aspius aspius* and *Silurus glanis*. For the 0+, important interannual variations were observed from few individuals to several tens of thousands per year. The analysis of capture periodicity for the most abundant species at adult stage demonstrated the presence of stable behaviours between years for the *Abramis brama* and *B. bjoerkna* respectively a Q50 of the capture day of the year from 108th to 144th day at mean=17°C and from 118th to 155th day at mean=18°C. In contrast other species have patterns more variables (*Barbus barbus*: Q50 from 96th to 266th day; *R. rutilus*: from 10th and 309th day). Finally the 0+ exhibited a capture periodicity stable in time during the summer.

SESSION B1: Policy & Management

The fishway guide to the galaxy

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Abstract Body:
During the last decades, the biological understanding of connectivity between fish habitats has increased. This has resulted in restoration objectives, legislation, national and international guidelines demanding to restore connectivity for fish at anthropogenic migration barriers in many countries. In response, a large number of distinct fishways have been developed which has resulted in an increased body of literature focusing on maximizing fish passage.

However, unsuitable fishways and poorly performing fishways and are still being constructed. Reasons may be an insufficient communication of research results but also a disconnect between fishway experts and users responsible for improving connectivity such as water authorities, NGOs, consultancies and hydropower companies. This seems especially true in cases concerning connectivity at numerous local scales such as groundsills, culverts and weirs. There are millions of such small barriers and they are blocking fish movement corridors all over the world but fishway expertise usually focuses on larger projects such as dams and large hydropower stations.

To address this challenge we have developed an easy to understand guide which helps to find the best solution possible to improve connectivity for aquatic organisms in each case. Its architecture is based on a hierarchical decision tree which

is easy to handle and implement. The guide fits on one page and will lead the user to the right type of solution which can then be detailed further based on specifics from the latest research and incorporate input from interested stakeholders. The guide addresses a vast array of artificial barriers and can be actualized while research is progressing. The presentation aims to describe the guide, to explain its hierarchy and to discuss it with public at the conference.

Presenting Author Bio:
As an engineer in landscape planning and with a doctoral degree in fish biology Ulrich Pulg has the ideal requirements to solve multidisciplinary challenges in rivers concerning restoration and connectivity. He has 12 years working experience as researcher, river manager and consultant. He is specialized on: river restoration, evaluation and design of fishways, analyzing fresh water fish habitats and supersaturation.

German participatory forum on fish protection and downstream migration

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Abstract Body:
Fish protection and downstream fish migration has been an item of intensive and often controversial discussions in recent years in Germany, both from an environmental policy perspective and a technical point of view. In response, the Federal Environment Agency, with support from Ecologic Institute, initiated a Forum on Fish Protection and Downstream Fish Migration in 2012. The Forum includes participants from federal and regional water resource management authorities, nature and angler

NGOs, consultancies, water managers and hydropower. More than 200 stakeholders have engaged in a dialogue process on the following jointly-identified key topics: environmental policy and legal framework; river basin-related strategies; applied behavioral and population biology; technical measures for fish protection and downstream migration; monitoring.

The Forum has hosted a series of interactive workshops and conferences to foster dialogue and has achieved the exchange of information and experiences on the various topics put on the table. To increase acceptability and engagement of participants in the process, the Forum has not actively sought to reach consensus. In the outcomes of discussion on conflicting topics, both common and differing opinions have been taken on board. In addition, a common understanding has been developed on the current state of knowledge and technology that needs to be taken into account for fish protection, downstream fish migration and the conservation and establishment of fish populations. Next to the identification of key problem areas, the Forum experts proposed initial solutions and identified needs for further research and practical action.

In 2014, the Forum produced a synthesis as a result of the discussions taking place so far during the workshops. The Forum participants have highlighted the improvement that has taking place in the debate culture on the topic of fish protection and downstream migration within Germany due to the Forum events. The participants highly recommended continuing this type of dialogue process.

Presenting Author Bio:

Dr. Eleftheria Kampa is a Senior Fellow at Ecologic Institute focusing on water and river basin management and policy, with specific emphasis on the EU Water Framework Directive. She has worked on numerous research projects funded under the Framework Programmes FP5, FP6, and FP7 of the European Commission as well as on service contracts for national and European institutions. She works on the WFD implementation (especially on hydromorphological pressures, measures, and heavily modified water bodies), river

restoration, biodiversity protection and stakeholder participation processes.

Management of first dams in the tidal area of the Gironde estuary

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Abstract Body:

The particular case of the first dams met by the European eel migrating in the tidal area of the Gironde estuary is examined here. For these obstacles, typological elements are proposed, based on the nature of the hydraulic dams, but also on that of its downstream and upstream areas. Various technical tries are already performed to minimize impact of these dams, in tidal areas.

These obstacles exist to prevent and limit entrance of salt or brackish water in the swamp and to prevent floods.

Glass eel and tidal and marine young species colonize these areas carried by the stream. The actual management of these dams doesn't permit to the different species to go upstream because the dams are closed only 5 minutes after the flow inversion. The good management of these dams would allow the colonization of 37% of the space in the tributary or the swamp.

Since 2009, MIGADO Association, in collaboration with local users, tries to manage the dams with different systems adapted to the user needs and to the natural characteristics of the swamp.

The tests consist in installing :

- holds to prevent the closure of the tidal dams,
- stiffeners (« raidisseurs ») to slow down the closure of the tidal dams,
- optimized management of the present gate on the tidal dams,
- telescopic gate allowing to keep a upstream water level defined.

The evaluation shows promising results, answering to users' needs upstream (none

floods), a management adapted to the needs, and increase of fish population in the swamp and tributary (multiplied density by 20). There is no impact of suspension material entry in the middle.

All system can be adapted to each swamp and to user needs. This system, little expensive and autonomous, allows to glass eel to colonize swamp and tributaries in the tidal area.

Presenting Author Bio:

Vanessa LAURONCE is working with MIGADO Association since ten years. She's responsible of the eel program and sturgeon program in the organisation. The association exist to manage and follow migratory population in the Gironde Estuary, Garonne and Dordogne rivers.

Fish passage in large rivers: challenges and solutions

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Abstract Body:

Understanding and facilitating fish passage in large rivers is a major challenge. This challenge stems in part from the scarcity of surveys of large river, due the inherent difficulties associated with studying them. In addition large rivers host a great number of fish species differing in size, ecological requirements and swimming abilities. Notwithstanding the limited information regarding these topics, EU and national legislation require passage facilities for all species and size classes to reach the "good ecological status" till 2027.

VERBUND, the largest power plant operator in Austria, is responsible to implement these measures on a variety of big rivers in Austria and Germany. First projects started in the mid-1980ies at the Power plant Greifenstein at the Danube followed by more than 15 fishways at a variety of large Rivers (Danube River, Inn River, Salzach River, Drau River, Möll River, Mur River).

Most of the projects have been accompanied by a scientific monitoring program.

In our contribution we present our experience and learnings gained with construction, operation and functionality of different types of fish ladders at big rivers including the "Hydrodynamic fishlift", conventional vertical slot passes, and nature-like bypass channels.

The projects show that the requirements formulated in the EU-WFD cannot be achieved by measures to improve fish passage alone. In order to achieve the objectives the improvement of habitat conditions is required. One of the key habitat types in large rivers are permanently connected side arms, which provide spawning grounds and shelter from ship-induced waves.

A stepwise procedure using different types of fundings has proven successful so far to implement the environmentally and economically feasible in a reasonable time frame. It is also important to co-ordinate all actions with the different types of usage of the Danube (Energy, navigation, flood protection, ...) and the responsible stake holders.

Presenting Author Bio:

Dr. Walter Reckendorfer is Freshwater ecologist at VERBUND Hydro Power GmbH, the largest power plant operator in Austria. His study areas have covered fish and invertebrate ecology and river restoration with a focus on large floodplain rivers. He received his Ph.D. in Freshwater Ecology from the University of Vienna in 2002. Previous academic work included positions as a Research associate at the University of Vienna and as a Senior researcher at the WasserCluster Lunz. He published several peer review papers in national and international journals with a focus on large floodplain rivers and taught courses at the

University of Vienna and the University of Natural Resources and Life Sciences, Vienna.

Lessons Learned from Tropical Storm Irene 2.0: How Flood Resiliency Benefits of Stream Simulation Designs is Changing Policy within the U.S.

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Abstract Body:
Stream simulation design is a geomorphic, engineering, and ecologically-based approach to designing road-stream crossings that creates a natural and dynamic channel through the crossing structure similar in dimensions and characteristics to the adjacent, natural channel, allowing for unimpeded passage of aquatic organisms, debris, and water during various flow conditions, including floods. A retrospective case study of the survival and failure of road-stream crossings was conducted in the upper White River watershed and the Green Mountain National Forest in Vermont following record flooding from Tropical Storm Irene in August 2011. Damage was largely avoided at two road-stream crossings where stream simulation design was implemented, and extensive at multiple road-stream crossings constructed using traditional undersized, hydraulic designs. Cost analyses suggest that relatively modest increases in initial investment to implement stream simulation designs yield substantial societal and

economic benefits. Numerous other examples across the country of stream simulation designs surviving large flood events underscore these benefits. Four years after the historic Irene flood event, policy changes at state and federal levels across the U.S. suggest that the flood resiliency of culverts is gaining momentum as a policy driver amid growing public sensitivity to climate change risks and the importance of restoring ecological connectivity and protecting investments in transportation infrastructure.

Presenting Author Bio:
Nathaniel Gillespie has been with the USDA Forest Service's headquarters since 2011 as the Assistant National Fish Program Leader. The USDA Forest Service manages over 193 million acres within 155 National Forests & Grasslands across the United States. The Forest Service manages many of the remaining intact headwater aquatic habitats in the country for myriad aquatic species of fish, mussels, crayfish and amphibians, many of which are protected under the Federal Endangered Species Act. Mr. Gillespie formerly worked for Trout Unlimited on their Science Team. He received his masters of science from the University of Michigan.

SESSION C1: Prioritizing and Evaluating River Connectivity for Fisheries Health

Prioritizing barrier removals in Great Lakes tributaries: Balancing tradeoffs between native and invasive fish species

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Abstract Body:

Tributaries to the Great Lakes are highly fragmented by dams and road crossings that act as potential barriers to migratory fishes, restricting their access to historical riverine spawning grounds. There is growing investment in removing or modifying barriers to restore native fish migrations and ecosystem function, but these efforts may also increase available habitat for invasive sea lamprey. The restoration community lacks a systematic method for comparing these costs and benefits to assess which barrier removal projects would offer the greatest return on investment. To address

this problem, we developed a basin-scale mathematical optimization model to prioritize barriers for removal on the basis of upstream breeding habitat for both native and invasive fishes. We parameterized the model using an extensive database of dams and road crossings; economic models of projected barrier removal and lampricide application costs; and historical data describing distributions of native and invasive species. We describe trade-offs resulting from increased habitat access for native migratory fishes and sea lamprey that would accompany different barrier removal scenarios. We further discuss the sensitivity of the model to uncertainty in estimates of tributary suitability for native and invasive species and investigate the benefit of simultaneously planning barrier removal and lamprey management actions.

Presenting Author Bio:

Jesse O'Hanley is a Senior Lecturer (Associate Professor) in the Kent Business School, University of Kent, UK. He obtained a B.S. in Biological Sciences and an M.S. in Engineering-Economic Systems and Operations Research both from Stanford University and holds a Ph.D. in Environmental Science, Policy & Management from the University of California, Berkeley. Before joining Kent, Dr. O'Hanley worked as a postdoctoral fellow in the Environmental Change Institute, University of Oxford on the prediction of biodiversity impacts of climate change. Dr. O'Hanley's research focuses on the development of decision support tools for environmental planning and management. Recent and current lines of inquiry include river infrastructure mitigation and placement, nature reserve network design, and species distribution modeling. He has worked closely over a number of years with government agencies and NGOs on the development and application of optimization based approaches for river infrastructure mitigation and placement. He has long-term research and consultancy projects spanning California, Oregon, Alaska, Maine, the Great Lakes region and the UK.

The ICE protocol for ecological continuity: a new tool to evaluate the upstream fish passage success at physical barriers

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Abstract Body:
The recording and classification of obstacles that can interfere with the movements and migrations of fish is critical information to plan river restoration program. To date a major problem is to determine the potential effect of each obstacle and to select the problematic sites that should be improved to restore longitudinal connectivity (construction of fish passage facilities, removal or modification of the obstacles). Fish passage success about an obstacle is complex and depends on the hydraulic conditions over and at the foot of the obstacle in relation to swimming and leaping capabilities of the fish species concerned. This selection and classification is too often biased because managers lack information's on the fish capabilities to leap physical obstacles. The need for a simple, reliable and standardised assessment method for use by a wide range of environmental stakeholders rapidly became evident. We responded to the challenge and developed the ICE protocol as the basis for the required ecological-continuity assessment method, particularly in the context of the European Water Framework Directive implementation. The ICE protocol coordinated by ONEMA is based on an integration of the topographical and hydraulic characteristics of obstacles with the physical capabilities (swimming, jumping

or crawling) of the fish species analysed. It requires the gathering of standardised descriptive variables on each obstacle. The result of the analysis is an indication on the risks of a structure constituting a more or less severe obstacle (4 classes) for a given fish species (n=47) or group of species. Particular attention was paid to the practical aspects of the method (time required and necessary human resources) to facilitate its use in a wide variety of situations and areas. Each procedure is presented as a flow chart to assist in decision-making, thus making the protocol easy to use for a wide range of people.

Presenting Author Bio:
Michaël Ovidio, PhD, Fish Biologist, Scientific Expert and Associate Professor. University of Liège, Head of Laboratory of Fish Demography and Hydroecology.

Assessing longitudinal connectivity affected by cross-sectional barriers in a riverine bidirectional network

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Abstract Body:
Disruption of longitudinal connectivity is a main problem in most of the world rivers. Spain, as a country with one of highest rates of cross-sectional obstacles per river, needs a strategy to restore longitudinal connectivity in riverscapes. Graph theory based approaches have proven as a suitable tool to measure the connectivity in the landscape. Unlike terrestrial habitats, where it has been profusely used, riverine systems still remain scarcely studied under this focus. There is a need to adapt the currently

available knowledge on terrestrial habitat connectivity assessment to the management of river networks. In our study the broadly used Probability of Connectivity Index has been used to assess the global connectivity loss due to artificial obstacles (dams and weirs) in two medium sized river basins networks in Central Spain (Cega and Pirón). However, unlike previous studies, this time both differential downstream and upstream passability (directional connectivity) has been accounted through a purposefully adapted version of the Conefor software package. Passability has been quantified for every obstacle by means of an index that takes into account the requirements of every fish species in the community. This procedure ranks all the obstacles in the river network according to their individual contribution to the global loss of connectivity (upstream and downstream). It is therefore a tool that provides river basin management plans (RBMP) knowledge on the expected global benefits of the removal of each obstacle.

Presenting Author Bio:

PhD student in Ecology: conservation and restoration of ecosystems.

Prioritizing efforts to restore habitats and longitudinal connectivity for the rehabilitation of the European sturgeon (*Acipenser sturio*) in a German lowland river

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Abstract Body:

This study focused on assessing the rehabilitation potential of the Spree-Havel River system for rheophilic and anadromous fish species using the European sturgeon *Acipenser sturio* as indicator species. An age-structured population model for the sturgeon was set up to predict the potential effects of different river rehabilitation scenarios on the population development.

The scenarios included: 1) solely the provision of longitudinal connectivity without further habitat enhancements, 2) providing longitudinal connectivity in combination with moderate gravel addition and modified flow conditions below weirs, and 3) providing longitudinal connectivity in combination with significant riverbed modifications to create spawning habitats. All three scenarios have been calculated for four adjacent river segments of in total

220 km length allowing for cumulative assessments. The main aim of this simulation study was to identify the best solution for the combination of habitat enhancement and connectivity measures to achieve the maximum ecological improvement of riverine fish assemblages at feasible efforts.

Restoration of river connectivity is the main prerequisite for the re-establishment of a variety of diadromous species including sturgeon, but by itself it will have little potential to support their populations. At least moderate improvements of the hydro-morphology and habitat structures (restoring about 30% of the potential habitats will result in 30,000 m² spawning habitat) will be essential for the long-term success. This rehabilitation in conjunction with longitudinal connectivity over the 220 km long river course will dramatically increase the population potential. As a result, the sturgeon population of the Havel-Spree river system could contribute an estimated share of 41% to a potential sturgeon stock of the River Elbe catchment (148,268 km²), accounting for 15,400-42,000 juvenile fish annually recruiting from the system and an annual return of 4,300-11,700 spawners.

Presenting Author Bio:

CW performs research on fish assemblages of large rivers for more than 20 years. Research interests cover primarily structuring factors, fish assemblage dynamics, functional traits and process-based fish environment interactions as well

as river rehabilitation, connectivity and fish-based environmental assessments.

Supporting decision-making for improving longitudinal connectivity for diadromous and potamodromous fishes in complex catchments

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Abstract Body:

Preservation and restoration of Europe's endangered migratory fish species and habitats are high on the international river basin policy agenda. Improvement through restoration of longitudinal connectivity is seen as an important measure, but although prioritization of in-stream barriers has been addressed at local and regional levels the process still lacks adequate priority on the international level. This paper introduces a well-tested method, designed to help decision makers achieve the rehabilitation of targeted ichthyofauna more successfully. This method assesses artificial barriers within waters designated under the Water Framework Directive (WFD), Europe's main legislative driver for ecological improvement of river basins. The method aggregates migratory fish communities (both diadromous and potamodromous) into functional biological units (ecological fish guilds) and defines their most pressing habitat requirements. Using GIS mapping and spatial analysis of the potential ranges

(fish zonation) we pin-point the most important barriers, per guild. This method was developed and deployed over a 12 year period as a practical case study, fitting data derived from the 36 regional water management organisations in the Netherlands. We delivered national advice on the prioritization of a total of 2924 barriers located within WFD water bodies, facilitating migration for all 18 indigenous migratory fish species.

Presenting Author Bio:

Niels is senior Project Manager at the Royal Dutch Angling Organisation (Sportvisserij Nederland). On the theme of fish migration he joined forces with the World Fish Migration Day and cooperated in the Living North Sea Programme. Niels published several fish-migrating related studies e.g. on tracking the highly endangered European sturgeon (*Acipenser sturio*) in the river Rhine and North Sea and on the downstream migration and mortality of Atlantic salmon smolts in the river Meuse. The article of this oral presentation (improving longitudinal connectivity in complex catchments) is build on 13 years of experience in the Netherlands.

SESSION D1: Fishway design and hydraulic modelling

Classification of flow patterns in a nature-oriented fishway based on 3D hydraulic simulation results

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Abstract Body:
In order to fulfill the requirements of the EU Water Framework Directive concerning the restoration of fish passage in rivers, various types of (near-natural and technical) fishways have been built in recent years. For optimization of planned structures as well as for monitoring of the performance of existing fishways, their hydraulics has to be studied. 3D hydrodynamic numerical modelling is a useful tool to predict hydraulic quantities and analyse flow pattern. Many studies using hydraulic simulations deal with technical fishways. In contrast, nature-oriented fishways have rarely been numerically modelled so far.

In the framework of R&D activities at Karlsruhe Institute of Technology, a high resolution 3D-hydraulic model of a section of a nature-oriented bypass channel (rock cascade pass) has been developed. The basis of a hydraulic model is a 3D-model of the fishway's topography. Since fishways of a nature-oriented design type are characterized by highly irregular structures, the build-up of such a model is very challenging. In this study, the method of terrestrial laser scanning was used for detailed geodata acquisition. The hydraulic model was validated using, inter alia, acoustic Doppler velocity measurements. Simulations using the computational fluid

dynamics software FLOW-3D were performed for two hydraulic scenarios.

The simulated hydraulic quantities (velocities, water levels) and their distribution along the vertical and horizontal axes have been investigated and compared to critical values concerning fish passability specified in technical standards. A method of categorization of flow patterns is proposed, which enables a schematic visualization of complex flow conditions. In this way, potentially critical zones can be located and specific flow patterns can be identified. This method of analysis has a high potential in terms of addressing environmental issues concerning nature-oriented fishways and river restoration projects.

Presenting Author Bio:
Rebekka Czerny is a scientific assistant at Institute for Water and River Basin Management, Karlsruhe Institute of Technology (KIT). She studied Civil Engineering in Karlsruhe (major fields of study: hydraulic engineering and water management) and now works in the field of hydraulic simulation. Rebekka Czerny has been working on numerous projects concerning flood simulation, hydraulic simulation of rivers with automated barrage control, and high resolution hydraulic simulation. Her doctoral research study deals with detailed flow simulation of nature-oriented streams based on high resolution topographical data acquired by terrestrial laser scanning.

How to investigate the influence of auxiliary discharge on the attraction of fishways

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Abstract Body:

Several types of fish passage are increasingly being installed in river barriers to restore the longitudinal connectivity of fragmented riverine habitats. A vertical slot fishway installed in the Açude-Ponte weir at Coimbra (River Mondego, Portugal) was monitored to model the efficiency of this infrastructure for anadromous fishes (i.e., sea lamprey *Petromyzon marinus* L.; allis shad *Alosa alosa* L. and twaite shad *Alosa fallax* Lacépède, 1800) throughout 2013 and 2014 spawning seasons.

Abstract Body:

Adding auxiliary discharge to the outflow of the fishway extends the attraction flow further into the tailwater and serves to guide fish to the entrance. Due to conflicting interests between ecological demands and hydropower generation this additional discharge is subject to critical scrutiny. How much auxiliary water is needed for a certain effect?

Suggestions about the necessary discharge vary and only few studies have been conducted so far. The German Federal Institute of Hydrology and the German Federal Waterways Engineering and Research Institute will address this question at four pilot sites in German waterways as part of a research program on ecological continuity.

However, developing a study design is not an easy task: Which is the best explanatory variable to investigate - a certain amount of discharge (which is easier to control) or a distinct flow pattern in the tailwater (which is more likely what fish will notice)? Is the total number of fish that find the fishway a good response variable? Where and how should we count the fish? How do we deal with the multitude of environmental parameters that also influence the number of migrating fish? Which sample size will suffice and what level of probability can be considered adequate?

To deal with these questions we have worked out a study design that includes several statistical approaches (blocked design, baseline measurement, regression techniques). We have developed discharge scenarios on the basis of CFD and used 2012-2013 monitoring data from a Vaki-Counter at the River Moselle to simulate effects and necessary sample sizes. We also used this data to find out which environmental parameters influence the number of migrating fish and may thus influence our studies. We like to share and discuss our results and approaches with colleagues from different regions and professions.

Modelling the efficiency of a vertical slot fishway for anadromous fishes

First Author Name:

Fish passage was assessed using a video recording system. Simultaneously, eight abiotic parameters, considered as potential predictors of fishway's use by anadromous fishes, were continuously recorded during the entire study period. Boosted Regression Trees (BRTs) analysis was applied to relate the use of the fishway by sea lamprey and *Alosa spp.* with the abiotic predictors. To complement this data, a passive integrated transponder (PIT) antenna system was used to quantify passage efficiency for sea lampreys. Size frequency distribution and total biomass of fishes that successfully transposed the fishway was also estimated.

Video data show that in the migratory seasons of 2013 and 2014, 8333 and 21979 sea lampreys passed through fishway, respectively, and a total of 7503 and 3404 *Alosa spp.* individuals transposed this infrastructure during the same period. About 30% of PIT tagged lampreys transposed the fishway. BRT models identified the river flow as the most important variable to explain use of the fishway by anadromous fishes. The relationships of this variable with the fish passages suggest that sea lampreys and *Alosa spp.* use the fishway preferentially at relatively low flow conditions that maximize the attraction efficiency of the fishway entrance. Finally, results obtained with this study were used to implement a sub-sampling methodology (video processing) to estimate the total amount of fish (lamprey and shads) that annually use the fishway during their spawning migrations.

Presenting Author Bio:

Gabriela Cardoso is from Oporto, Portugal, is a grant researcher in MARE - Marine and Environmental Science Centre. Has a degree in Environmental Engineering by Polytechnic Institute of Viana do Castelo and a master in Natural Resources Management and Conservation in a shared course from University of Évora and the Technical University of Lisbon. Under the master thesis worked in the monitoring of a fishway where used a series of methods for assessing the efficiency of the infrastructure and also in different research projects in the field of aquatic resources.

Experimental study on flow patterns in vertical slot fishways

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Abstract Body:

The vertical slot fishway is one of the most commonly used fish passage facilities in Germany. The flow conditions within fishway play an important role in the establishment of ecological connectivity, because they determine whether fish can pass, with regard of their given swimming performance. Earlier studies have shown that two different types of flow patterns, separated by a transition area, may develop in the pools depending on the width-to-length (B/L) ratio of the pools and the slope of the fishway.

In order to gain insight in the formation of different flow patterns, an extensive study of different geometric parameters was performed, with a total of 60 different designs. Different pool geometries and slopes were installed in a physical model at Theodor-Rehbock-Laboratory of the Institute for Water and River Basin Management (IWG) in Karlsruhe. Flow patterns were recorded photo-optically by long time exposure, water depths were measured with an ultrasonic distance sensor and flow velocities by ADV. The measurements were analysed to obtain quantitative information about flow patterns, velocities, energy budget of the pools, relationship between discharge and flow depth and water level difference between adjacent pools. Unlike in previous studies, not only the B/L ratio but the entire pool geometry was varied in accordance to the German guidelines. Small slope ranges between 2.8 and 5 %, typical for Federal German waterways, were studied for the first time.

Both flow patterns could be observed under identical B/L and slope. The results show that parameters apart from the B/L ratio and slope are essential for determining the

formation of flow patterns. Especially the variation of the slot angle had a large influence on the flow patterns. The flow velocity measurements show differences between the two flow patterns in terms of position and magnitude of maximum velocities in the pools.

Presenting Author Bio:

Verena Höger is a hydraulic engineer and PhD student at the Institute for Water and River Basin Management (IWG) of the Karlsruhe Institute of Technology (KIT). After graduating at the Karlsruhe Institute of Technology (KIT) in 2012, she worked as a scientific assistant at the Federal Waterways Engineering and Research Institute of Germany. Her work focuses on physical modelling and laboratory studies of vertical slot fishways.

Towards effective, bi-directional selective fish passage

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Abstract Body:

Barriers interfere with aquatic connectivity by preventing or limiting migratory fishes from spawning and other life history processes, and there is increasing pressure to restore connectivity. However, conflicting management objectives exist in many jurisdictions where barriers to fish movement inhibit the restoration of native fishes but protect native fish communities above barriers from undesirable invasive species. In the Laurentian Great Lakes, barriers are an important management tool in the control of invasive Sea Lampreys. Sea Lampreys remain highly destructive in the Great Lakes, and are a constant threat to a 7 billion dollar fishery. Developing selective, effective bi-directional fish passage to remove Sea Lampreys while allowing the

passage of native fishes has become an issue of great importance for Great Lakes fisheries managers. To date, efforts have included a variety of approaches including velocity barriers, seasonal barriers, trap-and-sort fishways, and eel ladders. The integration of emerging technologies, such as push-pull and electrical and pheromone guidance and advances in engineering, such as eel-style ladder traps are providing hope that better selective, effective bi-directional fish passage solutions are possible. The Great Lakes Fishery Commission is developing a research theme specific to selective bi-directional fish passage in the hopes of resolving the conflict between aquatic fragmentation and invasive species control.

Presenting Author Bio:

Tom Pratt is a research scientist with Fisheries and Canada who primarily studies fishes of conservation concern.

SESSION E1: Fish Migration River Project, Fish Migration at tidal barrier 'Afsluitdijk'

Fish Friendly Spill gate management Afsluitdijk

First Author Name:
Wilco de Bruijne

First Author Affiliation:
ARCADIS

Abstract Body:
The 'Afsluitdijk' is the largest salt water barrier in Europe and was constructed for sea flood protection in the Netherlands. The dike body causes a sharp boundary between the Wadden Sea and the delta of the river IJssel. There is no brackish estuarine zone anymore and the natural habitat of estuarine species has therefore completely disappeared. Besides that, the Afsluitdijk blocks migration routes of various anadromous and catadromous fish species among which Atlantic salmon, sea trout, lamprey species, shad species, smelt, three spined stickle back and European eel.

The discharge of the river IJssel is spilled through spill gates at low tide. The spillgates close at high tide, therefore there is only a net output of fresh water. Large numbers of migratory fish are attracted to the fresh water flow in the Wadden Sea, however there is no alternative migration route into lake IJsselmeer and the River IJssel available nearby.

In 2013 the project 'Fish Friendly Spill gate management Afsluitdijk' was started by Rijkswaterstaat. The project consist of three phases: 1. Inventory of possible alternative forms of spill gate management which allow fish to enter the fresh water zone (2013); 2. Testing of a chosen preferred variant of alternative management (2014); and 3. The implementation of the preferred variant (2015).

The presentation focusses on the project process, the possible forms of alternative spill gate management, the results of the

testing fase and the recommendations for the implementation phase.

Presenting Author Bio:
Wilco studied aquatic ecology and waterquality management at Wageningen University and Research Centra (graduated MSc). He is now consultant aquatic ecology and waterquality at ARCADIS for 6 years.

The FishMigrationRiver

First Author Name:
Roef Mulder

First Author Affiliation:
De Nieuwe Afsluitdijk

Abstract Body:
The FishMigrationRiver is an innovative fish passage designed to break the Afsluitdijk-barrier for fish migration. The Afsluitdijk is a barrier between the tidal Wadden(/North) Sea and inland waters since it was constructed in 1932. The barrier is almost identical to the Haringvliet and Ganzepoot, but the solution is completely different (see other abstracts).

The FishMigrationRiver is a large-scale tidal fish passage and is designed to facilitate all species 24h/day and 365 days/year. After years of preparation the project has entered the phase of realisation. I will present the ecologic constraints of the current situation and the relation with backland Lake IJsselmeer and the Rhine, present the main results of the research-phase (focus on fish-ecology) and explain the design and design-challenges. I hope to inspire the attendants to consider applying this concept to other (inter-)national barriers.

Presenting Author Bio:
Ecologist and ProjectManager in nature development

The 2 and 3D hydrodynamic functioning of a Fish Migration River through the “Afsluitdijk”

First Author Name:
Gijs van Banning

First Author Affiliation:
ARCADIS

Other Authors:
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3. Belinda Kater
4. Wilco de Bruijne

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Abstract Body:
The “Afsluitdijk” is an icon in the Netherlands. It is the 32 km long closure barrier, which separates the nature of the tidal Wadden Sea from the fresh IJssel lake. It was built for safety and economic developments between 1927 and 1932. Fish like salmon, eel and smelt, have great trouble in passing the remaining discharge gates near Den Oever and Kornwerderzand. The “FishMigrationRiver (FMR) Afsluitdijk” is a unique project near Kornwerderzand, allowing a variety of fish to reach their spawn, bread and living grounds. The FMR creates an intertidal zone, where fresh and saline water meet and fish might migrate, without jeopardizing the safety or increasing the salinity on the IJssel lake. Call it a barrier for water and salt, but open for fish almost continuously. An important step for the evaluation of the functioning of the FMR is the hydraulic operability. A series of hydrodynamic investigations was carried out to evaluate the various aspects of the FMR. They concern, the water exchange, the salinity, the velocities, the morphology and of course the behaviour of the fish. This presentation focus is on the hydraulic functioning of the FMR. Other presentations in this session focus on the ecological part of the FMR.

Presenting Author Bio:

Jos van der Baan is Junior Advisor of the Rivers Coasts and Seas section of the Water & Environment Division of ARCADIS in the Netherlands. He graduated two years ago from the Technical University of Delft. During his study he specialized in coastal dynamics and river engineering, graduating on coastal morphology. In the period of employment he worked on projects requiring the analysis of complex coastal environments of diverse nature. Challenges are often tackled with the use of various modelling software tools. The modelling tools are applied to simulate systems to study flow, wave and transport in open water, in 2 and 3D. Areas of interest are: coastal morphology, water refreshment, transport of cohesive and non-cohesive sediment, salinity and temperature.

Behaviour and abundance of diadromous fish at a large tidal barrier: in view of the Fish Migration River passage

First Author Name:
Erwin Winter

First Author Affiliation:
IMARES

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2. Ben Griffioen

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Abstract Body:
Closing-off the estuary Zuiderzee with a 32 km dam (Afsluitdijk) had severe consequences for fish migration between Wadden Sea and rivers IJssel/Rhine and Vecht. Plans are proposed to build a large fish passage (‘Fish Migration River’) next to the discharge sluices in the Afsluitdijk at Kornwerderzand. This passage of several km length is unique in also allowing incoming tide, thus facilitating fish using selective tidal transport. To come to an optimal design and placing of entrances that efficiently will attract diadromous fish, several studies were carried out in spring 2014 to study behaviour and abundance of migratory fish. The seaward side of the sluices were monitored with lift nets, mainly targeting flounder larvae, three-spined stickleback, smelt and glass eel. DIDSON observations were made to determine

vertical distribution of fish. An acoustic telemetry experiment (18 VEMCO receivers) was carried out to study searching behaviour and passage success of sea lamprey, houting and sea trout. Abundance estimates for the different species varied from several tens to hundreds of millions. The spatial dynamics of small fishes in time in the Kornwerderzand discharge basin were large. Numbers of small fish in the discharge basin were high, but the highest concentrations occurred at different locations in time.

Lower numbers of glass eels and sticklebacks after highwater than before upcoming tide are in accordance with Selective Tidal Transport, although smelt numbers were similar after high water, suggesting more active swimming behaviour. Telemetry data showed large dynamics and intensive searching of the whole discharge basin by the fish. Passage success of sea lamprey appeared to be limited to 12-25%. In addition, substantial delay of sea lamprey migration was indicated. Passage success of houting and sea trout appeared to be larger than 50%. In this, discharge events, tidal current, wind and active swimming all play a role.

Presenting Author Bio:

Erwin is a research ecologist at IMARES, Wageningen UR, in the Netherlands.

He has been working on mainly fish migration and behaviour of fish in both riverine and marine environments for twenty years now. Most of the studies concern the effects of human activities or anthropogenic structures, such as weirs, dams, hydropower or pumping stations and offshore wind farms on fish populations, often using telemetry or DIDSON techniques. He received his PhD from Wageningen University on a study on the effectiveness of a series of fishways in 2007.

Hydrodynamics within a fish migration river between saline and fresh water

First Author Name:

Theo van der Kaaij

First Author Affiliation:

Deltares

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Abstract Body:

The presentation addresses the preliminary design of a fish migration river between the saline Dutch Waddensea and the fresh water lake IJsselmeer. An important constraint is that there should be no leakage of saline water from the Waddensea to lake IJsselmeer since this lake serves a fresh water reservoir for the northern part of the Netherlands. However, the fish migration river should provide a sufficient lure stream, increased levels of fresh water odours, in the Waddensea allowing fish to find the entrance of the fish migration river. In addition, the tidal range within the fish migration river should preferably allow for the development of brackish inter tidal areas

In our study we used a 1-dimensional hydrodynamic model (SOBEK) in combination with a 3-dimensional hydrodynamic model (Delft3D-Flow) of the fish migration river. These models compute water levels, flow velocities and salinities within a schematized fish migration river. The 1-dimensional model, due to its limited computational time, served as a "quick-scan"

model allowing many iterations (scenario simulations). The 3-dimensional model, requiring much more computational effort, was only used for a small number of selected scenarios and mainly served to examine the salinity structure within the fish migration river.

The mean water level in the Waddensea is higher than the mean water level in lake IJsselmeer. Therefore, without additional measures, regardless of its length a fish migration river level will result in a leakage of salt. Hence, a valve temporarily closing the migration river during flood is necessary. Main finding of our study is that, applying a valve, the fish migration river will not leak salt and will provide sufficient lure stream.

Presenting Author Bio:

Mr. Van der Kaaij graduated in 1988 at Delft University of Technology in coastal engineering. After fulfilling his military service, he joined the Dutch Ministry of Public Works where he was involved in

numerical modelling of wind driven currents in shallow lakes. He joined WL | Delft Hydraulics in January 1990. Mr. Van der Kaaij is an expert on hydrodynamics, stratification, salinity intrusion and spreading of waste loads and cooling water. He is one of the early developers of the Delft3D modelling suite. His experience covers both the development of the modelling suite, the use of numerical models in practical applications as well as teaching how to apply these models in numerous countries.

SESSION A2: Free Migrations for Fish: Final seminar

**Entering Fort Knox, the tale of the brave.
The policy process and cooperation in
choices regarding fish passes in Wadden
Sea tributaries.**

First Author Name:
Jasper Schut

First Author Affiliation:
Regional Water Authority Noorderzijlvest

Abstract Body:

This presentation targets to give the audience an impression of the unique cooperation between different governmental organisations within the fish ecology policy cycle in a globally unique nature reserve, “the Wadden Sea”. In 2012 the project “Ruim Baan voor Vissen” (translation: Free Migrations for Fish) was started. A short overview of Dutch and European regulations and policies will be given. These policies are at the basis of the measures taken in the “Ruim Baan voor Vissen” project. The key-idea is the from Sea to Source approach, in which free migration from the sea to the headwaters of a river is aspired. The from Sea to Source approach also forms the basis in the different measures that are taken in the “Ruim Baan voor Vissen” project. One of the important topics in this project is aiming at mitigating migration obstacles like pumping stations and sluices in fish migration routes, between coastal (salt) waters and the fresh water habitats.

Because the before mentioned flood protection measures along the Dutch coast, the fresh water habitats are blocked for migratory fish, leading to severe ecological effects. At 14 different location in the Northern part of the Netherlands, measures were taken to mitigate the effects of infrastructure.

These measures were subsequently monitored for their effectiveness. This presentation gives a status update of the cooperation and preliminary results.

**Like shooting fish in a barrel: migratory
behaviour of fish at intertidal fish passes
in Dutch Wadden Sea**

First Author Name:
Jeroen Huisman

First Author Affiliation:
VHL Applied Sciences University/
Wageningen University

Abstract Body:

The Wadden Sea is a large intertidal area in the Northwest of Europe and is listed on the UNESCO’s World Heritage List (UNESCO 2009). The tributaries and estuaries in the Dutch part of the Wadden Sea are relatively small and as such have suffered extensive habitat loss and habitat degradation due to empoldering and measures ensuring flood protection e.g. pumping stations, weirs and sluices.

The Wadden Sea and its intertidal barriers offer a unique opportunity to investigate migratory behaviour of fish and fish pass functioning with regards to diadromous fish. To facilitate fish migration intertidal fish passes in the Wadden Sea are often designed to temporarily let water in and/or out from tributaries. Combining the temporal aspects of aforementioned fish passes with the temporal spatial behavioural patterns of fish migration is a challenge. How to combine fish pass functioning with the needs of present fish species and different life stages?

The intertidal pumping stations Duurswold, de Drie Delfzijlen en de Helsdeur are researched using telemetry. We have used acoustic telemetry (*Anguilla anguilla*) in order to investigate behaviour and route choice of seaward migrating silver eels. Analyses of data will provide insight in for example delay and route choice. In addition, a number of migrating silver eels have been detected along the Dutch-Belgian coast which raises the question which routes are favoured by silver eels on their way to the Sargassosea and why.

At the pumping station “De Helsdeur” we have PIT-tagged a number of three spined sticklebacks to investigate fish pass functioning in relation to intertidal migratory behaviour and interspecies variation of three spined sticklebacks (*Gasterosteus acculatus*). Results show that sticklebacks mainly migrate during daylight and at upcoming tides.

Presenting Author Bio:

Jeroen Huisman is a researcher-lecturer at the VHL Applied Sciences University in Leeuwarden and Wageningen University. He is working on researching migratory behaviour of migratory fish in relation to performance of intertidal fish passes in the Wadden Sea region. He has been working on fish ecology, fish passes, policy and management issues for more than ten years. Studying fish ecology in the Wadden Sea region is particular interesting.

From banging your head into a tidal barrier to migration further upstream. Migration doesn't stop at the coastline

First Author Name:
Peter Paul Schollema

First Author Affiliation:
Regional Water Authority Hunze en Aa's

Abstract Body:

For many decades the abundance of small diadromous fish has been monitored in the Waddensea region by IMARES on a small selection of locations. In 2001 Rijkswaterstaat Noord Nederland initiated a 3 year study at 23 locations to get a better spatial understanding of the abundance of diadromous fish at the different tidal barriers. This study was carried out by RIKZ and Wintermans Ecologenbureau in close cooperation with several Regional Water Authorities, professional fishermen, sport fishermen and many other volunteers. As part of the "Ruim Baan voor Vissen" project this study was repeated from 2012-2014 in order to determine if there were any long term developments notable in the numbers of diadromous fish. During the presentation the results of this study will be shown.

Showing up at a tidal barrier and getting past it is one thing...but how do the fish succeed migrating further inland to their spawning grounds? The last few years several studies have been carried out (or are still running) to answer this question. Examples like the migration of River Lamprey to the River Drentsche Aa (VEMCO) or smaller diadromous species (PIT) in River Westerwoldsche Aa will be presented. These results will be combined with more technical information about barriers on the route and the chosen technical fish pass solutions.

Fish migration facilities on the salt-fresh water border of the Wadden Sea

First Author Name:
George Wintermans

First Author Affiliation:
WEB

Abstract Body:

From the mid 1980's onwards salt-fresh water transition area's received increasing interest from water management organizations and researchers. In this development salt-fresh water nature values and migratory fishes especially, became goals or targets in water management plans. As for fishes these plans were based on a catchment basis approach in which the salt-fresh water transition areas were both the entrance and exit of the catchment basin. The first fish migration facilities in the transition area were constructed along the coast of the Wadden Sea and gradually spread out along the Dutch coast.

In this presentation an overview is given of the various fish migration facilities developed, realized and planned along the coast of the Wadden Sea; from a more or less copied natural situation (fish ladder) to a (complicated) civil engineered construction. The underlying knowledge available at the time of development and the major considerations, pros and cons of the different types will be addressed. Based on the experience and knowledge acquired over the years the outlines of future salt-fresh water migration facilities is given.

Design of Tide Gates for Fish Passage and Estuary Enhancement

First Author Name:
Michael Love

First Author Affiliation:
Michael Love & Associates

Abstract Body:

Tide gates are frequently placed at confluences of streams with tidal waters. These gates prevent tidal waters from inundating low-lying lands while allowing stream flows to drain during lower tidal stages. Traditional tide gates effectively preclude an estuarine environment

upstream of the gate and often block native fish from entering these tributary streams. In recent years, a new generation of tide gates has been installed with the intent of improving fish passage and allowing a limited amount of tidal inflow into the stream to create a longitudinal transition from the marine to freshwater environment.

This new generation of tide gate uses side-hinged doors that open wider to permit efficient outflow and produce slower water velocities to accommodate fish passage. These gates also allow a limited amount of tidal water to flow upstream. Inflow of tidal water is regulated to mute the peak tidal stage and preventing upstream tidal flooding. The muted tide is regulated by either:

- 1.a small adjustable opening that functions as an orifice and sized to prevent excessive tidal inflow, or
- 2.a mechanical float system that holds the gate open until the upstream stage reaches a predetermined threshold.

Design of these muted tidal systems involves extensive hydraulic analysis to evaluate fish passage, prevent upstream tidal flooding, and create the desired estuarine conditions, including vegetation zonation. This presentation will illustrate the types of analysis and considerations employed with this new generation of tide gates. Two recently constructed tide gate replacements designed for passage of all life stages of Pacific anadromous salmonids will be used as case examples to highlight the design process.

Presenting Author Bio:

Michael Love graduated from California's Humboldt State University in Environmental Resources Engineering in 1996. He started his career conducting fish passage field research and developing the FishXing software. Since then, Michael has designed numerous technical and nature-like fishways, as well as stream, wetland, and estuary enhancement projects. When not working, he enjoys spending his summer gunkholing along the Pacific Northwest coast in his sailboat, Pangaea.

Optimisation of adjusted barrier management to improve glass eel migration at estuarine barriers

First Author Name:

Ans Mouton

First Author Affiliation:

Research Institute for Nature and Forest

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Abstract Body:

Estuarine barriers may significantly reduce the upstream migration of diadromous fish species like the European eel (*Anguilla anguilla* L.). Previous research showed that limited barrier opening during tidal rise was a cost-efficient and effective mitigation option to improve upstream glass eel migration, without significant intrusion of sea water. We optimised this adjusted barrier management to improve eel passage at a three different tidal barriers in Flanders, Belgium, blocking the most important migration routes for glass eel in Flanders. Specifically, three hypotheses were tested. The first hypothesis analysed the impact of the number of barriers opened on the upstream glass eel migration. The second hypothesis evaluated the relation between the size of the barrier opening and glass eel migration.

Finally, we tested whether the suggested adjusted barrier management may lead to a significant increase in conductivity. Increased opening of one barrier appeared more efficient than opening several barriers slightly. Conductivity increased during periods of extreme drought and at base flow, but decreased within 24h after the first peak flow. This indicates that adjusted barrier management does not entail salt intrusion, as long as this management is not applied in extremely dry periods. Since the adjusted barrier management is easily implemented and could be applied on numerous tidal barriers, the presented results may contribute to restoration of eel populations

worldwide and be of interest to a wide range of river managers and stakeholders.

Presenting Author Bio:

Ans Mouton obtained his degree in Environmental Engineering at Ghent University in 2004. Between October 2004 and October 2008, he was a PhD student at the Department of Applied Ecology and Environmental Biology of the Faculty of Bioscience Engineering of Ghent University under the supervision of Prof. dr. ir. Peter Goethals. His research was supported by Prof. dr.

Bernard De Baets of the Department of Applied Mathematics, Biometry and Process Control of the Faculty of Bioscience Engineering.

As a BOF grant holder he developed species distribution models for fish and invertebrates in rivers. He taught various courses and practical exercises, while he also tutored several Master theses. Ans Mouton presented his work on several international conferences during platform and poster presentations.

In 2006 he was awarded the Best Student Paper and Presentation Award on the iEMSs Biennial Congress (Burlington, USA). He is the author of several peer-reviewed publications in international journals and cooperated with research institutes and universities worldwide.

Since October 2008, Ans Mouton works at the Research Institute for Nature and Forest (INBO) as research scientist Management Aquatic Species and Ecosystems. He was the project leader of different Flemish research projects and participates in several European research projects, such as the COST 626 European Aquatic Modelling Network programme and the Interreg IVB programme 'Living North Sea'.

SESSION B2: Environmentally-enhanced turbines and turbine passage survival (I)

Improvement of Computational Tools for Biological Performance Assessment of Hydroelectric Turbines

First Author Name:
Marshall Richmond

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Pacific Northwest National Laboratory

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Abstract Body:

The technical evaluation of fish passage conditions is becoming an integral part of projects to install new or replace existing hydroelectric turbine units. In the design phase, these evaluations depend on laboratory and computational modeling techniques that simulate prototype conditions. For instance, laboratory experiments with beads have yielded observational data on collision occurrence and frequency in turbine physical models. On the computational model side, simulations have been used to assess hydraulic conditions hazardous to fish passage such as rapid decompression, extreme shear flow, and likelihood of collision on turbine runner blades. The present work expands on the previous modeling studies of biological performance assessment at projects in the Columbia River Basin, in the U.S.

Pacific Northwest. The preceding studies have laid the groundwork for the use of computational fluid dynamics (CFD) in biological assessment of turbine passage. This presentation describes continued work by Pacific Northwest National Laboratory (funded by US Department of Energy) to improve its biological performance

assessment (BioPA) software and to test the model against field observations. Specifically, two model enhancements will be discussed: (1) the generation of multiple passage pathways through the turbine to account for turbulent dispersion in BioPA, and (2) the implementation of overset (moving) mesh simulations to better account for the actual motion of fish and autonomous sensor devices. We incorporated these recent developments into the BioPA for an existing Kaplan turbine unit installed at the Ice Harbor Dam on the Snake River. Autonomous sensor devices were used in past field studies to evaluate the hydraulic conditions when the unit operated at three discharges. We calculate and compare statistics from both the field data and BioPA modeling results to assess the accuracy of the simulation model and its assumptions. Specifically, we compare signatures of absolute pressure and probability of collision with the runner blades.

Presenting Author Bio:

Dr. Richmond is a Chief Engineer in the Hydrology Group. His professional experience includes basic and applied research, university teaching, and project management. His principal areas of expertise are in the development and application of computational models of hydrodynamics, sediment transport, and contaminant transport in environmental systems, computational fluid dynamics (CFD), physical modeling of hydraulic structures, fisheries engineering, and turbulence modeling in CFD. Dr. Richmond is the developer of the MASS1 (Modular Aquatic Simulation System) one-dimensional and MASS2 two-dimensional hydrodynamics and water quality computer models. He is the co-developer of an individual model for fish called FINS (Fish Individual-based Numerical Simulator). He is currently leading the development of a three-dimensional CFD model for engineered and environmental systems.

Certification of 'fish-friendliness': looking through a glass darkly

First Author Name:
Maarten Bruijs

First Author Affiliation:
DNV GL

Abstract Body:

The past years, improvement of fish survival at hydropower dams has shifted from development of fish guidance systems towards the development of 'fish-friendly' turbines. A variety of technical features of turbines is altered in order to reduce mortality of fish passing the turbine. Data on mortality rates at traditional, currently applied turbine types, shows a great variation for fish species and life stages. 'Improvements' applied in novel turbine types must thus be tested thoroughly, both in small-scale (laboratory) flume test as well as under real-time field condition, before any conclusion can be drawn for long term application.

The current question is, how to test the fish-friendliness of a turbine, such that water authorities, regulators, permitting authorities, etc, will accept a 'minimum' (?) of fish mortality. A variety of new turbine types as well as turbine test facilities are under development. Any statement on improvement of fish survival requires certification on this matter. For this, there is a strong need of a protocol to test the 'fish friendliness' independently. As it will take many years before new turbine types have long-term data on fish mortality, test protocols must be designed to provide the best possible representativeness.

Presenting Author Bio:

Mr Maarten Bruijs holds a M.Sc. in aquatic ecology from the Radboud University of Nijmegen in the Netherlands (aquatic ecology: eco-physiology and ecotoxicology). Maarten is sr. consultant and has worked for DNV GL product group 'Process & Cooling Water' since 2000. In general, Mr Bruijs' duties as a consultant cover 'power plants and the effects on aquatic environment' and vice versa. His main topics concern the effects of cooling water systems and hydropower facilities on the aquatic environment, i.e. fish ingress and biofouling problems.

Mr Bruijs is responsible for consultancy and research projects on the effects of fish passage at hydroelectric power plants activities and the effects by impingement and entrainment on fish populations as a result of thermal power plants. Additionally,

he is involved in R&D and test / feasibility studies of fish deterrent systems at water inlets of hydroelectric and thermal power plants. He also provides assistance with translating the ecological and regulatory aspects in the design of cooling water intakes of newly planned power plants. The topic of fish mortality and ecological effects due to passage of hydropower stations and ingress in cooling water systems is often under discussion in the Netherlands. In his function as independent expert, DNV GL is asked for advice by the different parties involved. By seeking this advice, both governments and the E-sector can take well-founded decisions with respect to their interests and requirements as a result of objective explanation of the problems, specific research into solutions and possibilities provided. His main work area in this field is the Netherlands, but also other European countries and the USA. Also, in his function, he is regularly asked to take part in (inter)national independent expert groups to provide guidance in projects. Furthermore he is involved with EIA studies for new power plant facilities.

He is involved in assessments of fouling communities on submerged industrial structures and equipment, and its impact on the daily operation of the installation, ranging of marine off shore wind turbines to coastal sea cooling water intake system. He is also involved in research project investigating mitigation options to prevent fouling, ranging from chemical fouling control to surface treatment technologies, such as coatings. For this topic he deals with the optimisation of water treatment (Pulse-Chlorination®) in order to have control over the macrofouling, and is involved in (inter)national projects. M Bruijs is patent holder of the Sparker technology as a method for fish deflection to avoid excessive impingement of fish in cooling water intakes (patent number 1034953). Mr Bruijs has very good editorial skills and is (co-)author of scientific publications, lectures and book chapters.

A quantitative, traits-based approach for choosing and prioritizing study species for evaluating the impacts of turbine passage

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Brenda M. Pracheil

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Abstract Body:
The choice of study species when conducting environmental assessments of hydropower facilities is of great importance from a licensing and policy perspective. Power analyses are commonly used to provide quantitative backing for the numbers of study organisms and trials used, but there is not frequent use of quantitative methods for choosing appropriate study species. Species choice can be especially important when measuring the impacts of ecosystem alteration, such as in a hydropower system, when study species must be chosen that are both sensitive to the alteration and of sufficient abundance for study. In this study, we step through two examples using a combination of GIS, a fish traits database, and multivariate statistical analyses to present a quantitative, traits-based approach for designating study species. In our first example, we present a case study where we select broadly-representative fish species for understanding the effects of turbine passage on fishes based on traits that suggest sensitivity to turbine passage. In our second example, we build off of our first example and present a framework for selecting a surrogate species for an endangered species. We suggest that our traits-based framework can provide quantitative backing and added justification to selection of study species while also delineating the expanded inference space of study results.

Presenting Author Bio:

Dr. Brenda Pracheil is a Research and Development Staff Associate at Oak Ridge National Laboratory and an Associate Editor of the North American Journal of Fisheries Management. She received B.S. and B.A. degrees in Biological Sciences and Philosophy and a Ph.D. in Natural Resources from University of Nebraska-Lincoln, a M.S. in Zoology from Michigan State University, and conducted postdoctoral studies at University of Wisconsin-Madison.

Investigations into fish friendliness of ultra low head tidal and river turbines

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Abstract Body:
The recent guideline regarding fish friendliness, issued by the Dutch government stating a mortality rate of max. 0,1 % per passage, demands innovative turbine solutions. The search for the fish friendly turbine, as outlined in the presentation, covers:

Status: Fish friendliness of low head power station Linne (river Meuse) In the quest for fish friendly turbine alternatives for power station Linne, the fish friendliness of the current turbines is analysed using the model developed at Eindhoven University, coupled to detailed Computational Fluid Dynamics (CFD). With incorporation of the power plant control algorithms, fish mortality is predicted over the entire operating window, with the hydrographical data providing an annual mortality rate. Barotrauma and Shear have not been found threatening mechanisms. Blade strike is identified as the most dangerous mechanism, the model quantifies 12,7 % mortality rate for Eel length 65 cm.

In addition, the effect of improvement of fish friendliness on revenues and costs is made.

Model test and testing of innovative turbines
During May and June 2015 fish friendliness tests will take place with life fish, to demonstrate fish friendliness of two innovative, scale model tidal turbines. The results will also serve further validation of the model, that will be used to predict fish friendliness of full scale (up to 8 meter diameter) low head turbines. The test set-up is designed in accordance with a general testing protocol (that will be outlined in the presentation). The set-up itself comprised an open, pump activated loop, ultra low head (1 meter @ 1 m³/s) configuration, situated at the river bank of de NederRhine at Nuon/Vattenfall's hydropower station Maurik. In the presentation the test-rig design, general testing protocol and results will be outlined.

Towards full scale fish friendly tidal and river turbines
The validated model and life-fish test results are used to predict the fish friendliness of full scale turbines. The work which is ongoing (but will be finished and presented in June), indicates a mortality rate < 0,5 % for an 8 m diameter propeller turbine, which still exceeds the new Dutch Standard, but however is a major improvement. In future, the model will be used to further optimise (reduce) fish mortality of ultra low head tidal and river turbines.

Research supported by Essent Power, RWS and the EU Interreg project Pro-Tide.

VisAdvies protocol for testing and evaluating pumping station pumps on fish survivability

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4. VisAdvies BV

Abstract Body:

In the context of fish welfare, pump manufacturers focus on the development of fish friendly pumps. The assessment of fish survivability in a field situation turns out to be difficult. Lack of migration (eels), presence of fish or insufficient species composition with a narrow range in length class at the moment of the research leads to unreliable conclusions. Therefore a guideline is developed, based on forced exposure of fish, to test and evaluate fish friendly pumps with a standardized method: "VisAdvies protocol for testing and evaluating pumping station pumps on fish survivability". The protocol serves two purposes. First, the guideline gives direction to the way the test should be performed.

It advises in the fish species the numbers and size classes and the zero-groups (untreated fish) that should be used. It describes how damage and mortality should be categorized in different groups. Part of the test is the assessment of delayed mortality that may take place a few days after the actual test.

In the second place is the guideline concerned with the evaluation of the results. The final outcome gives the score, based on the survivability rate of all species. A separate test should be carried out for all combinations of pump speed (rpm), discharge (m³/min), and head (m) that are of interest.

The protocol will be illustrated by means of a test in a dry dock in the Netherlands, on a pump of the Bedford company. The pump was especially designed to be fish friendly.

Presenting Author Bio:

Hendry Vis works in the Netherlands at VisAdvies for seven years as a project leader. He is specialized in telemetry projects. With PIT telemetry he studies fish migration and the efficiency of fish passages.

An Overview of the Ice Harbor Turbine Replacement Project

First Author Name:
Martin Ahmann

First Author Affiliation:

U.S Army Corps of Engineers

Other Authors:

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3. Bob Davidson
4. Jason, M. Foust

Other Authors Affiliations:

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4. Voith Hydro, Inc.

Abstract Body:

In March of 2010 the US Army Corps of Engineers' (USACE) awarded a contract to Voith Hydro to design and supply new turbine runners for installation at the Ice Harbor Lock and Dam located on the Lower Snake River within the State of Washington, USA. The contract included design and supply of both a fixed and an adjustable blade turbine runner for replacement of two failing units within the six unit powerhouse. The new turbine runners were to be designed for "safer" fish passage as a primary goal, and increased efficiency as a secondary goal. The hydraulic design of both runner types was a collaborative effort by the USACE's Walla Walla District (NWW), Engineer Research and Development Center (ERDC), Hydroelectric Design Center (HDC), National Marine Fisheries Service (NMFS) and Voith Hydro. The design criteria and the design evaluation process were developed by the USACE over years of both field and laboratory research through the Turbine Survival Program. The two runner types were designed through an iterative process of Computational Fluid Dynamic Model analysis, performance model testing for power, efficiency and cavitation, and physical hydraulic model testing for evaluation of the turbine passage environment. This presentation provides a broad overview of the research, design criteria and guidelines, the design and evaluation process, and future biological field testing efforts supporting the Ice Harbor turbine runner replacement project.

Presenting Author Bio:

Mr. Ahmann is a Senior Hydraulic Engineer for the US Army Corps of Engineers' Walla-Walla District. He is a registered professional engineer and has been

involved with the hydraulic design of fish passage improvements at the USACE hydropower projects for 18 years. Martin is the senior technical lead for the USACE Turbine Survival Program, which was established to improve turbine operations and design for safer fish passage throughout the Federal Columbia River Hydropower System (FCRPS). He is also the Walla Walla District's lead hydraulic engineer for the Ice Harbor turbine design and replacement project.

SESSION C2:

Policy: does passing laws promote passing fish?

EU Water Framework Directive

First Author Name:
Lourdes Alvarellós

First Author Affiliation:
European Commission

Abstract Body:

DG Environment (EU Commission) will address the importance the EU environmental legislation to ensure protection and restoration of aquatic ecosystems, but also the need for improving the implementation of existing legislation. The focus will be the Water Framework Directive (WFD), but other relevant EU environmental legislation will be briefly presented (in particular nature legislation). The general objective of the WFD is good ecological status by 2015, as well as avoiding any further deterioration in the status of water bodies. The WFD classification scheme for determining the ecological status is based on biological quality elements, of which the fish populations is the element most affected by the hydromorphological alterations (longitudinal obstacles).

The hydromorphological elements are also an important part for determining the status of water bodies, especially when these are affected by physical modifications. The WFD requires the achievement of good status even in water bodies affected by existing or new infrastructure, unless some strict conditions are met. In these cases, for which there are justified reasons not to attain good status, the objective is achieving good ecological potential, which is an ambitious objective as well and a strong driver for river restoration, which requires to improve the flow regime and fish migration.

The Commission has assessed how these obligations have been reflected in the first RBMPs and has identified areas for improvement. Those relevant for fish migration and river restoration will be presented, including some good practises and some common challenges to be address in different Member States.

On March 2015, the Commission will publish a Communication on the progress with the Programmes of Measures, with specific recommendations per Member State. A summary of relevant issues will also be presented. Finally, the 3rd Water Conference will be held in March 2015 and any relevant feedback will as well be raised.

Translating Regulation into Outcome

First Author Name:
Andy Don

First Author Affiliation:
Environment Agency (England)

Abstract Body:

The Environment Agency (EA), a non-departmental public body charged with environmental protection and regulation in England, implemented strategy and process to deliver tangible improvements to eel passage and screening across a range of impacting Sectors and individuals.

The Eels (England and Wales) Regulations 2009 came into force on 15 January 2010 to support the UK in implementing EC Council Regulation (1100/2007). Under this European Regulation, the UK must take actions to halt and reverse the decline in the European eel stock, aiming to meet a target set for the number of mature adult eels leaving each river basin to return to spawn at sea. The EC Eel Regulation requires UK to consider eel passage as part of the solution.

The EA has adopted a risk-based approach in implementing the Regulations. For legacy structures including obstructions and abstractions, a desktop prioritization process was undergone. This utilized standard metrics that could be consistently applied to a range of locations and scenarios. This ranked the circa 26,000 obstructions and 21,000 abstractions into High, Medium and Low categories, final Quality Assurance being applied by operational staff locally. These categories related to the risk to eel and therefore to the timeline for implementing site improvements. No improvement measures were sought for sites in those parts of river catchments that had a low likelihood of ever being naturally colonised by eel.

Sites were aggregated by purpose into broad Sectors. National fisheries staff were able to provide technical support to this process drawn from published EA guidance documents that included Best Practice solutions.

A Cost Benefit Analysis tool was utilized to apply consistency, proportionality and rigour to the Sectors and individuals. When key CBA thresholds were not reached, an 'Alternative Measures' process was used to allow benefits for eel to still be realized.

The number and variety of site improvements is discussed.

How migrating fish survives between law, politics, and permits for hydropower

First Author Name:

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Abstract Body:

Although hydropower is a small energy source in the Netherlands, it is often discussed in the media, among stakeholders, and in politics. On the one hand, the Dutch government promotes the development of sustainable energy. On the other hand, these projects can cause damage to migratory fish. Since the Dutch large rivers are crucial as main ports for many migratory fish species, the water manager (Rijkswaterstaat) has developed an official policy rule for a transparent decision-making on hydropower issues. The rule provides a specific framework for decision makers when assessing projects for hydropower stations. It aims to allow for new initiatives while at the same time it enables the reaching of fish-protection

targets set under three important policies for protection of migrating fish (Regulation for Eel, Benelux Decision, and the WFD). Stakeholders from both fishing organizations and hydropower companies have been consulted in the drafting of the framework. The framework consists of a description of available techniques and criteria for fish damage, including an explanation on how and where they are applied. The damage on two vulnerable species (Eel and Salmon) needs to be tested during downstream migration. If the damage on these species meets the criteria set in the policy rule, the level of protection at the plant is considered to be sufficient for the protection of the whole fish community. In two large river stretches which are suitable for hydropower, cumulative fish damage caused by hydropower needs to be lower than 10% for both eel and salmon. If the present damage in the river stretch is already higher than 10%, new hydropower stations are only allowed when fish damage is lower than <0,1% per location. In other water bodies important for fish migration, damage must be always lower than 0,1% per water body.

The Swiss way to re-establish free fish migration

First Author Name:

Martin Huber Gysi

First Author Affiliation:

Bundesamt für Umwelt BAFU

Abstract Body:

The Swiss way to re-establish free fish migration

As a counter-project to a people initiative by fisheries- and non-governmental-organizations several modifications of the water protection act (and associated legislation) were enacted in Switzerland in 2011. The main topics of this revision were "space provided for waters", structural restoration and the refurbishment of hydropower (including fish migration). Therefore the Cantonal authorities were obligated to do a "strategic planning" until 2014 and the necessary funding mechanisms were established. The operators of hydropower plants are fully compensated for the necessary measurements by a consumer-paid fund which is raised by 0.1 Rp./kWh. Until the

end of the time-limit (2030) totally 1 Billion SFr. will be invested in the refurbishment of hydropower in Switzerland.

During the planning-phase the Cantons identified approximately 1000 hydropower based obstacles to need remediation (Upstream as well as downstream migration resp. fish protection). The strategic restoration plans and the (financial)-requests of the operators have to be authorized by the national regulating office, which is presenting an overview of the new legislation, the major findings of the strategic planning and some first examples of measurement taken.

Converting Government policy into practice by restoring the Connectivity of English Rivers for the Free Passage of Fish

First Author Name:
Jim Gregory

First Author Affiliation:
Environment Agency

Other Authors:
Emma Washburn

Abstract Body:

River obstructions are major obstacles to connectivity and have been responsible for the decline of many diadromous fish populations. In the past fish passage solutions were built opportunistically. However with the introduction of various European Directives and recognition of a need to be more strategic in planning solutions the Environment Agency has developed an approach that ensured resources, knowledge and technical capacity were operationally aligned and optimised to get the greatest ecological benefit from re-connecting river systems for the free passage of fish.

This paper will show how we have prioritised obstructions using a digital representation of the river system based on a high resolution river centreline network. Potential obstructions to fish on the network were identified from features previously mapped by Ordnance Survey, Britain's national mapping agency. We were able to precisely map the locations of nearly 26,000 weirs, dams, barrages, waterfalls, sluices and other obstructions. Network analysis

techniques enabled us to gather metrics on tidal distance distance upstream to key features and head drop using LIDAR data. The data has been used directly in fish population models and to help focus resources to resolve fish and eel passage issues through prioritisation initiatives. We have also developed crowd sourcing initiatives to map and gather data on existing and newly discovered obstructions through a smart phone App, with our partners in the Scottish Environmental Protection Agency. We show how we have 1) embedded an objective focussed and prioritised approach to achieve legislative commitments, 2) centralised the service to help with delivery and improved contractor and project management capability (and capacity) through the production of a Fish Pass manual and 3) developed and improved fish pass technical knowledge and resilience to get better value for money.

Presenting Author Bio:

Jim's 20 year career in fisheries began using acoustic and radio telemetry to monitor fish movement in impounded rivers. An early adopter and champion of split-beam acoustics and imaging sonar for fisheries monitoring, he has developed monitoring tools and techniques for fish passes and has a long association with technology based fish monitoring methods.

Awarded the Winston Churchill Medal from HM Queen for international work on fish monitoring, he is a former Editor of FISH magazine and Vice chair and Fellow of the Institute of Fisheries Management. Jim now manages a team of technical specialists and is responsible, among other things, for providing a fish passage advisory service for the Environment Agency and their delivery partners.

Eel Recovery - it is not just about fishing

First Author Name:
Andrew Kerr

First Author Affiliation:
The Sustainable Eel Group

Other Authors: D. Buysse*, A. M. Mouton, M. Stevens, T. Van den Neucker and J. Coeck.

Abstract Body:

The background to this topic is the most recent report on implementation of the eel management plans from the European Commission to the Parliament 24th October 2014. Whilst there are several messages particularly on the difficulties of stock measurement and incomplete reporting the most powerful in order to achieve and maintain the recovery are on the importance of unblocking the migration pathways both in and out. Here are just three key statements from the report.

“Progress was made in implementing management measure related to fisheries but that other management measures, such as improving habitats, combating parasites or predator control have often been postponed or only partially implemented.”

“More attention should be given to management measures related to these non-fishing anthropogenic mortality factors, the majority of which has only partially been implemented by Member States.”

“Non-fishing anthropogenic mortality factors include hydropower and pumping stations, habitat loss or degradation, pollution, diseases and parasites.”

The paper presented would concentrate on the positive and seek to find and then tell the story of where migration pathways have been addressed and provide evidence of the difference these are making. Some evidence has already been collected for the last SEG Newsletter attached.

Entry Examples will be drawn from: (1) the Mediterranean on the Camargue (2) The Bay of Biscay the Arzal Dan on the Vilaine (3) The UK West and East Coasts.

Exit Examples will be drawn from Sweden. Willem Dekker's Paper (am requesting) it says that mortalities in Sweden from Hydro are greater than fishing Mortality of European eel after downstream migration through two types of pumping stations D. Buysse*, A. M. Mouton, M. Stevens, T. Van den Neucker and J. Coeck.

Article first published online: 27 AUG 2013. DOI: 10.1111/fme.12046. © 2013 John Wiley & Sons Ltd

An example from a country which has now brought legislation into force will be England and Wales. The Statutory Instrument of 2009 comes into effect in stages – one of

which is to compel owner of obstructions which are of high risk to screen them from January 2015. OFWAT the regulator for the Water Industry has just agreed an expenditure of £70m over the next five years to support this work.

The presentation would conclude that restocking and translocation can help as an emergency measure but that the only lasting and therefore truly sustainable solution is through opening the Migration pathways.

Presenting Author Bio:

Andrew founded the Sustainable Eel Group (SEG) following his Chairmanship of Gloucestershire Wildlife Trust and Chairman of the South West Wildlife Trust. He lives near the River Severn and was concerned that no organisation was trying to save the endangered eel, a fish with a strong local tradition and culture. Andrew's background is deep in the field of management consultancy - human resources and strategy development. He was formerly a cavalry officer in the British Army.

SESSION D2: Holistic case-study

Reconnecting the Rivers

First Author Name:

Dr Stephen Marsh-Smith

First Author Affiliation:

Executive Director Wye and Usk Foundation

Abstract Body:

The Wye and Usk Foundation (WUF) is a registered charity set up to restore the fisheries and ecology of the Wye and Usk which flow from mid Wales to the Severn estuary. Both rivers and the Severn estuary are EU designated Special Areas of Conservation and the designation includes Atlantic salmon, Twaite shad, sea and river lamprey. Both have substantial runs of European eel.

The two rivers have suffered significant declines of migratory fish, especially Atlantic salmon (Wye) shad (Usk) and eel (both). The presentation describes the 18 year effort to re-establish fish access and the problems involved: apathy, historical poor understanding of fish biology, conflicting interests (historic weirs and ancient bridges) and differing overall strategy. By 1995, < 50% of the Wye's salmonid habitat was inaccessible, including the Wye's biggest tributaries, Lugg and Monnow. Nonetheless the WUF and partners, the Environment Agency have completed over 81 fish passes or easements, 24 weir and 120 other barrier removals, re-establishing access to over 834km of previously inaccessible stream. Funders include EU fisheries fund, ERDF, Defra and private funding.

Monitoring has been by electrofishing, redd counting, counters and egg surveys (shad) and an in-depth study of the recolonisation by salmon has been made on the river Arrow a stream of some 35km. This tributary flows from Wales to England and has had over 14 pass or easements fitted. Electrofishing fishing and redd counting has plotted the extent of recolonisation by salmon.

As a subsidiary benefit, monitoring has shown a substantial rise in the number of adult trout found upstream of the former barriers.

The proposed presentation will demonstrate the historic loss of habitat (mapping) the methods deployed to correct, monitoring results in a highly photographic PowerPoint. It was previous shown to a wide audience on World fish Migration Day, May 2014

Presenting Author Bio:

Dr Stephen Marsh-Smith OBE Biog. Following a successful career in dental surgery, both in practice and teaching at university (Bristol), SM-S became founder, chairman and later chief executive of the Wye and Usk Foundation which was formed in response to declining salmon numbers, the organisation has developed into one of the UKs largest charitable river and fisheries trusts now with a staff of 26. The focus has been the delivery of sustainable restoration of salmon but has extended into wider catchment management and ecosystem service repair. This ranged from (2000) commercial net buy outs in the Severn estuary, 1000km of riparian habitat restoration to the largest ever successful acid waters project in the UK. In 2011, he was honored with an OBE for Services to the Environment. He lives in Powys, Wales with artist wife Seren on the banks of the Wye.

River restoration in an urban context. Denmark's largest nature restoration in the city of Copenhagen.

First Author Name:

Peter Bønløkke Adamsen

First Author Affiliation:

Ramboll Denmark

Abstract Body:

When doing river restoration within and in connection with major urban areas, experience shows that it is important to think holistically to get the best solutions. Furthermore, a close cooperation between different municipal departments (8 different in Copenhagen) and the consultant will result in innovative solutions not previously identified.

Background: Copenhagen has a vision to transform the stream Harrestrup from a former sewage channel to a combination of nature and recreational park through the

existing parks with the aim to increase quality of life and value for the city. The top priority is to meet the water plans and above all to create a good water environment in good ecological status according to the EU Water Framework Directive. This will contribute to the fact that the stream Harrestrup with the surrounding areas can have a greater biological diversity than is the case today. Next comes the recreation needs to open up the best possible access to and varied use of the blue/green areas. Climate adaptation is the third priority while ensuring that the river and the green areas can be used as drainage for the city during extreme rainfall.

For the Municipality of Copenhagen Ramboll has designed a master plan for the restoration of the stream Harrestrup. The presentation will focus on the ecological and climatic aspects of the master plan, and hopefully inspire participants to think holistically, when working with nature projects in or related to urban settlements.

River connectivity for fish – a multi-scale, multi-purpose approach

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Abstract Body:
Fragmentation of lotic river stretches by the presence of artificial barriers leads to loss of longitudinal connectivity and promotes species isolation, being deleterious of free

movements of fish within a given river network. This movement impairment detracts fish species from completing their life cycle and potentiates genetic impoverishment and disappearance of populations. The present work presents techniques to define the problem by quantitatively determining the connectivity of a river network and identifying intervention priorities, but also helps to enhance connectivity by determining best-practices to increase fish negotiation of fishways. This work was carried out at multiple scales and has multiple purposes being a holistic approach to longitudinal connectivity problems in river networks. It progresses scientific knowledge and moves a step forward in terms of river network studies, improving both problem definition and solution definition.

Coimbra Fishway: Restoring connectivity in River Mondego

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Abstract Body:

River Mondego is the largest Portuguese river with its basin entirely within national territory. The Açude-Ponte dam was built in Mondego in the 80's, along with three other large dams to mitigate floods and to allow the integrated use of river basin water resources for hydroelectric power generation, public supply, industry and irrigation.

Considering the river importance for several fish species, namely sea-lamprey and shad, a fishway was constructed. Several structural and hydraulic problems soon revealed that this fishway was inefficient therefore this dam became the first impassable obstacle in the River Mondego. In 2011, after several years of biological and hydraulic monitoring, and once the reasons for the fishway inefficiency were perfectly identified, a vertical-slot fishway was built to restore river connectivity.

The efficiency and effectiveness of the Coimbra Fishway has been studied since 2012 using several monitoring techniques (visual counts, biotelemetry techniques and CPUE abundance with electrofishing).

Monitoring results show that several autochthonous species use the fishway, including the diadromous sea-lamprey, allis and twaite shad and European-eel. More than 1,500.000 fish have used the fishway during the upstream or downstream migration. PIT telemetry has shown an efficiency of 30% for *Petromyzon marinus* and 14% for *Luciobarbus bocagei*. Pre and post fishway construction electrofishing monitoring shows improvements in sea-lamprey larvae abundance both upstream and downstream from the Açude-Ponte dam.

Coimbra Fishway project is improving fish migration in River Mondego, but it's also an integrated project involving other important aspects such as fisheries and river basin management and environmental education. Changes in exploitation regimes of upstream hydropower dams and in the Açude-Ponte are also planned to increase the fishway efficiency. Finally, several activities have been carried out in association with this project to raise public awareness regarding environmental issues, particularly those related with river longitudinal continuity.

Presenting Author Bio:

Environmental engineer that works at the Portuguese Environmental Agency, entity responsible for the maintenance and exploration of the dam (açude ponte de Coimbra) and associated fishway

Direct and indirect consequences of river fragmentation for spring and autumn spawning fish

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Abstract Body:

Fish passages are thought to mitigate negative effects of river fragmentation on migratory fish, however, their effectiveness is still debated. We here aimed to determine how dams, despite being equipped with fishways, affect the movement of the two common salmonid species European grayling (*Thymallus thymallus*) and brown trout (*Salmo trutta*). We analysed 28 years of upstream fishway passage data in combination with radio telemetry data in two high gradient, low-temperature Norwegian rivers.

Dams with fishways delayed the upstream spawning migration of European grayling in spring by one to two months. Radio-telemetry indicated structural upward movements of European grayling in March and April, while fishways typically opened

late May or early June. This delay in upstream migration shifted their migration into periods of peak spring flood. Spawning migration of brown trout in the autumn was not fully completed when the fishways already closed for the winter, thus not all individuals could complete their migration.

Both brown trout and European grayling are partial migrants within the freshwater of the studied river systems, i.e. only part of the individuals in the population migrate. We show in a conceptual framework how increased costs of migration can reduce the proportion of migrants in these populations, and therewith lead to increased density dependent effects among the enlarged number of resident individuals. Fragmentation can therefore, indirectly, also affect the fitness of resident individuals in populations far downstream barriers. Given the increased number of barriers currently being built worldwide, it is important to realize that only proper management of fishways can avoid unexpected effects of habitat fragmentation on both the migratory and resident individuals in fish populations.

Presenting Author Bio:

Casper van Leeuwen is a postdoctoral researcher in ecology and evolution with an interest in biological dispersal, animal behaviour, plant and animal physiology, and in particular the interaction between these components in an evolutionary context. Experienced in ecological fieldwork, laboratory experiments, population genetics, phylogenetics and statistical analyses. Currently her is working on the effects of river fragmentation for migrating salmonids in Norway.

Conservation of a landlocked salmonid population in a regulated river: Taking a holistic approach

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Abstract Body:

The regulated River Klarälven hosts an endemic population of landlocked Atlantic salmon (*Salmo salar*). During the 1960s the population reached an all-time low, and extensive stocking, trapping and transportation of spawners past eight dams, together with a no-fishing policy in the lake, has led to an increase in the population. In an attempt to further improve the situation for this landlocked population, we have taken a holistic approach in evaluating where further measures are needed. Hence, we have measured trap efficiency for upstream migrating spawners at the lowermost dam, spawning success, overwinter survival of post-spawners, downstream passage success of smolts and kelts and smolt production. Here, I present an overview of our eight years of research in the River Klarälven, focusing on trap efficiency for upstream migrating spawners and smolt production. Trap efficiency varied from 18-78%, depending on river discharge and experience of the fish. Estimates of smolt numbers, based on mark-recapture studies, were difficult to obtain in high flow conditions, and our best estimates revealed a minimum smolt run of approximately 4,000 in one year and 20,000 in a subsequent year. A simple population model was developed for the River Klarälven, where we used our own data and data from the literature to estimate the number of return spawners. We found that the model predictions did not match well with the observed return rates. We believe that this discrepancy is related to the difficulties in estimating smolt production and downstream passage success in large rivers with highly variable discharge regimes.

Presenting Author Bio:

Larry Greenberg has a PhD in ecology from Cornell University, USA. After a postdoctoral stay in Sweden and a brief stint at Michigan State University, he established permanent residence in Sweden. From 1988-1998 he was employed by Lund University in southern Sweden. Since then he has moved to Karlstad University, where he actively pursues teaching and research in stream ecology.

SESSION E2: Re-opening the Rhine Delta for migratory fish

Roadmap for fish migration: opening up the Haringvliet and regional waters in the Rhine Delta

First Author Name:
Steven Visser

First Author Affiliation:
WFD Rhine-West Water Council

Abstract Body:

The Rhine West Water Council is responsible for the regional implementation of the Water Framework Directive (WFD) and contributes to the River Basin Management Plan of the Rhine. The Rhine-West river basin is situated in the most western part of the Netherlands. It is highly industrialized and urbanized. Yet it is of major ecological importance with several ecologically important areas and main open connections from the sea to the rivers of the Dutch Delta. Thus, the Rhine-West region is a gateway to Europe, both economically and ecologically.

In this duo-presentation, we would like to focus on:

- The Rhine-West Roadmap for Fish Migration, which complements the (inter)national Masterplan for fish migration (ICPR) which focuses on national waters. The roadmap highlights the importance of connecting the highways (national waters) to the regional roads (waters) in regards to fish migration. Its planning method makes good use of regional fish expert knowledge. The Roadmap easily identifies obstacles to fish migration and enables the selection and prioritizing of successful measures. The method is relevant to the restoration of all migratory fish, particularly in regard to the EU Eel Directive.
- The re-opening of the Haringvliet sluices (the Kier), one of the main hotspots for fish migration in The Netherlands. The presentation will highlight how 'the Kier' will give a strong impulse to the recovery of

estuarine fish such as salmon, eel and sea trout in the Rhine and Meuse river basins. The presentation will also focus on the difficult decision making process which was necessary to re-open the estuary partly, with respect to all water users in the delta (including agriculture, fisheries, industry and drinking water).

Presenting Author Bio:

Independent water management consultant, with more than 15 years of experience in water management related projects in The Netherlands and abroad (including Kyrgyzstan, Pakistan, Bangladesh, Vietnam, Nigeria and Trinidad & Tobago). Works mainly for regional- and national governmental organisations, such as water boards, provinces and ministries. Secretary to the WFD Rhine-West Water Council.

The North Sea Canal: a highway for fish and ships

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Abstract Body:

The North Sea Canal is a very suitable entrance for diadromous fishspecies, such as eel, flounder, 3-spiny stickle back, smelt e.g. Some characteristics of the canal are favouring the migration of diadromous fish, in special the existence of a gradient of salt, the full exchange of water in and out of the shipdocks at IJmuiden and the numerous connections of the canal with its surrounding polders and main inland waters.

The last 20 years, there are a lot of measures taken along the borders of this waterbody, to ensure an unprohibited migration of (diadromous) fish between sea,

canal and smaller waterbodies in the polderlandscape.

The oral presentation focuses on three subjects:

- 1) the diversity of technical solutions for fish passages, adapted to each local situation (an overview)
 - 2) the measures for fish migration taken at IJmuiden and the Oranjesluizen (Amsterdam)
 - 3) the good cooperation between regional water managers to operate successfully on this subject
- Moral of the presentation: fish connects!

Presenting Author Bio:

Author Bio of the first author:

Marco van Wieringen

Advisor Water at Rijkswaterstaat from 1994 until now.

Before 1994 he was leading an enterprise in Aquatic Ecology.

Education: higher vocational education (HBO), Botanical Analyst at STOVA, Wageningen

Cross border practical/applied experiences with Germany; the Alosa Alosa LIFE+ project-success story

First Author Name:

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Abstract Body:

In 2007 a LIFE+ project aiming at the reintroduction of the allis shad to the Rhine system started by Rheinische Fischereiverband 1880e.V. and partners. Between 2008 and 2012 about eight million shad larvae were produced and transported to Germany where they have been released in the Hessian and North Rhine-Westphalian parts of the Rhine basin. In 2014, the first year after a 4 to 5 years period in the sea, hundreds of Allis Shad have been recorded returning to the Rhine system for spawning. In order to form the basis for a future allis

shad stock in the Rhine, and to develop a natural stock in the long term, monitoring will be continued until at least 2015. After 2015 it seems that stocking is also needed to maintain a self-sustaining population.

The presentation will focus on what methods were used, e.g. for the purpose of sustaining the wild stocks, breeding stocks have been established in which the conditions of successfully keeping shads in captivity are studied in order to enable the fish to reach maturity in captivity. Such ex situ stocks are to breed offspring for stocking purposes and to successively reduce the impact on the wild stocks.

Discussion:

-What lessons can we learn from this success story, e.g. comparing the Allis Shad project with the Smolts project.

-How many more years of stocking and monitoring will be needed?

-How can WFD norms for migratory fish stocks (mainly high flow river upstream, R1) be attained in the Rhine Delta (low-flow rivers downstream)?

What is realistically attainable?

Presenting Author Bio:

Senior Project Manager Sportvisserij Nederland. Fish habitat suitability research, monitoring, tracking surveys, consultant for angling clubs. Specialist in stocking Salmon smolts and Allis Shad.

Downstream migration of 2+ salmon smolts (*Salmo salar*) in the river Meuse in the Netherlands with special attention to the effects of passing hydro power stations and the loss of fish by predation

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Abstract Body:

Downstream migration of 2+ salmon smolts (*Salmo salar*) was studied in the Meuse in the Netherlands, in the period 2009-2013. Smolts (n =897) with implanted NEDAP transponders, were released at different locations in the lower part of the Meuse in Belgium (Berwijn, Moelingen) and the upper part of the Meuse in the Netherlands (Stevensweert, Linne), and tracked by NEDAP trail stations at 41 fixed locations distributed along the Meuse and the Berwijn to the North sea (distance more than 300 km). Over the period 2009-2013 70% (n = 628) of the smolts were detected. Numbers of smolts reaching the North sea varied per year, with a minimum of 0% and a maximum of 15% of the detected fish. The route prevailingly used to migrated to sea by way of the Haringvliet. Duration of smolt migration was mostly less than one month, with average migration speeds always below 1.2 m/s. The influence of the hydro power station (HPS) Linne on the migration was examined. Yearly mortality per km of smolts, over the river stretch Linne – Lith (130 km) turned out to be higher especially in a short distance downstream of the HPS, indicating a vulnerability of the species which is higher for passing the hydropower station than for passing the weir. Also attention was paid on losses by predation of Cormorants.

Presenting Author Bio:

The author is involved in several studies on fish and fish migration for more than twenty years. Other fields of interest tidal energy, hydropower and fish passages.

The Rhine Sturgeon Project: a brief overview and a look into the future

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Bram Houben

First Author Affiliation:

ARK Nature

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Abstract Body:

Once the Rhine was one of the key areas for the European sturgeon. In 2010, WWF the Netherlands and ARK Nature started with

the Rhine Sturgeon Project in close cooperation with other organizations. Now, ARK Nature, the Royal Dutch Angling Association, Rotterdam Zoo and WWF the Netherlands would like to make the river Rhine part of the habitat of *A. sturio* again.

A lot of work is done over the last years. The first releases of sturgeons in the Rhine in 2012 generated a lot of positive attention. We were able to inform a large audience and gained support.

We concluded that one of the next best steps is a repetition of the experimental releases. It is very important to continue with the experimental releases. Not only to obtain more scientific research and results, but also to keep the attention and the focus on the project in the society and of policy makers.

A long term investment leading to a formal re-introduction is the final goal. Therefore the experimental releases are accompanied by a process to gain more support for sturgeon conservation and protection in the Rhine system in the Netherlands and in Germany as well as in the coastal fishery.

Support and approval from the Dutch government and the implication of the German counterparts is very important, for a long term project like this is.

During this presentation we would like to present a brief overview of the work that is done last year to gain more attention for the sturgeon conservation in the Netherlands and Europe. But also we would like share our experiences off setting up a new reintroduction project for a highly protected species in Europe.

International implications of the plan to re-open the Rhine Delta for migratory fish

First Author Name:

Peter Philipssen

First Author Affiliation:

WFD Rhine-West Water Council

Abstract Body:

Implications of the KIER-besluit for the region (salt intrusion), nationally (improved fish migration in the mouth of the river) and internationally (towards Germany). Highlights of a new project focusing on connecting regional waters with the Nieuwe Waterweg Rotterdam; how are regional waters

connected with the mainstream throughout the Rhine river basin (Masterplan Migratory Fish, crucial to Eel migration), how are the Meuse and Scheldt commission involved? How is the WFD and fish migration used as a driver for funding some flood schemes in the UK.

Presenting Author Bio:

Advanced experience in river restoration, in particular fish migration. International consultancy and EIA projects in ecological restoration, coastal zone and flood management (Caribbean, Indonesia, US and UK). WFD Coordinator Fish Migration Rhine-West River Basin.

SESSION A3: EU-funded projects: Restoration of European Rivers

Migratory fish recovery and improved management in the final stretch of the Ebre River (Catalonia, NE Iberian Peninsula; LIFE MIGRATOEBRE)

First Author Name:
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First Author Affiliation:
Director of IDECE (Institute for the Development of the Regions of the Ebre River)

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6. DG Fisheries and Maritime Affairs, Ministry of Agriculture, Livestock, Fisheries, Food and Environment of the Government of Catalonia

Abstract Body:
The aim of the LIFE MIGRATOEBRE project (LIFE13 NAT/ES/000237) is to promote the recovery of ecological connectivity within 10-20 years in the lower Ebre River and Delta (in a stretch of 115 km from the Mediterranean Sea), and a healthy and sustainable population of migrating fish: European sturgeon (*Acipenser sturio*), European eel (*Anguilla anguilla*), twaite shad (*Alosa fallax*) and sea lamprey (*Petromizon marinus*), among others native species. It is focused on long-term sustainable investments adapting all present river obstacles to allow fish migration (upstream and downstream); increasing twice the river spawning habitat availability, and the

distribution and growth areas of migrating fish.

Main activities of the LIFE MIGRATOEBRE project are:

1. Apply ship locks fish-friendly improved management at Xerta's weir (located at 58 km from the sea) and at Flix dam (located at 115 km from the sea), and to monitor it regularly.
2. Install a fish lock at Xerta's weir, and a fish ramp at Ascó's weir (located at 104 km from the sea), and to monitor it regularly.
3. Undertake a pilot project of European sturgeon restocking through experimental releases in the lower Ebre (downstream and upstream Xerta's weir).
4. Develop a communication campaign and a community involvement plan for students, general public, farmers, fishermen, anglers, electric companies, tourism stakeholders, regional and local authorities. It will include the production of a great temporary exhibition, the creation of an interpretation center of fish migration in the Xerta's ship lock house and a network of volunteers.

This LIFE project started in 1/07/14 and will finish in 30/06/18.

More information in: www.migratoebre.eu

Presenting Author Bio:

Marc Ordeix I Rigo (Vic, Catalonia, 1966). Biologist by the University of Barcelona, Diplomate in Water Technology by the Polytechnic University of Catalonia (Barcelona), Master in Conservation of Nature and Natural Resources Conservation by IUSC (Barcelona) and Master in Ecology and Biodiversity Management by the Autonomous University of Barcelona (Bellaterra, Catalonia).

He worked on analysis of water and control of wastewater treatment plants between 1989 and 2001. He also participated in numerous zoological and limnological studies.

From 2001, he coordinates the CERM, Center for the Study of Mediterranean Rivers, environmental area of the Ter River Museum, in Manlleu (NE Catalonia; www.museudelter.cat/cerm). Its purpose is the study, dissemination and preservation of the Ter River and, by extension, other Mediterranean rivers and continental water ecosystems. The CERM is focused on ecological status assessment of rivers and lakes (riparian vegetation, aquatic macroinvertebrates, fish), and assessment

of solutions to improve river connectivity for fish and ecological restoration projects of water inner systems. It also drives river conservation projects –riparian vegetation restoration, river habitat restoration and fish migration improvement-, mainly associated to land stewardship agreements. The CERM is also involved on environmental education –it provides training to thousands of students each year- and actively participates in public awareness. It works essentially in the whole of Catalonia, collaborating with universities and other institutions, but also participates in several international projects. From 2006, it assesses fish passages in Catalonia. For 2014-2018, the CERM is a partner and he is the Scientific coordinator of the LIFE MIGRATOEBRE project: Fish migration species recovery and sustainable management of the final stretch of the Ebre River.

Ljubljana connects – enabling fish migration

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Abstract Body:
The heavily degraded area of the Ljubljana River corridor upstream and downstream of the Ljubljana urban area is an important habitat for the fragmented and heavily endangered populations of Danube Salmon (*Hucho hucho*), Danube Roach (*Rutilus pigus*) and Striped Chub (*Leuciscus souffia*). Nowadays the water level upstream of the weir on the Ljubljana River is too low therefore during low flow conditions the main Ljubljana River channel is not connected to its tributaries. This represents a great obstacle for the habitat connectivity along the river reaches which is worsened by the improperly working fish passes.

To enable fish migration along the river concrete restoration measures were performed. The reconstructions of sill and two fish passes on the Ljubljana River have been implemented and barrier's lifting system on the weir was modernized.

During the entire project fish monitoring is being performed in different ways. It helps us to evaluate if concrete restoration actions (restoration of sill, two fish passes and a barrier) were successful and if fish migration is improved.

We follow fish migration with marking the fish with Visible Implant Elastomer (VIE) tags. Regarding the location of catch we implant tags beneath transparent or translucent tissue combining different tag locations (dorsal fin, post ocular tissue) and colours (red and yellow).

The success of restoration actions is monitored with the use of on line connected cameras installed on the fish passes. Records from the camera are analysed to evaluate number and type of fish using the fish pass.

The data gathered from the fish monitoring will contribute to a better understanding of fish migration along the Ljubljana and Sava River and will help to evaluate the project success.

Think big: adding large structures to improve ecosystem health

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4. Landscape Ecology Group, Depart of Ecology and Env Science, Umeå University, Sweden.

Abstract Body:

The Vindel River is one of the few free-flowing large rivers in Europe. The river and its entire catchment are part of the Natura 2000 network. The river was exploited for timber floating between 1850–1976; rapids in the main channel and tributaries below the alpine tree line were channelized to increase timber transport capacity. Side channels were cut off and the flow was concentrated to a single channel from which boulders and large wood were removed. Hence, previously heterogeneous environments were replaced by more homogeneous systems with limited habitat for riverine species. The Vindel River LIFE project (LIFE08 NAT/S/000266) works with the restoration of 25 tributaries in the Vindel River system. The project strives to alleviate the effects of fragmentation and channelization in affected rapids, to improve the quality of water and riparian habitats. The work has included the construction of over 1000 spawning grounds for brown trout, removal of 17 splash dams, the relocation of rocks into the channels, and the strategic placement of large boulders and dead wood in over 50 km of river.

Follow up studies have been done in the channels that have been restored with “demonstration methods,” where previously best-practice restored reaches have been re-restored by adding large boulders and large wood (i.e., entire trees, including root wads) from adjacent upland to the channel. The demonstration restoration has generated wider and more complex streams, which in turn has led to more variable water flow and higher water levels. This will decrease the risk of erosion during high flow and reduce the risk of losing spawning areas. However, fish population data collected by electrofishing before and after restoration show very inconsistent results among tributaries. This highlights the need for considering potential catchment scale degradation and not only concentrating on reach scale problems in order to re-establish ecosystem health.

Presenting Author Bio:

Dr. Johanna Gardeström has a PhD in Marine Ecotoxicology and has also undertaken research on pesticide effects in agricultural streams.

She currently works at Umeå University in Northern Sweden, where she leads the 5-year restoration project Vindel River LIFE, an EU funded LIFE Project.

In this role she has the overall responsibility for the management of the project, coordinating the work of the different beneficiaries, informing stakeholders and the public about the project and reporting the progress to the EU.

Fish habitat restoration in the LIFE – project Grote Nete

First Author Name:

Bianca Veraart

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Province of Antwerpen

Abstract Body:

In 2005 the province of Antwerpen started a partnership with the NGO Natuurpunt in the context of the LIFE – project Grote Nete. The province department of Integrated Water management, responsible for managing the typical lowland streams in the Grote Nete catchment, is an important partner in restoring lowland river systems. This river system is home to more than 15% of the Flemish population of brook lamprey (*Lampetra planeri*) and spined loach (*Cobitis taenia*), fish species in decline at European level. An important goal of the project was the re-naturalisation of a manmade lowland stream, the Kleine Hoofdgracht. The fish monitoring before realization indicated already a good presence of brook lamprey and some rheophilic species as the chub (*Squalius cephalus*) and the common dace (*Leuciscus leuciscus*). Also Burbot (*Lota lota*) is present thanks to a re-introduction project.

The province of Antwerpen had two objectives in the restoration project. The first objective was creating natural floodplains by removing unnatural dikes along a stretch of almost 700 m. The second objective was habitat restoration for Annex II fish species. Brook lamprey and spined loach need, at least for a part of their life cycle, shallow water. We created 7 zones with shallow water and small variations in topography. We also constructed meandering side channels for some rheophilic species.

The following years we continue the restoration in this catchment thanks to new LIFE-projects: LIFE Grote Netewoud and LIFE Most-Keiheuvel. Objectives are the restoration of the typical lowland streams along 1 km and fish migration restoration. The last objective is a true challenge. Discharge can be very low and some typical fish species (brook lamprey, spined loach) can take only small steps. The T0 monitoring in the LIFE-project Most-Keiheuvel already indicated a big weir is a barrier for a rheophilic species as the common dace.

Presenting Author Bio:

In 1998 Bianca Veraart graduated in Biology, specialization hydro-ecology, at the University of Antwerp. Between 1998 and 2002 she worked as a researcher for the Ecosystem Management Research Group at the University of Antwerp, collaborating in different projects related to ecology and river systems and supporting students. In 2002 she started at the governmental organization province of Antwerpen.

As a project manager of the department integrated water management she became a specialist in stream restoration and fish migration.

Cipriber project: Actions towards the protection and conservation of Iberian cyprinids of community interest

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Abstract Body:

In recent years many studies have pointed out a decline in the populations of some threatened fish species in Duero and Tagus basins as well as an increase in distribution of invasive species. Mostly, this is due to river habitat deterioration by existing pressures over the river courses.

In order to protect and provide the basis for the recovery of these populations, the Duero Basin Authority as coordinating partner, and with the collaboration of the Tagus Basin Authority, the Department of Development and Environment of the Junta de Castilla y León (the regional government) and Natural Heritage of Castilla y León Foundation has promoted a project that has been selected in the 2013 call for the LIFE program.

The target species are endemic native cyprinids of Community interest (Sarda, Alagon stone loach, Duero nase, etc...) located in SCIs in the western of the Salamanca province (Spain).

This presentation sets out the targets and action lines of the project, among which demolition of obsolete dams and new fish pass passages on weirs in use are basic tools to achieve river habitat conditions that allow a better distribution and population status. Removing existing pressures in water courses and restoring habitat will allow to progress towards good environmental status. The river restoration appears, therefore, as essential instrument to achieve an improvement of biodiversity.

Other important objectives are the development of a breeding protocol to offset the current regression status, improve the scientific and technical knowledge on these species and define a fish and water management program.

The project also has an important content of dissemination, communication and public participation as key elements to address some actions for longitudinal continuity recovery as dam removal, since some groups such as councilors, anglers, etc. are still reluctant to this kind of measures.

LIFE+ SEGURA RIVERLINK, implementing a green infrastructure approach

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Abstract Body:

The Segura River, located in southeastern Spain, is one of the most regulated rivers in Europe, creating severe environmental problems and breaking connectivity. The LIFE + SEGURA RIVERLINK project, co-financed by the LIFE Program, aims to promote and support the environmental recovery of the Segura River Basin by improving and strengthening the connectivity between natural ecosystems, promoting the conservation of an area with an exceptional environmental value and improving its public use.

The main actions include the removal of an unused weir and the construction of eight fish passages, being this a pilot experience in the Segura River Basin and a still uncommon practice in Mediterranean areas. To support these actions, ecological restorations will be implemented in each demonstration site.

The target specie of the project is the *Luciobarbus sclateri* (Southern Iberian barbel), Iberian endemism and the only autochthonous specie in the project. The rest of sentinel species are *Pseudochondrostoma polylepis* (Iberian nase), *Gobio lozanoi* (Pyrenean gudgeon) and *Alburnus alburnus* (Bleak). Monitoring activities will assess the performance of these actions with the hope of validating the Green Infrastructure approach in river basin management and its possible extension to the official River Basin Management Plan of the Segura River Basin.

The project also includes the creation of a Land Stewardship Network that seeks to involve different stakeholders in the river management as well as an Environmental Educational Program and a Volunteering Program to promote environmental awareness in society. This project will protect local aquatic and riverine habitats, allow fish migration along an important

sector of the Segura River, improve ecosystem services, build a cadre of scientific and social knowledge to improve river management quality and help local and regional governments to comply with EU Water Framework Directive and facilitate the implementation and enforcement of EU policy and legislation on biodiversity conservation.

Presenting Author Bio:

Head of service in Segura River Basin Authority (Confederación Hidrográfica del Segura). Forest and Water management engineer. Hydrology and river restoration expert.

SESSION B3: Environmentally-enhanced turbines and turbine passage survival (II)

Replacement Turbine Design for Improved Fish Passage at Ice Harbor

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Abstract Body:
In the summer of 2014, an extensive hydraulic development was completed for replacement fixed and adjustable blade turbines for the US Army Corps of Engineers' (USACE) Ice Harbor Lock and Dam. During the hydraulic design phase, fish passage considerations made up the primary evaluation criteria, including minimum pressures, shear, flow quality, and blade strike. Expected fish passage characteristics for each set of proposed geometries were evaluated using both Computational Fluid Dynamic (CFD) calculations and physical model testing. Turbine performance characteristics, such as power and efficiency, were also considered as secondary evaluation criteria.

For both machine types, several design and test loops were completed. At the end of each iteration, the design team, consisting of engineers and biologists from the USACE, Voith Hydro, and the National Marine Fisheries Service (NMFS), evaluated the results and identified aspects of the fish passage environment that could be improved. As the design process neared completion, final improvements to the overall fish passage environment involved making

compromises between the individual design criteria. The current paper presents computational and model test results to illustrate the detailed design and evaluation process, including the trade-offs that were made leading up to the selection of the final prototype fixed blade turbine geometry. Comparison of the fish passage evaluations for the fixed blade solution with those of the existing Ice Harbor Kaplan geometry shows significant potential for fish passage improvement.

Presenting Author Bio:
Dr. Jason Foust is employed by Voith Hydro, Inc. in York, Pennsylvania. After completing his graduate studies in Experimental Fluid mechanics, he began working as a hydraulic engineer. Since that time, Dr. Foust has focused on design and testing for turbine rehabilitation projects. In addition to his design responsibilities, he has also been involved in the development of environmentally friendly hydro turbines in regard to turbine aeration and fish passage.

Alden Fish-Friendly Hydropower Turbine: History and Development Status

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Douglas Dixon

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Electric Power Research Institute

Other Authors:
2. Tim Hogan

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2. Alden Research Laboratory

Abstract Body:
An innovative technology that has potential to contribute to renewable energy development with reduced impacts on downstream fish passage is the Alden turbine, originally developed by the U.S. Department of Energy's (DOE) more recently enhanced by the Electric Power Research Institute (EPRI). This turbine is designed to allow the safe passage of fish through the turbine eliminating the need for expensive screens and bypasses and loss of generation via spillage for fish passage. The turbine features a helical-shaped runner with only three blades. Pilot-scale tests demonstrated that fish survival, when scaled

to a full-size field installation, would be in excess of 98% for many fish species. EPRI, with DOE support, funded Alden and Voith Hydro to enhance the turbine's conceptual design performance through modification of the hydraulic passageways, including the spiral case, distributor, runner and draft tube. The final stage of the Alden turbine design effort included a model test at Voith Hydro's hydraulic laboratory in York, PA, in addition to the updated mechanical and balance of plant equipment sizing necessary for an actual field installation. Model testing indicated a maximum calculated prototype efficiency of almost 94% at conditions corresponding to a prototype net head and flow of 92.0 ft and 1,504 cfs, respectively. The next stage in developing the Alden turbine is a field demonstration project. While EPRI had two field demonstration projects in development, both have been cancelled because of economic reasons unrelated to the cost of the turbine. EPRI is now actively seeking a new demonstration site. The conference presentation will review the detailed results of the mechanical, hydraulic and efficiency performance of the model Alden turbine and its predicted field performance and relative cost compared to conventional Kaplan and Francis turbine designs.

Presenting Author Bio:

Douglas Dixon is the Program Manager of EPRI's Fish Protection Issues Program. He has over 40 years of professional experience in environmental impact analysis and nearly 20 years in the design and evaluation of fish passagwe and protection technologies. He received a PhD in Marine Fisheries Science from the College of William & Mary and a BA from the State University of New York at Geneseo.

Alden Fish-Friendly Hydropower Turbine: Potential Application, Performance and Economics

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Alden Research Laboratory, Inc.

Other Authors:

2. Doug Dixon
3. Timothy Hogan

4. Celeste Fay

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Abstract Body:

The Alden fish friendly turbine is designed to safely pass fish downstream at hydroelectric projects while generating power. The new technology was developed with funding from the U.S. Department of Energy's (DOE) Advanced Hydro Turbine Systems Program and more recently with funding from the Electric Power Research Institute (EPRI). Applications for the new technology include using the turbine as a downstream fish bypass, passing minimum environmental flows, adding new capacity, and new developments at non-powered dams. With further development, this new technology could also be considered to replace existing conventional units. This turbine has been designed and model tested by Voith Hydro and is available for commercial application. This presentation will provide examples of potential full-scale installation applications. The examples range in size from 7 MW to 70 MW and varying fish species including eels, salmon, shad, herring and shortnose sturgeon. Information presented will include overall powerhouse arrangements, predicted fish passage survival for varying fish species and sizes, estimated equipment costs and estimated total project costs. In addition, comparison to conventional Kaplan and Francis turbines will also be presented.

Evaluation of Potential Retrofit of the Alden Fish-Friendly Turbine

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5. New York Power Authority

Abstract Body:

The Alden turbine was developed through industry-U.S. Department of Energy collaborative funding to provide safe turbine passage for fish at hydropower projects. The turbine was designed to minimize the probability and consequence of blade strike and keep pressure changes and shear forces within limits tolerable by fish. Suitability for retrofit was not a design criterion, and application of the Alden fish-friendly turbine has historically focused on new powerhouse development in order to provide flexibility in arranging the larger Alden unit. After evaluating typical Francis and Kaplan turbine geometries and completing a basic Alden turbine retrofit study, it was found that matching the pin circle diameter of the Alden turbine distributor to that of the existing turbine will lead to minimal physical reconstruction but a relatively low power output.

Increasing the size of the Alden turbine will provide an improvement to the power output but also increase the needed physical reconstruction between the existing and proposed systems. An evaluation of energy generation was completed for a hypothetical, site-specific retrofit. Energy generation given the existing Alden unit design without a fish bypass flow was 1.6% less than the base case including a fish bypass flow. A re-designed Alden unit more suitable for the site head was predicted to yield a generation loss of only 0.7%. Improvements to fish passage survival with the Alden turbine retrofit are length-dependent, yielding a predicted 23% improvement (i.e., an increase from 79% to 97% predicted survival) for 300mm fish.

Presenting Author Bio:

Dr. Jacobson is a Senior Technical Leader in EPRI's Waterpower Program, which encompasses conventional hydropower as well as marine and hydrokinetic technologies. His professional work over the past 25 years has focused on environmental assessment in aquatic ecosystems. Prior to joining EPRI in September, 2009, he worked in the environmental consulting arena, most

recently for 13 years as the founder and principal scientist of Langhei Ecology, LLC. Dr. Jacobson's specialty is design, analysis, and interpretation of monitoring and assessment programs to support environmental decision-making. Since 1998, Dr. Jacobson has been a faculty member of the Johns Hopkins University, Krieger School of Arts and Sciences, where he teaches a graduate course on ecological assessment. 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.

SESSION C3: Good examples - where are they?

Running with renewal: reflections on restoring the sea-run fisheries of Maine's largest river - the Penobscot - while maintaining energy production

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Abstract Body:
Dams have impeded fish on Maine's Penobscot River for centuries, blocking connections between inland waters and the sea; people and the river. Populations of sea-run fish, once measured in millions, plummeted to fractions of their historic counts. In 2004, an innovative agreement between the Penobscot Indian Nation, a hydropower company, conservation groups, and resource agencies resolved decades of conflict over fisheries and hydropower. The Penobscot River Restoration Project, a collaborative initiative to restore self-sustaining populations of sea-run fish, charted a whole-system approach endeavoring strategic removal of multiple barriers while rebalancing hydropower. The Penobscot River Restoration Trust, a non-profit established to work with Project partners to fulfill restoration goals, acquired and decommissioned three large mainstem dams in order to remove the two lower-most (completed in 2012 and 2013) and build a nature-like channel around one further upstream (underway). Widely acclaimed as a model for cooperative conservation, the Project provides 11 species of native fishes with significantly improved access to critical habitat within nearly 1,000 miles (1609 km) of watershed. Targeted species include endangered Atlantic salmon, endangered short-nose and Atlantic sturgeons, American

shad, river herring and American eel. Terrestrial and avian wildlife will also benefit from this "refueled" system. By re-establishing connections between inland waters and the sea, the Project promises renewed ecological functions, cultural interactions, and economic activities throughout the watershed and entire Gulf of Maine. Project effects are already being realized. In 2014, nearly 400,000 river herring passed the former Veazie dam; 800 shad were counted, a 100-fold increase from pre-Project counts. The Penobscot Nation will be hosting three years of national canoe racing. This presentation will inform watershed managers, resource specialist, and restoration interests by sharing creative steps taken to balance energy production with ecological and community values through a review of Project accomplishments and initial monitoring.

Presenting Author Bio:
George P. Aponte Clarke is Deputy Director Penobscot River Restoration Trust.

George holds an MS from University of Michigan School of Natural Resources and Environment in Environmental Policy with a focus on technical and policy matters concerning water resources and watershed management. George has been working on the Penobscot River Restoration Project since 2003 where he performs a variety of project management and administrative tasks, most recently coordinating technical aspects of the Great Works and Veazie dam removals and Howland bypass construction. His more than twenty years of professional experience also include work as a policy analyst on stormwater and land use issues for the Natural Resources Defense Council, technical expert on watershed management issues for the Great Lakes Commission, and as a consulting field geologist. George spends his "play-time" with water as much as possible, in both its liquid and frozen (preferred) forms.

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Balancing power production and fisheries restoration in the Penobscot River watershed: background, updates recent successes and difficulties

First Author Name:
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The Nature Conservancy

Abstract Body:

In 1820 the Penobscot (USA) Maine's largest river was first completely dammed, effectively blocking passage of what was likely an annual run of well over 10 million fish including over 100,000 now-Federally Endangered Atlantic salmon. Populations of sea-run fish plummeted to a fraction (thousands to mere hundreds) of historic counts and marine fisheries which foraged on the searun adults and juveniles also declined precipitously.

Through an innovative FERC relicensing process, a multiparty agreement was signed in 2004 by the hydropower company, a new NGO, The Penobscot River Restoration Trust (the Trust), as well as signatories from state and federal agencies. This agreement resolved decades of conflict over fisheries and hydropower in this most critical river for Atlantic salmon.

Looking at a system of dams rather than one at a time, allowed a solution that increases power generation at six dams while increasing fish passage at five others. It led to the acquisition and decommissioning of three large mainstem dams and removal of the two lowest-most dams in 2012 and 2013. The development of a river-like bypass around an upstream dam is under construction. Once finished, mainstem dam improvements will increase access to over 1,000 miles (1609 km) of habitat upstream, meanwhile energy generation already has increased slightly above pre-project levels.

At the same time a coalition of restoration partners are restoring access to tributaries through dam removals, upgraded culverts at road stream-crossings and developing effective fishways to other tributary waters – especially with ponds for alewife spawning. Early results include hundreds of thousands of new fish coming upstream and we are at the front of the projected population growth.

This presentation summarizes creative problem solving balancing energy production with ecological values and

reports on the stunning biological responses to restoration in the first of recovery.

Presenting Author Bio:

Joshua Royte is the Conservation Planner for the Maine Chapter of The Nature Conservancy, a global non-profit conservation group dedicated to protecting biodiversity around the world by protecting the lands and waters all things depend on. This position entails mapping and prioritizing conservation, helping develop strategies and measure results of our work for the protection of landscape-scale forest and freshwater projects. Current priorities include restoration of river connectivity in the Penobscot River and priority waters around Maine. Joshua received a B.A. from Bard College in 1985 and Masters' from Yale School of Forestry & Environmental Studies in 1987. After post-graduate work Josh directed The Chesapeake Bay Foundation's Fox Island Center, was an environmental planner for the National Capital Parks and Planning Commission, and conducted rare species, natural community and wetland inventories for Woodlot Alternatives, Inc. before joining The Nature Conservancy.

Finland's National Fish Passage Strategy: From fish stocking to fishways

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Abstract Body:

The biggest Finnish salmon and sea trout rivers were built for hydropower generation mostly during 1940's and 1950's. After this dam construction period, compensation for the damages to fish stocks focused on fish

stocking and many migratory fish stocks were maintained only in hatcheries. Construction of fish passages in Finland was less common than in the other countries in Central and Northern Europe.

The need for a National Fish Passage Strategy arose from the development needs in water management work to preserve wild migratory fish stocks. This need has been further reinforced by the international water management objectives especially under the Water Framework Directive of the European Union and objectives for the conservation of biological diversity. The new Fish Passage Strategy was prepared in a broadly-based development group, steered by the Ministry of Agriculture and Forestry. The strategy was adopted as a Finnish Government Resolution on March 2012. The purpose of the strategy is to steer the construction of fish passages during the first three periods of water management planning until the end of the 2020s.

The mission of the Finnish Fish Passage Strategy is to focus on supporting and rehabilitating the natural reproductive cycle of migratory species instead of fish stockings. The strategy engages national and regional authorities, research institutes, NGO's, municipalities, business life and interested citizen's to implement the strategy. With regard to the state the strategy is implemented within the government spending limits and state budget by utilizing, combing and reallocating funds from various sources.

According to the strategy there are seven prioritized objectives or measures that need to be considered in each project. The strategy also names 55 dams in 20 Finnish rivers which are prioritized for fishway construction in the first phase of the implementation. Examples of these rivers, under different phase of fishway construction, are given and the results discussed.

Presenting Author Bio:

Teppo Vehanen is a senior researcher at the Finnish Game and Fisheries Research Institute, Helsinki, Finland. He currently chairs the Technical and Scientific Committee of EIFAAC. He has been working with regulated rivers for more than ten years, and currently focuses on connectivity

issues. His research interests include also Water Framework Directive, especially evaluating biological responses to human influences on riverine fish community. Related interests include experimental studies, mainly with salmonid fishes.

Policy shift in reviving migratory fish stocks - examples from RESTORE Life+

First Author Name:
Jukka Jormola

First Author Affiliation:
Finnish Environment Institute SYKE

Abstract Body:

Migratory fish need free passage but also adequate habitats for reproduction.

Countless stocks of salmon and other species have vanished in European rivers through dam construction, but there are also encouraging examples of bringing them back. Contrary aims like increasing hydro power as renewable energy is a threat in many pristine rivers. Migratory fish with their several advantages for tourism and other ecosystem services need to be considered in all kind of river projects.

European Centre for River Restoration ECRR initiated the Life+ project RESTORE to encourage best practices of river restoration, including measures for migratory fish. A database of river restoration cases, River Wiki was created in the project. All good cases contributing fish migration in greater Europe should exist in the River Wiki.

Latest cases include not only fish passes or removal of obstacles, but also measures for restoration or construction of spawning and rearing sites and consideration of downstream migration. Defining environmental flows as basis for natural reproduction is more and more considered. A holistic approach, combining several river restoration measures in a large watercourse is the future river restoration. In the River Wiki large river projects can be described, showing also individual projects like fish passes, as parts of it.

The River Wiki is still in a developing phase, as the coverage of existing cases is good only in UK and some parts of Southern and

Northern Europe. From central Europe there are excellent cases of fish migration but numerous cases are still lacking. It would be essential to get good cases from Eastern Europe, where a lot of power plant construction is still ongoing. It would be important to show best practices for maintaining river continuity in countries where the biggest threats are. ECRR delivers advice how new cases can be added in the River Wiki.

Presenting Author Bio:

Jukka Jormola works in the area of river restoration, environmental river engineering and ecohydraulics, preparing guidelines and designing research projects.

An innovative solution for the Poutès dam to reconcile respect for biodiversity and need for renewable energy

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Abstract Body:

Located on the River Allier (France), the largest upstream tributary of the Loire River which is one of the longest river systems in Europe in which Atlantic salmon (*S. salar*) spawning migration occurs, the dam of Poutès was the scene of conflicts for decades. Outcome of a consensus between EDF, the French state, local elected officials and conservationists, an innovative project is running: the "new Poutès" reconciling respect for biodiversity and need for renewable energy. The new dam will be 5m high, against 18 currently, with a water reservoir of 300 m long against 3.5 km, promoting the return of the river in its natural bed. The current fish lift will be replaced by a vertical slot fishpass associated with major auxiliary flow and a surface bypass will allow smolt downstream migration. The design of the new dam and its fish migration devices requests the opinion of recognized experts

and led to the construction of a large physical model

(1:13) in the research laboratory of EDF (EDF Lab Chatou). This model represents the whole dam with an important upstream and downstream coverage.

It aims to maximize the attractiveness and the effectiveness of the fishway and the surface bypass. Innovative hydraulic modeling (LSPIV) is a valuable aid in the design. Concomitantly with the design of the new dam, a major scientific monitoring program was initiated to measure the environmental gain of this project on the salmon population, on sediment transport and fish habitat and on the holobiotic fish population. This monitoring program includes increasing knowledge about the initial ecological state, monitoring during construction and post-construction monitoring to evaluate the ecological gain. Innovative experiments (drone, acoustic...) are also conducted.

Balancing Ocean and Freshwater Survival Rates When Managing Anadromous Fish Passage

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Abstract Body:

Salmon conservation efforts typically assume that expediting smolt movements into the ocean to mimic historic flow conditions will improve overall survival in dammed river systems. Management agencies are therefore encouraged to reduce the duration of the freshwater migration phase by increasing migration rates using approaches such as increasing spill, transport, or reservoir drawdown and, in extreme cases, dam breaching. Telemetry results for Snake River Spring Chinook smolts in the Columbia River (western North America) allow us to

compare survival rates in four successive habitats in 2006-08: Hydropower system (8 dams), Estuary, River Plume, and Coastal Ocean. Relative to the Hydrosystem, daily survival rates were usually lowest in the Estuary and Plume, while Coastal Ocean survival rates were slightly lower than the Hydrosystem. Critically, marine survival rates never exceeded hydrosystem survival rates. It is also possible to compare the survival rates of various species of acoustically tagged salmon reaching the mouth of the Columbia River with those making a similar migration down the undammed Fraser River in Canada. We will compare these survival values and show how they are similar and where they are different.

Overall, because management actions reducing freshwater residence time increase saltwater residence time by equivalent amounts, accelerating the movement of smolts out of the hydrosystem may be counterproductive and be economically costly, because such actions may simply change the location where smolts die, not improve survival as intended. Whether a chosen hydrosystem action actually enhances salmon conservation thus depends upon whether ocean survival rates are higher or lower than in freshwater. Using the data collected over the past decade using rigorously designed telemetry systems, my company has been able to develop a useful database of comparative survival rates demonstrating that there may be significant opportunity to increase both salmon conservation and power generation in years of poor ocean conditions by slowing freshwater migration rates, because a net survival benefit may accrue from remaining in freshwater for longer periods. Simply put, freshwater losses may be lower than those experienced in the ocean.

Presenting Author:

David Welch is President and founder of Kintama Research Services, a company specializing in the design and deployment of large-scale acoustic telemetry systems in both the coastal ocean and large rivers and their application to fisheries management problems. David is the author of over 100 peer-reviewed papers and 200 technical reports. He has received many awards for his research, most recently the American

Fisheries Societies' Award of Excellence (2012) and the J.P. Tully Medal in Oceanography (2012) from the Canadian Society for Meteorology and Oceanography.

SESSION D3: Around the world: Fish Passage in Africa, Europe, America

Living North Sea

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Abstract Body:
Living North Sea was a €6.4M European project working from 2009 to 2013. It involved 15 organisations from seven countries around the North Sea to look at the combined issue of man made structures and the potential solutions to these problems. It looked specifically at the management issues around several species including sea trout, lamprey, and eel, and made management recommendations.

Presenting Author Bio:
Barry Bendall is a fish biologist

The Zoological Society of London's European Eel Citizen Science Programme

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Abstract Body:
The European eel has suffered severe declines in recruitment across its range and is listed as Critically Endangered by the

International Union for the Conservation of Nature.

ZSL field staff have been monitoring the upstream elver migration in London's rivers for ten years. In 2011, in order to expand the programme, we recruited the help of volunteer citizen scientists in this research. We have so far trained 396 citizen scientists and currently monitor recruitment at 11 sites in partnership with 14 organisations.

The presentation will include; a description of the monitoring methodology, an explanation of how we recruit and work with our citizen scientists, news of how, with our citizen scientists, we are now using monitoring data to advise the installation of eel passes over barriers and therefore enriching the ecology of London's rivers.

Our conclusions are that well designed citizen science programmes can:

- Produce valid data that can be used to guide conservation management decisions.
- Enable people to become more informed, active and skilled.
- Empower individuals and organisations.
- Build much needed capacity in the conservation sector.
- Be a very cost effective approach.

Presenting Author Bio:

Marine and freshwater ecologist working within the Europe Conservation Programme at Zoological Society of London. I manage a range of research and conservation projects applying innovative applications of new technologies and novel approaches to public engagement.

My current programme of work includes a European eel conservation programme involving; assessment of European eel movement and escapement in salt marsh habitat, monitoring elver recruitment in London's rivers, feasibility study of eel translocation and advising sustainable management of eel fisheries.

Establishment of the FISHTAC programme to use fish movement in water resource management in southern African

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Abstract Body:

The excessive use of aquatic ecosystem services in developing countries has caused a decline in ecosystem integrity and a loss of key ecosystem processes. Alterations to the habitat, flow and water quality variable states of these countries are amongst the main drivers of the decline in ecosystem integrity. The FISHTRAC programme has been established to promote the development of and use of fish movement variables within the evaluation of the ecological consequences of altered habitat, flow and water quality variable states in the southern Africa. Numerous studies have been undertaken through the FISHTRAC programme to evaluate the behavioural ecology, home range, daily and seasonal migratory behaviour and movement responses of fishes to changes in environmental variable states. Two recent case studies in the highly utilised Vaal River and Crocodile River have successfully demonstrated the value of using fish movement in resource management in southern Africa. These behavioural studies included the use of manual and remote fish tracking techniques developed for the FISHTRAC programme and a range of flow, water quality and habitat state evaluation methods. Various established univariate and multivariate statistical techniques and probability modelling techniques were used to evaluate the response of the fish behavioural data (up to 180 000 data strings) to the changes in environmental variable states. These case studies resulted in the establishment of a four primary levels of fish movement responses including the disruption of established behaviour, significant reduction in movement, prolonged residency of refuge areas and vacation of home ranges. These responses can be incorporated into water resource

management in South Africa, and used to monitor the wellbeing of the variable states in real time, remotely using the FISHTRAC approach.

Presenting Author Bio:

Gordon is an established aquatic ecologist with specialisation in ecological risk assessments, freshwater and estuarine ichthyology, environmental water requirements and water resource management. His extensive scientific profile includes the development of and application of regional scale ecological risk assessments techniques throughout Africa. This includes the development of the PROBFLO ecological water requirement approach and application of the approach for the second phase of the Lesotho Highlands Water Transfer Study. Gordon is also a co-developer of a programme established to promote the use of fish movement in water resource management in southern Africa. Gordon has extensive experience as a water resource manager and contributed to the establishment of various protection measures in numerous catchments in southern and central Africa. Gordon is also an ichthyologist and for more than a decade has been researching aspects of fish biology and ecology and the use of fish as ecological indicators throughout Africa to manage fisheries and the ecosystem in which they occur. Gordon manages the Aquatic Ecosystem Research programme at the School of Life Sciences of the University of KwaZulu-Natal. He collaborates with numerous international scientists on various international projects and programmes including an international Regional Scale Risk Assessment collaboration and a fish behavioural ecology collaboration.

Drivers of migratory life histories of riverine *Galaxias maculatus* in Chile: implications for management

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Abstract Body:

A relationship between life histories and increasing latitude has been described for Northern Hemisphere riverine fish, whereby life cycles that complete most of the growth in the ocean are favoured at higher latitudes. In the riverine ecosystems of the Southern Hemisphere many species of galaxiids display highly flexible migratory life histories and the mechanisms driving employment of different strategies remain unclear. Our objective was to unravel the mechanisms driving the selection of migratory strategies of *Galaxias maculatus* from rivers across a gradient of latitude.

Fifteen fish from three size classes as well as water samples were collected from upper, middle and lower sections of 10 river systems in Chile across latitudes 36°- 47°S. Otoliths and water samples were analysed for a suite of trace elements using Laser Ablation Inductively Coupled Plasma Mass Spectrometry. Otolith elemental composition was analysed through depth profiling to assess the frequency of marine migrations in each section of each river. The propensity of marine migrations was strongly related to latitude as well as flow and temperature dynamics of each river system. Fish in river systems at higher latitudes more frequently displayed use of marine and brackish habitats, potentially enabling them to maximise foraging opportunities and increase recruitment success. River systems originating from large Andean lakes with more predictable flow pattern (large scale spring floodplain inundations and therefore more predictable food supplies) accommodated more resident individuals with no marine signatures even at higher latitudes. Therefore, climate as well as both longitudinal (headwaters-estuary) and lateral (main channel-floodplains) hydrologic connectivity seem to govern migratory strategies of riverine *Galaxias maculatus*.

Consequently, management strategies that promote both lateral and longitudinal connectivity within riverine ecosystems are crucial to maximise habitat availability for native fish species. (Financial support: Fondecyt 3130690, DIUC 213.310.063-1AP)

The Houting Project

First Author Name:

Jan Steinbring Jensen

First Author Affiliation:

Danish Ministry of Environment, Nature Agency

Abstract Body:

The Houting (*Coregonus oxyrhynchus*) is an endangered species of European whitefish, in the Salmonidae family. It lives in salt water but spawns in freshwater (anadromous), and is vulnerable to relatively small habitat disturbances. It was previously distributed throughout the Wadden Sea (the Netherlands, Germany and Denmark) but it has declined severely and is now restricted to just a few rivers in Denmark. One of the main impediments to successful reproduction is the presence of even small obstacles in rivers during the spawning migration, as the houting is unable to pass weirs or make use of fish ladders. Furthermore, juvenile houting require large areas of reed beds or flooded meadows, where they forage for several months prior to migrating to the sea. Previous restocking attempts in Denmark have failed, because they were not followed up by habitat restoration. During 2005 – 2013 the Danish Nature Agency with the support of EU's LIFE fund conducted a € 20 mill. nature restoration project with the overall objective to restore and maintain a favourable conservation status for the houting in four Danish river systems. The presentation will give an overview on the results and lessons learnt during the project.

Presenting Author Bio:

Jan Steinbring Jensen works as a project manager on numerous river restoration projects in the south-western part of Denmark and is also responsible for the two national management plans for Houting and Salmon in Denmark.

Net Ecosystem Services Analysis as a Floodplain Restoration and Management Tool

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Abstract Body:
Established ecological fundamentals typically determine design, success and efficiency of restoration and management of floodplain and aquatic resources. Some of the more common criticisms center around the facts that commonly used methods: 1) do not have a quantitative basis for the estimates, 2) are not transparent to allow thorough review and stakeholder input, and 3) do not demonstrate direct and indirect benefits to the affected public. Integrating ecosystem services concepts and approaches and their evaluation for planning and performing ecological restoration is a practical alternative to the traditional restoration approach and can improve the restoration product, provide stakeholder support and ultimate value to the local public.

Increased human influence and potential global influences (e.g. climate change) will directly affect floodplains and aquatic resources in the future with potential for substantial changes in physical effects (e.g. flooding and storm events), chemical changes (water quality), biological (changes in habitat and species distribution), and ultimately how humans use the services provided by these ecosystems. This will have substantial financial and human use implications in floodplain areas and general ecosystem health that provide these services to humans. Recent scientific thinking is increasingly focused on an

ecosystems services approach. The concept, advanced by the United Nation's Millennium Ecosystem Assessment (2005), brings a fresh approach to identifying and managing environmental risks within the limited financial and infrastructural resources available to most entities. This presentation will focus on the use of Net Ecosystem Services Analysis (NESA) for maximizing benefit and prioritizing future expenditures. The key to this is the quantification and rigorous analysis of the services provided by ecosystems that are important to people. NESA case studies will be used to demonstrate quantification tools and approaches used in similar assessments to manage floodplain ecosystem services.

Presenting Author Bio:
Mr. Reub has 30 years experience related natural resource impact assessment, mitigation and restoration. His expertise is currently focused on integration of science-based strategies to maximize efficiencies in habitat restoration and planning. He has been involved in numerous large and small environmental assessments that encompass aquatic, estuarine, marine, riparian, and terrestrial environments as project manager, lead and contributing scientist, technical negotiator, and expert witness. Mr. Reub has extensive experience related to the valuation of ecosystem or habitat services, habitat restoration and landscape-level restoration/conservation planning. Mr. Reub is known for developing and working with interdisciplinary teams to solve interrelated issues ranging from physical and biological relations such as instream flows, wetland functionality, water and sediment quality, geomorphic changes and vegetation interactions to the social, cultural and political realities associated with natural resources.

SESSION E3: Workshop: Fish Passage in the Rhine River

History – from being extinct to the master plan migratory fish

First Author Name:
Laura Gangi

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ICPR, Koblenz, Germany

Abstract Body:

For the benefit of the Rhine and of all waters running into the Rhine, the members of the International Commission for the Protection of the Rhine (ICPR) – Switzerland, France, Germany, Luxemburg, the Netherlands and the European Commission successfully co-operate with Austria, Liechtenstein and the Belgian region of Wallonia as well as Italy. Nine states and regions in the Rhine watershed closely co-operate in order to harmonize the many interests of use and protection in the Rhine area.

One of the issues in the ICPR is the ecological river restoration, for which the Atlantic salmon has become the symbol. The Atlantic salmon used to be a widely spread species in the Rhine system. Historical figures on the supply to fish auctions count up to almost 250.000 in 1885. After that peak, the amounts diminished, until the complete extinction of the Salmon in the Rhine system in 1958.

In 1986, the Sandoz disaster practically wiped out the life in the main stream of the Rhine, when a storage of chemical pesticides burned down.

Already one year later, the ministers of the Rhine bordering countries brought the Rhine Action Plan into life. The ministers took the Salmon as symbol of a healthy Rhine, which was a rather brave thing to do given the fact that it was an extinct species at that time.

In the years that followed, the water quality improved significantly.

Nowadays we work with the 'Master Plan Migratory Fish Rhine', which aims at the restoration of a healthy aquatic ecosystem, which allows the existence of a population of Atlantic salmon. This objective is to be achieved by restoring river continuity – not only for Salmon but for all species – by

restoring habitats, and reintroducing young Salmons.

Upstream migration

First Author Name:
Nathalie Plum

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ICPR, Koblenz, Germany

Abstract Body:

Until 2013, almost 500 barrage weirs were made passable for fish by building fish ladders and by even removing the barriers. The most commonly used types are the pool-weir and the vertical slot passages.

A special measure has to be taken at the main 'front door' of the Rhine and Meuse rivers, the Haringvliet, that currently is shut from the sea by a dam that only allows downstream migration. In 2018 the dam will be partly opened, in order to make upstream migration possible.

In the Upper Rhine, five barrages still have to be provided with fish passages in order to meet the Rhine objective of 'passability' to Basel in 2020. The fish passage at the Strasbourg impoundment will start operating in 2015. The same year, construction work on the fish passage at the Gerstheim impoundment will start in order to reconnect the Elz-Dreisam area with the Rhine. The experience and assessment of the effectiveness of the fish passages in the river system built so far will contribute to improve the technical solutions still to construct. The transfer of fish into the old bed of the Rhine in the region around the impoundment Vogelgrün/Breisach is a technical challenge. An efficient fish pass system at the impoundments Rhinau, Marckolsheim and Vogelgrün on the Upper Rhine still must be planned and implemented. Another issue regarding upstream migration is posed by fishing along the river, both by anglers and professional fisherman.

Habitats restoration and stocking

First Author Name:
Karin Camara

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North Rhine-Westphalia State Environment
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Abstract Body:
Between 2000 and 2013, 250 hectares of habitats were made accessible to the dynamics of the Rhine. All in all more than 1,000 hectares of spawning and juvenile habitats are supposed to be opened in the Rhine catchment. The ecological network and the recovery of habitats benefit to migratory fish, but also to local fish species and invertebrates.

Millions of young Salmons (and other species) have been stocked. All over the Rhine system the benefits of these actions are to be seen, by growing numbers of fish that had not been seen since long. There are even places where salmon stocking can step by step be reduced because of natural reproduction (in parts of the River Sieg system in the lower reaches of the Rhine) even though such stocking measures on the long run remain absolutely essential in the upper reaches of the Rhine, in order to increase the number of returnees and to enhance the carefully starting natural reproduction.

Downstream migration

First Author Name:
David Monnier

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Abstract Body:
With the growing numbers of fish migration along the river Rhine and its tributaries, it became clear that not only the upstream, but also the downstream migration must be secured. The effects of hydropower installations are becoming more and more visible. Partly this is because there are more fish that can be damaged, partly because the policies on renewable energy increased the number of hydropower installations. In

2013, the Rhine Ministers stated that for juvenile Salmon or adult Eel, the downstream migration in the turbine areas is critical because of the great danger of injuries, particularly in cases of successive hydropower plants. The Ministers asked the ICPR to intensively work on the joint determination of innovative techniques of downstream migration at transverse structures.

Regarding hydropower, in the Rhine system, the Kaplan turbine seems to be the dominant type used, especially along the main stream of the river. Other types used are the Francis and the Banki-Mitchell turbine. Currently, the number of 'micro-hydropower' installations is growing. Switzerland has excluded installations >1MW from public funding, because smaller installations have a negative cost-benefit performance when it comes to financial and environmental costs compared to the power benefits.

For smaller installations (<50m³) screens seem to be an adequate solution to protect fish against the passage of turbines. The results of investigations in various installations in the Rhine system suggest that the bar width of the screen should be around 10 mm. The function control at the installation in Kostheim (built in 2011, screen 20 mm) showed a very high mortality. For bigger installations, more research is urgently needed.

Overall downstream migration success

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David Monnier

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Office National de l'Eau et des Milieux
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Abstract Body:
The Rhine countries identified 552 major bottlenecks (height > 2 m) for downstream migration along the river Rhine and its bigger tributaries (> 2500 km², map to be shown). Only few obstacles have downstream migration facilities installed (29 out of 552; about 5%). Little is known exactly on mortality during downstream migration, even if downstream migration facilities have been installed. Though there is an expected positive effect of those facilities.

In France, some estimations are made on the downstream migration success. The effect of hydropower on fish migration does not only depend on individual installations, but also on the amount and type of installations in a certain river stretch. A study on the Moselle (2009) showed that Eels that have to pass all hydropower installations only have 3% chance of reaching the mouth of the Moselle unharmed. A recent study on the Ill (2014) on Eel and Salmon (Smolts) took into account the spread of the populations in the river basin, their periods of downstream migration and the hydrological data during those periods, as well as the data on the hydropower installations in the river basin. It concluded a reduction of the production of the Salmon with 26% and of the Eel of 29% because of hydropower.

A combined German-Dutch study to the success rate of downstream migration of Smolts from the Sieg river using telemetry, showed that only 18% successfully reached the North Sea although on this route, there are very few hydropower installations.

Future challenges

First Author Name:
Eddy Lammens

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Rijkswaterstaat, Ministry of Infrastructure and the Environment, Lelystad, Netherlands

Abstract Body:

As explained in the previous presentations, since the late 80s of the last century a lot of effort has been spent into building up new salmon populations in the Rhine by stocking juveniles, restoring spawning places and building fish passages. After more than 25 years we have to conclude that a self-sustaining population is not yet realised. In fact since 2007 there is a declining trend of returning salmons, while the reason for this decline remains unknown. In the life-cycle of salmon there are several bottlenecks to pass and in the coming years we plan to analyse the most critical ones.

Some examples of possible increased mortality in some of these phases of the life-cycle:

- During the phase of downward migration of smolts there is evidence of high and possible increased mortality by predators

and hydropower stations. The evidence is given by telemetry research presented by Breukelaar. Future research has to be focussed on this kind of mortality.

- At the end of the period at sea an important bottleneck (literally) occurs at the river-mouth at Haringvliet, when the adult salmon return to the river and are gathered at the Haringvliet weirs. There is still fishery allowed outside a 250 m zone from the weirs. There are signals that the fishery increases and we will give more attention to this in the next years.

- When entering the river a large part of the incoming salmon makes a turn and goes back to sea. We plan to analyse and explain this behaviour by giving attention to the genetic composition of these individuals and by comparison with the introduced individuals.

- In addition to that we have to investigate the functioning of the fish passages, which may lose their efficiency in the course of time.

- Apart from the salmon eel, allis shad and houting profit from these measures as well. In particular the latter two are good examples of gradually restoring populations in some parts of the Rhine river basin.

SESSION A4: Standardising Fish Pass Evaluation

Standardization of Study Design and Data Parameters for Analysis of Fish Passage Performance

First Author Name:
Christopher Bunt

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Biotactic Inc.

Abstract Body:

Abstract – A meta-analysis was recently designed and executed to compare attraction efficiency and passage efficiency of pool-and-weir, Denil, vertical-slot and nature-like fishways from evaluation studies conducted worldwide since the late 1980s. Studies were considered appropriate for inclusion in the analysis if they used similar methodology, to minimize confounding factors, and to permit valid statistical comparisons of the data. Unfortunately, it was necessary to exclude potentially valuable data from several dozen performance evaluation studies due to inconsistencies in data collection methods, and consequential deviation from the strict rubric that was developed for this work. From an initial pool of over 150 fishway evaluation studies, only 19 studies were comparable, with data from 26 species of anadromous and potamodromous fishes from 6 countries. Each species was separated by year and taxonomic family into a matrix with 101 records that followed the rubric, and produced data that could be standardized and compared with PCA and logistic regression modelling. Details of the rubric and rationale for its development will be described, in addition to major findings from the meta-analysis including the need for more standardized research. Until this is done, existing data are insufficient to support confident fishway design recommendations.

Time-to-event analysis as a unifying framework for fish passage evaluations

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Abstract Body:

The field of fish passage is beset by claims of performance that are often either unsubstantiated, or quantified in ways that contain logical flaws, oversights, or alternative interpretations. Claims of successful passage based on fishway counts are widespread, but typically fail to ask the basic question of how many fish tried to pass but failed, how many attempts did it take to pass, and how much effort was expended trying to pass for fish that passed as well as for those that failed. Understanding the duration of effort and when fish are available to pass is essential to identifying causes of fishway failure as well as for identifying truly effective structures. In order to properly understand the effectiveness of fishways it is necessary to measure three distinct phases of passage: discovery, or approach to the fishway entrance; entry into the fishway; and ascent (or descent in the case of downstream passage). By measuring the times, frequencies, durations, and fates of each of these steps it is possible to accurately measure performance of each one, and also to determine locations and conditions that limit passage performance. Time-to-event analysis—a suite of tools developed for survival studies—is ideally suited for providing these metrics, and provides least-biased estimates of performance while controlling for conditions that change over time.

Presenting Author:

Dr. Castro-Santos is a researcher with the USGS Conte Lab where he performs studies on fish passage and behavior. His interests center on behavior, physiology, and statistics, with a unifying theme of developing appropriate metrics to quantify performance.

Playing the long game: the need for more than a standardised approach to fish passage evaluation

First Author Name:
Paul Kemp

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University of Southampton

Abstract Body:

Globally, freshwater ecosystems harbour a disproportionately high biodiversity, yet rates of loss are higher than for those in the terrestrial or marine environment. In Europe, a major reason why member states fail to meet Water Framework Directive requirements to ensure water bodies achieve good ecological status is due to the impact of a high density of river infrastructure, the legacy of a long history of river engineering.

Fish passes are widely installed to mitigate for the environmental impact of barriers, yet efficiency is rarely evaluated. Today the need for robust and standardised methods to evaluate fish passes is recognised. This requires identification of areas where understanding is limited, and the development of a coherent programme of fish pass evaluation so that knowledge gaps may be closed. Coherent field evaluation (telemetry) studies should quantify delay and the efficiency of: a) attraction, b) entrance, and c) passage.

Comparisons of efficiencies obtained against predefined goals should be biologically relevant, focusing on values expected to maintain sustainable populations taking into account cumulative impacts of barrier networks.

Achieving this would represent a “great leap forward”; but is only half the challenge. It is likely that a standardised evaluation will highlight the high degree of variability in efficiency and that most fish passes perform at levels below expectation. Thus, there is an equally important need to understand why fish passes provide only half-way technologies and partial solutions, and in some cases prove to be ecologically damaging. The main focus of future research should be to improve fish pass design through collaborative and holistic experimental studies that return to

fundamental first principles to enhance understanding of fish performance (e.g. swimming, leaping, climbing) and behaviour (e.g. motivation, response to hydrodynamics, acoustics and other stimuli), the results of which are validated in the field.

Presenting Author Bio:

Paul Kemp is the founding director of the International Centre for Ecohydraulics Research and Director of the EPSRC funded Centre for Doctoral Training in Sustainable Infrastructure Systems at the Faculty of Engineering and the Environment, University of Southampton. His research interests relate to the application of behavioural ecology to understanding and solving challenges in water engineering. Particular interests relate to how the physical environment (e.g. hydrodynamics and acoustics) influence the behaviour and physiological performance of fish, and how manipulation of that environment by engineering means can be used to mitigate for negative impacts of water resource development. Specific applications include fish pass and screening design, assigning compensation flow regimes, and improving habitat restoration strategies. Paul has extensive experience advising governmental and non-governmental organisations and industry on fish passage and screening, including the Parliamentary Office of Science and Technology, DEFRA, the Environment Agency, the Scottish Executive, EU, the Chinese Ministry of Water Resources, US regulatory agencies, and Swedish and Brazilian Hydropower Industry.

Fishway monitoring practice and guidance in Germany

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Abstract Body:

There has been an interest to demonstrate the effectiveness and efficiency of fish passes by means of biological monitoring as long as these facilities have been built to safeguard fish migration or restore fish passage at obstacles. Although monitoring of fish passes has been performed for over a century in German-speaking countries, there exists no standard on monitoring and performance assessment. Techniques, methodologies and evaluation of the results are very different in practice. Therefore it is difficult to compare results between different sites and fish pass designs, to derive fish pass requirements, and to improve fish pass designs.

In order to develop a methodology and valuation mode for monitoring of both fish passes for upstream migration, and downstream fishways and fish protection facilities, a working group was established within the German DWA Technical Committee on Fishways. Initially the group developed a fishway performance classification, and provided expert advice for the new German DWA Standard M 509 "Fish passes and other hydraulic structures passable for fish" (2014).

In this new Standard design parameters of fish passes are derived from the biological requirements of fishes. Compliance with the specified technical parameters is seen as key for assessing the function of fishways. In terms of quality assurance, compliance is required in the design phase, as well as during construction and operation.

Numerous monitoring methods are available to examine different aspects of fishways, e.g. (entrance) attraction and passage. These methods are presented and evaluated as to their applications in the new Standard. In all there is no standard method. Every study design must be adapted to the respective location and question(s) to be answered.

The presentation will illustrate the new German approach to fish pass design, monitoring, performance assessment and classification, and quality management process.

Presenting Author:

Marq is a specialist in fish passage, river restoration, hydraulic & dam engineering, hydropower, and integrated catchment management. His work experience comprises policy and feasibility studies,

project management, and technical designs including hydraulic modeling, economic assessments and construction supervision for public and private clients. Due to several professional affiliations, for example being chairman of the Expert Committee on Fishways of the German Water Association (DWA), and member of the "EIFAAC Group on Fish Passage Best Practices" of the European Inland Fisheries and Aquaculture Advisory Commission, Marq is familiar with and involved in water policy issues, long-term water management strategies and development of best practice guidelines.

A working guide for site specific evaluations of fish protection and bypass systems

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FLUSS Presenting Author: Falko Wagner

Abstract Body:

The importance of an unaffected fish migration in rivers to maintain or establish near-natural fish communities represents a scientific and a social consensus. This is underlined by European laws as the European Water Directive, demanding the ecological connectivity of rivers.

In the last decades increasingly fish protection and bypass systems were developed and installed to reduce mortality at hydro power plants and water abstraction facilities. To prove their efficiency, usually a site-adapted monitoring is necessary. Until now neither German nor European standards for a recommended monitoring design are available. This leads to inconsistent methodological approaches, concerning sampling design and data analysis of individual studies. Therefore results of those studies are hard to compare.

Generally links of causes and effects might be masked by methodological background noise. The German Federal Environment

Agency (UBA) therefore funded a report to provide the basis for a monitoring working guide including methodological guidelines for site specific evaluation process.

The working guide in its current state provides guidelines for preparation, conduction of the experiment and data analysis. Its aim is to simplify the selection of the appropriate sampling methods, sampling time and target fishes (species and development stage). 20 metrics are given as quantitative base for an evaluation of fish protection and bypass systems. Metric thresholds for a sufficient site specific ecological connectivity are not given yet, due to the lack of a sufficient database for their calibration on ecological demands.

The first version of the working guide will be revised and further updated under the direction of the German Association for Water, Wastewater and Waste (DWA). The presentation of the current state aims to facilitate the discussion of the methodological approach to evaluate fish protection and bypass systems.

Presenting Author Bio:

Since 09/2012 Lecturer at several Universities

Since 07/2005 Founding and leading the Institute of aquatic ecology and fish biology

Jena 06/2003-06/2005 Research associate at the Bauhaus-University Weimar

04/1999-06/2003 Research associate and PhD-student at the Friedrich-Schiller-University

Jena 10/1993-12/1998 Diploma student at the Friedrich-Schiller-University

Jena 03/1989-12/1991 Work as fishermen (inland fisheries)

Monitoring Fish Pass Performance: Towards a European Standard

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Abstract Body:

We need more, and better, fish pass performance data in order to inform and improve on our current fish pass designs. Relatively few fish pass construction projects currently budget for accompanying monitoring programmes and those monitoring studies that do take place vary widely in terms of the terminology and methodology used. This variability of data and lack of transferable knowledge is a major constraint on the development of fish pass design internationally. In order to maximise the benefit from expensive monitoring studies, the results need to be pooled and compared, which is not possible when studies measure different efficiency and effectiveness metrics.

A standardised approach which defines the terminology, metrics and provides a framework for experimental design to achieve robust measurement of these metrics would help to address this issue. Standardising fish pass evaluation would help to improve the accuracy of efficiency and effectiveness estimates and provide information in a transferable form that can then be used to compare across studies and fish pass types, ultimately improving fish pass designs.

Methodological standards in Europe are developed through the European Committee for Standardisation (CEN); typically taking 3 years to reach publication. A 'Fish Pass Evaluation' New Work Item proposal has been

submitted to CEN with the UK's Environment Agency leading the project.

This presentation will provide an outline of the CEN Standards process, the vision for what a fish pass monitoring standard could contain and an update on progress. It is hoped that this will stimulate discussion and involvement from fish passage scientists, both within and beyond the 33 Member States, which is critical to the successful development, implementation and potential exportation of a European Standard, thereby increasing the pool of comparable data.

Presenting Author Bio:

Emma's interest in fish pass monitoring started with her PhD:

'Factors influencing salmonid use of a tidal pool and weir fish pass' and has continued unabated throughout her 13 years working for the Environment Agency. She now sits in a National team and works in an advisory role, providing specialist technical advice, information and data to support colleagues.

SESSION B4: Swimming capabilities/ Fish behaviour

How Fast Do Fish Swim? A Global Assessment of What We Know and What We Don't Know

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Abstract Body:

Central to the question of river connectivity is the question of fish swimming performance. As fish passage challenges move away from individual species concerns to more holistic ecosystem considerations the demand for swimming performance data across a wide range of species is growing.

In order to establish a baseline for what is known, we have compiled a species list for which swimming performance is known using three leading databases: the Joint AFS-EWRI Fish Passage Reference Database, the USFS Fish Passage Resource Library, and the Department of Fisheries and Oceans Canada's Ichthyomechanics Database. Between these three databases the swimming performance of 233 individual species have been catalogued. The most recent global fish species count from FishBase and the Catalogue of Fishes indicate that there are 32,900 known species of fish. We therefore are certain that we know some information about the swimming capability of 0.7% of the world's fish species.

In order to establish what is unknown, a semi-automated journal search of each of the 33,000 species is underway. Full results of this assessment will be presented at the conference. Conservative early estimates are that some swimming performance data exists for at most 10% of the world's fish

species. There is a wide range between what we know with some confidence (0.7%) and what we're confident that we don't know (10%), indicating a need for the expansion of existing databases.

This investigation focused solely at the species level. Similar investigations at the genus and family levels will likely provide estimates of abilities where species level data are incomplete. A regional study for fishes in the State of Ohio, U.S., indicates significant improvement in knowledge at coarser scales.

Further resources dedicated to the development and maintenance of these databases would foster the growth of the global fish passage community.

Presenting Author Bio:

Dr. Hans Tritico is an assistant professor of Engineering at the University of Mount Union. He is one of the five founding members of the engineering department and devotes much of his energy nurturing the next generation of engineers. His 14 years of research expertise are in stream restoration and fish passage engineer. He holds B.S. and M.S. degrees in civil engineering from the University of Michigan and Washington State University. He holds a joint Ph.D. in civil engineering and aquatic ecology from the University of Michigan. He is married and has two young children.

New insights into schooling behaviour in response to flow

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Abstract Body:

Gregarious behaviour is found throughout the animal kingdom.

Although many fish species live in groups during a certain period of their life cycle,

rarely has this collective behaviour been incorporated in fish passage studies, which tend to focus on individual behaviour of target species. Near fish passes, local hydrodynamics are highly variable, potentially affecting school cohesion. Since schooling has several drivers, such as anti-predatory benefits and energy savings mechanisms, a loss of school integrity might be a reason fish passes act as an ecological trap for fish species that live in schools. An understanding of how hydrodynamics, encountered near fish passes, affect school cohesion and schooling behaviour is needed. A 'back-to-basics' study was executed that explored the response of fish schools to hydrodynamics in an experimental setting. The Common Minnow (*Phoxinus phoxinus*) was chosen, since it is a strong schooling species and abundant in English rivers. Minnows are quite similar in morphology and swimming movements to the important (migratory) salmonids and could therefore serve as a proxy. Movements of schools of two individuals were recorded in flowing and standing water, and their individual trajectories extracted from video data. Results show that minnows switch from a tandem configuration in standing water to a close side-by-side configuration in flowing water. Modelling work revealed that in this side-by-side configuration, energy savings could not be realised. It was concluded that fish aim to maximize information transfer when encountering flow and therefore have to rely on vision more than their lateral line system as the effectiveness of the latter is disturbed by the flow conditions. These findings suggest that passage of schooling fish is highly dependent on flow characteristics as these determine the success of collective movement and navigation through fish passes.

Presenting Author Bio:

After completing an MSc in Marine Biology (2008) and a second MSc in Physical Oceanography (2011), I started my PhD at the University of Southampton in 2012. My research focuses on the behaviour of fish schools in moving fluids, while other work has investigated the downstream passage efficiency of fish schools when encountering fish screens.

Fine-scale 2D acoustic tracking of the behaviour of salmonids to investigate delays and failures in fish passage; implications for assessing the efficiency of fish passes

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Abstract Body:

Many studies of fish passage are limited to consideration of coarse scale efficiency metrics; however the level of resolution they have for explaining changes in these metrics is often limited. In many cases assessments of fish pass performance are instigated due to (and complicated by) factors such as changes in fish pass design, construction of hydropower schemes and/or associated changes in hydro-morphology. In such cases finer scale descriptions of passage behaviour and fish pass proximity behaviour may be required to identify changes in passage efficiency and elucidate the factors influencing them. This presentation describes a five year acoustic tracking study (3 years pre and 2 years post installation of a co-located hydropower scheme with Larinier fish pass) of the 2D behaviour of 138 sea trout and 18 salmon as they

approached the fish pass entrance and hydropower outfall on Ruswarp Weir (River Esk, England). The study determined the fine scale (sub-metre resolution) spatial and temporal utilisation of the fish pass pool and approach behaviours; analysing these in relation to river flows, tidal conditions, operation of the hydropower scheme, a change in design of the fish pass and the associated changes in pool morphology. In particular the analysis considered the delays in fish passage and behaviours of fish that were successful or unsuccessful in using the fish pass, and the different conditions they encountered whilst approaching the fish pass. The results showed that alongside a significant increase in the proportion of failed passages (reduced fish pass efficiency from 100% to 69% for sea trout) there was a significant increase in delay of passages and changes in the behaviour of fish and spatial utilisation of the pool. Some of these changes potentially relate to operation of the hydropower whilst others may relate to changes in the pool morphology and fish pass.

Presenting Author Bio:

Richard has worked at HIFI for 13 years since completing his PhD on the ecology of fish populations in wetland systems for the Royal Society for the Protection of Birds; contributing to the successful conservation of the Bittern in the UK. As a senior research associate he specialises in developing ecological assessment tools using fish, assessment and management of conservation species, fish telemetry and qualitative modelling. Richard is also Honorary Treasurer and Council member of the Institute of Fisheries Management.

Ethohydraulics in turbulence: Fish behaviour in turning pools

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Abstract Body:

Space restrictions often necessitate the incorporation of turning pools in the design of fishways.

Several biological studies have identified potential problems fish have with turning pools, varying from disproportionate residence times, flow negotiating difficulties and even fish leaping out of the turning pool. Likewise, our research on fish passage times of a vertical slot fishway on the river Mosel in Germany, detected significant time lags in turning pools.

A number of potential explanations have been stated in the literature including confusion associated with large vortices, turbulence and complex flows, flow characteristics exceeding the swimming abilities of the fish, or fish could be using such basins to rest. The actual activity within these turning basins remains unknown and represents an important knowledge gap.

This paper presents the results of an HDX and sonar monitoring campaign, registering behaviour in a turning pool in a vertical slot fishway on the river Mosel in Germany, where increased passage times were recorded for several fish species in turning pools. Behavioural patterns like residence times, acc- and deceleration, resting and swimming tracks for both up- and downward migration are related to flow direction patterns described in a 3D hydraulic model. The results offer insights in the behavioural characteristics of migrating fish in turbulent basins, with direct implications on technical design features like rounded basins and additional baffle walls.

Presenting Author Bio:

Dr. Nijssen is a biologist who has worked for 10 years in both research institutes and engineering firms in Belgium before moving to Germany where he achieved a PhD in hydrology.

He now works for the Federal Institute of Hydrology in Koblenz.

Movement patterns of several fish species approaching and passing a vertical slot fishway

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Abstract Body:
Knowledge of fish behaviour at obstacles is still limited and therefore uncertainties exist regarding measures that have to be taken to ensure fish passage. One question that arises is whether fish, when encountering a barrier, tend to show searching behaviour or literally get trapped in a dead end while following migratory stimuli. To shed some light on this question, migration patterns of fish were investigated by using PIT technology at a vertical slot fishway with two entrances at the river Moselle. Additionally, sonar images were recorded by two DIDSON sonars at the entrances.

Tagged fish (roach, nase, brown trout, river lamprey among others) were stocked in the tailwater. The research setup consisted of HDX-antennae at the entrances as well as antennae at ten slots along the fishway. At the entrance, appearance and passage time of the tagged fish was registered.

Comparing these signals from every HDX-antenna along the fishway allowed analysis of fish passing individual sections or interrupting their upstream movement. Sonar recordings in front of the entrances were analysed with a focus on fish abundance and fish behaviour.

We observed species-dependent differences in the preference for an entrance location and configuration. Some individuals were found at both entrances, indicating a failed entrance attempt, followed by searching behaviour. However, most fish that passed the entrance structures showed a continuous upstream movement pattern.

These results help to understand fish behaviour at obstacles and may contribute to the improvement of fishways, especially with respect to location and construction of entrances as well as the passage of fishway sections.

Presenting Author Bio:
1999-2005: studies in Biology at Dresden University of Technology (TU Dresden)
2005-2011: research associate at the TU Dresden, Institute of Limnology and Institute of Waste Management and Contaminated Site Treatment
2008-2013: freelancer at the Deutsches Hygiene-Museum Dresden, teaching and supervision in a school laboratory
2012-present: research associate at the Federal Institute of Hydrology in Koblenz working at the topic of River Continuity

When and why do fish migrate in Mediterranean Rivers? Observations of fish pass assessments from Catalonia (NE Iberian Peninsula)

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Abstract Body:
Natural patterns of movement for Mediterranean native fish fauna, including their capability to use fish passes, are still poorly understood. Moreover, fish passage assessments could provide important knowledge regarding major causes and

capabilities for fish migration (Lucas & Baras, 2001; Roni, 2005).

We collected particular spawning periods of freshwater native cyprinid species (*Barbus graellsii*, *Barbus haasi*, *Barbus meridionalis*, *Parachondrostoma miegii*, *Squalius laietanus*) from Catalonia between 1987 and 1990 (Casals, 2005), among other periods and species (*Salmo trutta*, *Salaria fluviatilis*), including no native species as well.

We selected 5 fish pass assessments, at least, with good quality of river connectivity for fish (indicating that it allows the passage of the majority or all native fish species potentially present) carried out using methods which permit estimation of barrier effect on fish (direct inspection of fish pass facilities) at different river stretches and river basins from Catalonia (Fluvià, Ter and Ebre) between 2006 and 2014.

The assessed fish passes were: 2 fish ramps (1 of a gauging station and 1 of a hydropower weir), 2 pool passes (1 of a gauging station and 1 of a hydropower weir), and 1 ship lock fish-friendly improved management.

Hydrological and environmental parameters (i. e. flow, water velocities, water temperature and moon cycle) were also daily collected.

Spawning period was a primary driver of upstream fish migration, but a peak flow followed by a decrease of river flow, a minimum value of water temperature (variable between different species) and less bright moon phases were also important.

Presenting Author Bio:

Marc Ordeix (Vic, Catalonia, 1966). Biologist. From 2001, he coordinates the CERM, Center for the Study of Mediterranean Rivers, environmental area of the Ter River Museum, in Manlleu (NE Catalonia). Its purpose is the study, dissemination and preservation of the Ter River and, by extension, other Mediterranean rivers and continental water ecosystems. The CERM is focused on ecological status assessment of rivers and lakes (riparian vegetation, aquatic macroinvertebrates, fish), and assessment of solutions to improve river connectivity for fish and ecological restoration projects of water inner systems. It also drives river conservation projects –riparian vegetation

restoration, river habitat restoration and fish migration improvement-, mainly associated to land stewardship agreements. The CERM is also involved on environmental education –it provides training to thousands of students each year- and actively participates in public awareness. It works essentially in the whole of Catalonia, collaborating with universities and other institutions, but also participates in several international projects. For 2014-2018, he is the Scientific coordinator of the LIFE MIGRATOEBRE project (LIFE13 NAT/ES/000237): Fish migration species recovery and sustainable management of the final stretch of the Ebre River.

SESSION C4:

Eel downstream migration

(I)

Passage of downstream migrant American eels through an airlift deep bypass system

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Abstract Body:
Traditional downstream guidance and bypass facilities for anadromous fishes (surface bypasses, surface guidance structures, and behavioral barriers) have typically been ineffective for anguillid eels. Because eels typically spend the majority of their time near the bottom in forebay environments, deep bypass entrance structures with bottom entrances hold some promise for increased effectiveness as protection measures for this species. A new design of deep-entrance bypass system that uses airlift technology (the Conte Airlift Bypass) to induce flow in a bypass pipe was hydraulically and biologically tested in a simulated forebay environment under controlled laboratory conditions. Water velocities of 0.9 to 1.5 m/sec could be generated at the bypass entrance (opening with 0.073 m² area), with corresponding flows of 0.07 to 0.11 m³/sec. Gas saturation and hydrostatic pressure within the bypass pipe did not vary appreciably from a control (no air) condition under tested airflows. Migratory silver-phase American eels (*Anguilla rostrata*) tested at night under dark

conditions readily located, entered, and passed the bypass; initial avoidance rates (fish avoiding entrainment into the entrance) were lower at higher entrance velocities. Fish that entered the bypass pipe tended to enter headfirst, but those fish that then exited the pipe upstream (rejected the bypass) did so more frequently at lower entrance velocities. Eels appeared to swim against the flow while being transported downstream through the pipe; median transit times for each test velocity ranged from 5.8 to 13.7 sec, with transit time decreasing with increasing entrance velocity. There was no strong avoidance of the vertical section of the pipe which contained injected air. No mortality or injury of bypassed eels was observed, and individual eels repeatedly passed through the bypass at rates of up to 30 passes per hour, suggesting that individuals do not avoid repeated entrainment through the bypass.

Presenting Author Bio:
Dr. Haro is a Research Ecologist at the S.O. Conte Anadromous Fish Research Laboratory (Ecosystems Mission Area, U.S. Geological Survey) at Turners Falls, Massachusetts, USA and serves as a Principal Investigator and Section Leader of the Fish Passage Engineering Section. His present work involves migratory fish behavior, design, engineering, and evaluation of fish passage structures, fish swimming performance, and ecology and management of American eels.

Downstream migration dynamic of silver eel on the Rhine River, based on RFID telemetry

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Abstract Body:
The European eel stock collapsed in the 1980's and continues to decline gradually. In 2004, the European Union (EU) council

established a management plan and a regulations were initiated in 2007 to improve the recovery of the European stock. In France, an R&D program was launched in 2008 to study and understand the eel's behaviour and the impact of dams, including hydropower stations. The aim of this study action is (1) to estimate the migration route distribution (power house, spillway, dam, navigation locks) and (2) to study the migration dynamics of the silver eel according to environmental parameters. The NEDAP trail system, based on Radio Frequency Identification method, was used. Between 2010 and 2013, 6 detections stations were operational in the French part of Rhine River, and 2 additional stations have been installed in 2013. This network is connected to the Nedap network in Netherland and Germany. Therefore, eels can be monitored form French part of the Rhine River to the estuary, around 1000 km downstream the release point.

Environmental parameters, temperature, turbidity, conductivity are measured at 4 positions on the French part of the Rhine River.

On the first hydropower plant (upstream site), all the migration routes are monitored, i.e. power house, navigation locks and spillway. Downstream, a fifth station observes the difference of dynamic migrations between 2 parallel stretches, one with 4 HPP and the other without any obstacle.

Between 2010 and 2014, more than 800 fishes have been tagged and released.

Eels have been caught in the Rhine watershed, directly in the Rhine River (French part and German part) and in 2 tributaries of The Rhine, Moselle River and Ill River. We analyse the migration dynamic, i.e. migration routes distribution and migration velocity, according to environmental parameters, eel origins and location of the release point. Even if tagged eels comes from the same watershed, migration dynamic is different with the origins. We show that the movement of eels during the 10 days cannot be considered as migration behaviour with this telemetry method. This result has an impact on the migration routes distribution.

Eel protection on river Mosel with special reference to catch and carry

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LUWG, Mainz

Abstract Body:

Since 1995 between state authorities of rhineland-palatinate und RWE Power AG exits the project (EEL PROTECTION INITIATVE RP/RWE) to avoid/minimize the hydropower mortality of migrating silver eels in river Mosel and Saar. The ecology of Mosel (MQ 328 m³/s) and its tributary Saar (MQ 60 m³/s) is characterized by oceanic and rainy-dominated discharge, with high degree of variability. These rivers are regulated for shipping and subsequent hydropower purposes. The overall eel mortality due to hydropower is estimated about 77%. No realistic technical solution (physical barriers, bypass) could be elaborated with theses old hydropower station devices in these streams yet. The first-aid measure established in 1997 "catch and carry" was a pioneer action in germany and is still going on. A comprehensive knowledge of eel behaviour in relation to the optimal capture could be gathered. Besides an eel adjusted operation of the turbines one can calculate the contribution of "catch and carry" to the downstream eel migration resp. downstream mortality as substantial (24 %). Also there has been a socioeconomic impact of EEL PROTECTION INITIATVE on the traditional/artisanal fishery. The project between authorities an private enterprises causes positive and innovative attitudes on search of better solutions.

Presenting Author Bio:

14.01.1953; study fishery biology Kiel university 1971 - 1978; bavarian institute for fishery 1979 - 1982; managing director in aquaculture 1982 -1984; 1984 - 1990 fishery developing projects Central and South America; head of fishery department in rhineland-palatinate, Germany.

Effects of light on natural populations of European eel in Ireland

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T. Kieran McCarthy

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Abstract Body:

The typically nocturnal, lunar and seasonal activity cycles of European eel were documented during commercial eel fishery monitoring and eel population surveys in Ireland. The relationship of eel activity cycles to light levels were observed in all continental eel life-history stages (glass eel / elver, yellow-phase and silver-phase) and examples of these behaviour patterns will be presented. Anthropogenic light sources have also been shown to affect eel swimming activity and results of light deflection experiments undertaken in the River Shannon at Killaoe eel fishing weir during the 2014/2015 migration period will be described. The eel fishing weir is located immediately downstream of an old stone road bridge that crosses the river.

LED lights, mounted on the fishing weir, were directed upstream through the bridge's navigation arch, to which the fastest flowing water was diagonally (SE) orientated. Operation of the lights resulted in catches in nets at the navigation arch declining (as % of the total weir catch) from 30% (lunar dark peak) and 14% (mean during full lunar month) to approximately 5%. Eel numbers also passed downstream via the western bridge arches to the fishing net arrays downstream of them. This observation is consistent with the northerly direction of the light beams relative to the generally SE orientation of the illuminated water moving to the navigation arch. The potential use of eel fishing weirs such as the one at Killaloe for assessment of potential measures for mitigation of effects of hydropower dams on silver-phase eels will be discussed.

Presenting Author Bio:

Dr Kieran (T K) McCarthy has been researching Irish eels for four decades. At present he works with a small team, based at the National University of Ireland in Galway and in close collaboration with Electricity Ireland. He helped establish in 2014 a new EIFAAC working group project on downstream passage of fish at hydropower dams.

Current Status or Protection of Silver Eels at hydro Power Stations in Germany

First Author Name:

Rita Keuneke

First Author Affiliation:

Floecksmuehle Consultants GmbH

Abstract Body:

According to the Council Regulation of 18 September 2007 establishing measures for recovery of the stock of European eel, the Member States must significantly improve both upstream directed migration of juvenile eels as well as protection and downstream migration of Silver Eels at hydropower plants.

Since then, various measures have been implemented in some rivers and hydro installations: mechanical fish protection systems with a flow rate up to 70 m³/s combined with special bypass systems for eels. Trap and truck as well as eel friendly turbine management with early warning systems are measurements on large hydropower plants. Modified turbine runners are another possibility to save eel during their downstream migration. The contribution discusses the different methods and shows the advantages and disadvantages as well as their application.

Presenting Author Bio:

Dipl.-Ing. Rita Keuneke graduated in civil engineering from the University of Aachen, Germany, in 1990. From 1990 to 1999 she worked as a department manager at the municipal water management department of an engineering office in Aachen. From 1999 to 2014 she has been working as a project manager at Floecksmühle (consulting engineers) in Aachen. Since 2014 managing director of Floecksmuehle Consultants GmbH who are working as designers and experts for up- and downstream migration facilities, fish protection systems and hydro

power stations. Her work focuses mainly on expert's reports and scientific work on hydro power, passability of waterways and close-to-nature river development.

Development of passive monitoring tools of silver eel migration to trigger turbine management for fish protection

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Sonny Damien

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Profish Technology

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Abstract Body:

Reduction of fish mortality at hydropower facilities is an intense field of research for Power Companies. Nowadays, reduction of turbine capacity seems the most efficient methods, but require to be able to restrict the turbine management operations precisely to fish migration peaks to reduce loss of production to its minimum.

Based on the Ichtyos™ fish counting system that we use regularly to assess fish upstream migration in fish passes with a combination of laser-beams and video records, we recently adapted this technology to a silver eel specific pipe-like bypass installed at two hydropower facilities in Germany.

The association of infrared-cells and video records allowed us to record automatic detection results and video samples on a local hard disk remotely connected. A specific algorithm is being developed over the study still on going with very encouraging results in terms of counting and measuring eels.

The system is intended to send an automatic signal to an operator in case of eel passage detections who will then confirm it by the associated video sequence to finally start a turbine management procedure if necessary. One counting device could be used to manage several successive HPP in

a river system based on real lecture of fish migration, while several devices might be required as local factors could influence eel migration patterns.

This system presents the advantages to be a passive observation method, which is not invasive for fish, contrary to fish telemetry that needs to catch and surgically tag the fish. However, telemetry studies are still very important to assess fish behaviour and for instance improve the position of a fish counting system in the vicinity of HPP. Moreover, the global efficiency of an automatic counting and warning system can only be assessed by the use of telemetry studies.

Presenting Author Bio:

Damien Sonny has a PhD in behavioural ecology of fish and has an experience of 15 years in the academic and applied research dealing with fish migration issues linked with industrial water intakes. He contributed to the development of fish repulsion systems like the infrasound fish fence and the Neptun electrical barrier and is now mainly involved in fish protection programs at hydropower facility. Due to his participation to lot of international applied conferences, he is well aware of the last progress in this sector from different parts of the world. He is also member of different groups of experts at national and international levels.

SESSION D4: Fishlifts and Fish Locks

Merits and Challenges of Fish Lifts

First Author Name:
Keith Martin

First Author Affiliation:
Kleinschmidt

Abstract Body:

Merits and Challenges of Fish Lifts

Of the various types of technical fishways, fish lifts are one of the most operationally flexible yet most complicated upstream passage methods. Fish lifts are being installed with greater frequency and have enjoyed successes in passing many different species in the same facility. Fish lifts have been particularly successful in passing alosine species, and are a typical upstream passage solution for medium to high head dams. This presentation will discuss some of the advantages and challenges of constructing fish lifts and will highlight examples of fish lifts in operation.

Well designed fish lifts have the ability to distribute attraction flows in multiple locations to achieve different velocities in different zones of the fishway such as the entrance, crowder pool, holding pool, or transport flumes. This operational flexibility allows different flow fields to be established for optimal attraction and movement of different target species during different times of the upstream passage season. This flexibility requires complex hydraulic adjustments and automation of mechanical systems.

The inherent mechanical complexity of fish lifts means that it is important to engage a competent engineering consultant whose team understands the nuances of fish behavior as well as the technical challenges of such an important facility. This presentation will highlight some of the important design considerations for developing or evaluating a successful fish lift project.

Presenting Author Bio:

Keith Martin is a Senior Engineer in the Fish Passage Team at Kleinschmidt. For the past decade, he has specialized in the evaluation and design of fish passage

facilities and other hydropower infrastructure. His most recent work has been leading an engineering team tasked with improving upstream and downstream passage at five powerhouses as part of the Penobscot River Restoration Project. He is currently engaged in multiple fish passage design projects in the Northeast United States and Maritime Canada.

Developing an innovative fish lift system for the barrage at Lake Baldeney on the River Ruhr

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3. Ruhrverband

Abstract Body:

Lake Baldeney is the largest of the six Ruhr-reservoirs with a length of almost 8 km and a water surface of 2,64 km². The width of the dam, including the sluice and the hydropower station measures at 160 meters. The storage level represents 9 meters.

Being the operator of the weir, the Ruhr Association is responsible to implement measures to enable ecological passability. Due to limited space and the large head, common passage facilities, such as bypasses and technical slot passes were rated either too expensive, technically impossible to build or considered unsuitable from an ecological point of view. Against this background, an innovative fish lift system was developed for the site at Baldeney among others.

The system consists of two alternating lifts that allows a continual advancement to the headwater, and a downstream chamber which serves as an entrance structure. The cylindrical lifts have internal chambers which can be raised or lowered by variable water levels. For efficient entry and exit, the lift

chambers in the lower and upper end positions have a horizontally flow. To increase the attraction flow into the chamber, additional amounts of water were added.

Based on a combination of numerical and physical model tests as well as observations by didson-sonar, the overall system was hydraulically optimized. The evidence of the functionality with respect to the fish being able to pass through the facilities were conclusively proven by ethohydraulic studies.

The paper addresses the boundary conditions of the location Lake Baldeney and the overall study concept as well as introduces the optimized functionality of the lifting system. A detailed description of the model studies will follow in a separate paper called "Quality insurance in the planning of fish ways – example: a new fish lift system at Baldeney weir and the fish way at Geesthacht".

Hybrid model approach for designing fish ways- example fish lift system at Baldeney/Ruhr and fish way at Geesthacht /Elbe

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Abstract Body:

Within the context of designing a fish passage, engineers and planners are provided with numerous standardized constructions methods including the respective assessment criteria to ensure that fish are able to migrate at transverse structures.

Due to individual spatial conditions and boundaries, there is a need for special constructions at various locations. Because of lack of design specifications or lack of monitoring experience in the planning stage, the functionality of new systems and construction methods is not proven.

Comprehensive functionality tests are therefore to be implemented.

At the Baldeney weir an innovative fish lift is currently planned. The required system optimization and the verification of functionality were carried out on behalf of the Ruhrverband in a hybrid model approach, where physical and numerical models as well as ethohydraulic tests were linked. On the basis of a high resolution 3D flow model and a physical model in a 1:3 scale, the flow behaviour within the fish lift and its components was analysed and optimized for different geometrical scenarios taking fish biological limits into account.

The optimized geometry of the fish lift system was then placed into a situational similar model with a functional module of the fish lift and studied furthermore by using ethohydraulic tests. With the ethohydraulic tests, all phases of the fish passage (entry, lift passage and exit) could be examined with different fish species at different ages. The applied methodology and the effectiveness of the hybrid model approach within the context of planning a fish passage is illustrated by results of the conducted studies for the fish lift system at Baldeney and the fish passage in Geesthacht.

Presenting Author Bio:

Frank Seidel is head of the Theodor-Rehbock Hydraulic Laboratory at KIT and has specialised in physical modeling of hydraulic structures and the interaction of geometry and resulting flow field. In the recent years, also ethohydraulic studies were carried out at KIT including projects such as the fish way at geesthacht.

Evaluation of upstream migration at the fish lock Höllenstein (river Schwarzer Regen, Germany) using a simple camera system

First Author Name:
Maria Schmalz

First Author Affiliation:
institute of water management, urban water supply and ecology

Abstract Body:

The fish lock at the dam of the reservoir Höllensteinsee (river Schwarzer Regen, Germany) was built in 2013. The dam has a level difference of 13 m and is used for energy production. The fish lock was constructed in an old bottom outlet channel. The necessary dotation of 500 liters per second is energetically used by a micro turbine. In the year 2014 a monitoring was realized to proof the function of the fish lock for upstream fish migration.

Because of the water depth it was not possible to install fyke nets, thereby a simple, economical system with four waterproof video cameras, IR-spotlights and a computer equipped with an observation software was used. The cameras were installed at upper and lower entrance of the lock.

Over a period of 127 controlling days about 1400 fish of 12 species were sighted while leaving the upper entrance. Unfortunately the observation of the lower entrance showed a significant lack of entering the lock. Many fishes hesitated to enter the lock chamber or leave it again. Because of this, different parameters of the lock were changed: duration of the lock cycle (especially the duration of entering period), reduction of flow velocity in the lock chamber and installing a daylight spotlight within the chamber. Especially the illumination tends to result in higher passage rates.

Also shorter entering periods of maximum 20 minutes show slight effects. The period to exit the chamber should take about 30 minutes, but most of the individuals leave the chamber within the first 3 minutes after opening the door. There is no evidence that the fish lock is used by a significant amount

of downstream migrating fish. In spring 2015 the investigations will be continued to show more clearly the efficiency of the illumination and the duration of entrance period.

Presenting Author Bio:

study of biology in Stuttgart and Jena scientific staff at the university in Jena and Weimar since 2000 scientific staff of "Hydrolaboratory Schleusingen" special interests: fish migration (up and downstream), effects of water power plants on fish, fish populations

Improving the efficacy of yellow eels' upstream movements through fish lifts

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Abstract Body:

Fragmentation of the river continuum by high dams and subsequent reduction in upstream habitat availability has been cited as an important factor contributing to population decline of inland stocks of the European eel *Anguilla anguilla*. Due to their limited swimming capacity and elongated body shape, eels have typically some difficulty using traditional fishways because water velocities and turbulence limit their upstream movements. However, when it comes to use special fishways, such as fish lifts, the most cost-effective mitigation measures for passage across high dams, performance is often unknown.

Upstream yellow eel passage was continuously monitored at the Touvedo fish lift (Lima River, northwest Portugal) by a combination of video-recording and electrofishing sampling during two annual sampling periods to analyze the effect of

reduction of the free gap between the bars of the trapping cage on eel escapement: i) August 11 to September 12, the pre-treatment phase when the free gap was 23 mm and ii) March 13 to February 14, the post-treatment phase when the free gap was reduced to 5 mm.

Upon reduction of the free gap of the trapping cage, the number of lifted individuals increased more than threefold (1207 to 3852 individuals, Wilcoxon match-paired test, $Z=2.31$, $P=0.021$), though the seasonality of movements (>98% occurring from mid-summer to early autumn) and the environmental triggers of migration (lunar illumination and accumulated rainfall) remained similar during both periods. Differences in population size–structure were also noted between the pre- and post-treatment phases (Kolmogorov-Smirnov test, $Z=5.357$, $P < 0.001$), with a significant higher proportion of smaller individuals found during the post-treatment.

Reducing the free gap between retention bars of fish lifts may decrease escapement of small yellow eels, therefore expanding the use of such facilities for this and other small-sized species individuals.

Presenting Author Bio:

José Maria Santos is a post-doctoral researcher at Instituto Superior de Agronomia, University of Lisbon, Portugal. His research interests focus primarily on ecohydraulics, fish passes and freshwater fish ecology. His PhD (2004) was focused on the effects of flow regulations on fish population and communities and the role of different types of fish passes.

Improving the use of fish lift by eels and medium-sized cyprinid species

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João Pádua

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Abstract Body:

Different types of fishways have been implemented worldwide to mitigate the impact of dams on diadromous and potamodromous fish species. Among these, fish lifts stand as the most cost-effective mitigation measures for high dams.

The present study examines fish passage through the Touvedo fish lift (River Lima, northwest Portugal) along a 2.5 year period with the goal of: i) evaluating the conditions in terms of seasonal/daily fish movements patterns and to preliminary assess the overall efficacy of the facility (pre-treatment period, 1 year); ii) implementing specific measures to improve the efficacy previously recorded (6 months) and iii) evaluating the present conditions of the facility after measure implementation (post-treatment period, 1 year). Monitoring was continuously performed by using a combination of monthly video-recording and downstream electrofishing.

A total of 3389 fish were transferred by the lift during the pre-treatment period, of which 89.7% corresponded to Iberian nase (54.1%) and European eel (35.6%), which migrated mainly during summer and beginning of autumn, independently from time of day. Mean overall efficacy was higher for potamodromous cyprinid species (0.42-0.44) and lower for the eel (0.10). Differences between fish size, downstream and in the fish lift, were also noted. After implementing a set of specific measures, the post-monitoring annual period revealed a significant increase of eel abundance, which increased more than threefold (1207 to 3852 individuals), though the timing of movements remained similar as of the pre-treatment period. An overall increase in fish lift efficacy was also noted for eel (0.21) and potamodromous cyprinids (0.44-1.35). Differences in fish size also decreased.

The current work revealed that the use of the Touvedo fish lift by eels and medium-

sized cyprinid species can be improved by reducing the gap between retention bars in the fish lift and by improving the attraction flow at the fish entrances.

Presenting Author Bio:

Freshwater ecologist with a broad experience on ecological quality assessment in rivers and reservoirs. Was involved in the implementation of Water Framework Directive in Portugal, mainly in ecological quality assessment schemes. Working since 2009 at Energias de Portugal (EDP) where is dedicated to the theme of water quality, implementation of monitoring programs and evaluation of environmental flows efficacy.

SESSION E4: Panel discussion: Basin-scale thinking: Balancing strategic dam siting and fish passage facilities to maintain river connectivity

An index-based framework to assess river fragmentation and flow regulation and its application in basin-scale strategic dam planning

First Author Name:
Guenther Grill

First Author Affiliation:
McGill University

Abstract Body:

A renewed focus on large hydropower developments causes the rapid proliferation of new dams which may pose serious impacts on rivers, including those that support high levels of biodiversity or provide important sources of food from fisheries or flood-recession agriculture. To minimize the impact on fish populations, fitting new infrastructure with technology to improve fish passage and minimize fish loss is of paramount importance. On a basin-scale level, better dam planning strategies are needed that optimize the spatial arrangement of future dams in a river basin to promote large migration corridors and to maintain fish movement through the channel network in critical areas of the basin. We developed a globally applicable impact assessment framework based on a graph-based river routing model to assess river fragmentation by dams at multiple scales using data at high spatial resolution. We calculated the cumulative impact of a set of 6374 large existing dams and 3377 planned or proposed dams on river connectivity at basin and subbasin scales. The results of our research emphasize the need for water managers and planners to consider cumulative, large-scale impacts of multiple dams as part of an integrated 'river systems' mindset. We present examples of river basins where our framework can be implemented in strategic dam planning efforts and regional scenario developments to help identify the most critical sets of dams

or alternative options in efforts to minimize social and environmental tradeoffs associated with dam development while maintaining their socio-economic benefits.

Presenting Author Bio:

Günther Grill is a Postdoctoral Fellow at McGill University. He earned his Phd in Geography from McGill University in 2014, obtained a MSc in Geographic Information Science and Systems at the Center of Geomatics, University of Salzburg in 2005, Austria, and a MSc in Geography at Friedrich-Alexander-University in 2002, Erlangen, Germany. He also worked in local river development planning, contributed to assessment reports of the European Water Framework Directive and worked as a GIS-consultant to the Pan American Health Organization, Washington, DC. His current focus is global-scale hydrological modelling, to assess the status of free flowing rivers globally, including the impacts of dam construction on river fragmentation and flow regulation.

Using a GIS in basin-scale hydropower planning to preserve aquatic connectivity and minimize societal impacts

First Author Name:
Erik Martin

First Author Affiliation:
The Nature Conservancy

Abstract Body:

Hydropower development is expanding rapidly throughout the world, particularly in developing countries. As undammed basins are tapped for their electric potential, there is a narrow window of opportunity during the planning phase of development to select dam locations in a basin which minimize the loss of aquatic connectivity and other environmental and societal impacts, while maximizing power generation. This presentation will describe The Nature Conservancy's emerging work to develop a platform of tools and techniques using Geographic Information Systems (GIS) to identify scenarios, or combinations of dams in a basin, that strike a balance between the benefits and impacts of hydropower development. An overview of the concepts and architecture of this GIS platform will be presented. Examples

of the application of this platform will include case studies from the Magdalena River basin (Columbia), Tapajos River basin (Brazil), and Coatzacoalcos River basin (Mexico).

Presenting Author Bio:

Erik Martin is a GIS Programmer/Analyst with The Nature Conservancy's Eastern Division. He focuses on freshwater conservation with a particular emphasis on aquatic connectivity issues, technical GIS analysis, web-based decision-support tools, and workgroup coordination. He holds a Master of GIS from the Pennsylvania State University and a BA in Human Ecology from College of the Atlantic.

Basins that work for fish and energy: hydropower planning for fish passage in tropical rivers

First Author Name:

Jeff Opperman

First Author Affiliation:

The Nature Conservancy

Abstract Body:

Global hydropower capacity is projected to approximately double in the next several decades, powered by thousands of new dams. Most of this development will take place in South America, Africa, and Asia (China, South Asia, and Southeast Asia). While providing valuable energy to meet growing demands, this expansion of hydropower threatens the diversity and productivity of fish in many tropical rivers, including several river basins where fish provide the primary source of protein to rural communities and larger regional populations. Maintaining the movement of migratory fish within basins undergoing development is a key challenge for governments and those who plan, design, and manage dams. While improving fish passage at dams is critically important, this session will highlight how the spatial arrangement of dams in a river basin impacts fish movement through a channel network. The applied focus of the panel will be maintaining fish passage and migration within river basins that are undergoing development, with an emphasis on tropical

ivers. The panel will review current examples of fish passage that illustrate the need for a basin-scale approach, tools for assessing connectivity of different dam configurations, and examine the potential for system-scale planning for dam siting to produced more balanced outcomes between hydroelectric energy and fish migration.

Presenting Author Bio:

Jeff Opperman, Director of Sustainable Hydropower Strategy and Lead Scientist, Great Rivers Partnership, has been working to protect rivers and lakes for nearly 15 years. He has provided strategic and scientific guidance to freshwater conservation projects across the United States as well as in China, Africa and Latin America. Through scientific research and collaborations and technical support to field projects, Jeff focuses on improving the environmental sustainability of hydropower and protecting and restoring river-floodplain ecosystems. Jeff has served on scientific panels that provided recommendations for floodplain management to the California Department of Water Resources, Montana's Department of Environmental Quality and state and federal agencies for California's Sacramento San Joaquin Delta Restoration Plan.

Jeff earned his B.S. in Biology from Duke University and a Ph.D. in Ecosystem Science from the University of California, Berkeley. He then studied floodplain ecology during a post-doctoral fellowship at the University of California, Davis. His scientific and policy research has been published in journals such as Science, BioScience and Ecological Applications. Jeff strives to communicate the challenges and opportunities of protecting fresh water through op-eds, articles and blog posts in such places as The New York Times, Outside, Grist, and The Guardian.

Are fish passes the best strategy for fish conservation in South America?

First Author Name:

Paulo dos Santos Pompeu

First Author Affiliation:

Federal University of Lavras

Abstract Body:

Most of the large rivers of South America are impounded specially for power production. Fisheries management has been based on stocking, fisheries' harvest limits and the construction of fish passes. However, the low fishery yield and the precarious conservation status of native migratory populations in the dammed rivers indicate that these strategies have not been satisfactory. The objectives of such management strategies should be related to the existence of critical habitats, such as reproduction sites and nursery areas. Because most rivers in South America are serially impounded, there is substantial risk of confining populations within short reaches lacking critical fish habitats. In addition, large reservoirs impose a different kind of barrier to migrating fish, creating a diffuse gradient of hydraulic/limnological conditions that affects fish behaviour and functions as an extensive environmental filter that discourages downstream movements. Based on current and proposed river regulation scenarios, we conclude that conservation of Neotropical migratory fish will be much more complicated than previously believed, and in most situation fish passes will not be a solution. We propose that only by keeping free flowing rivers in the different river basins, we could maintain self-sustainable populations over the long term. In Minas Gerais state, Brazil, our data indicate that it would be possible to implement this strategy, transforming long stretches of river channels in conservation units, and losing less than 10% of the hydropower capacity. However, this initiative should be undertaken immediately, since 300 new dams are planned to be built in the near future, precluding the existence of long enough rivers to keep migratory fish populations.

Presenting Author Bio:

Fish biologist, PhD on Water Resources, Associate Professor at the Federal University of Lavras. The main subjects of research are fish ecology, impact of dams, and land use effects on the fish fauna.

SESSION A5: Dam removal

Increasing Dam Removal through Key Policy Changes in the United States

First Author Name:
Amy Singler

First Author Affiliation:
American Rivers/The Nature Conservancy

Abstract Body:

Dam Removal is arguably the most effective tool we have for restoring river habitat and fish passage. 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. Many dams are relics of old mills and the industrial revolution and are no longer maintained and in need of repair. The benefits of other larger dams may no longer outweigh the significant impacts to fisheries and river habitat.

If we are to make real gains in the rate of river and fisheries restoration through dam removal, then we need to identify opportunities to impact many dams at once rather than working one dam at a time. Reviewing patterns of dam removal over the last twenty years in the United States, American Rivers has identified key changes in policy that have increased the rate of dam removal.

This presentation will outline improvements to wetland regulations and dam safety in the United States as templates that could be replicated elsewhere in order to increase the rate of dam removal and discuss what these changes mean for river restoration and fisheries management.

Presenting Author Bio:

Amy works for American Rivers' River Restoration Program managing dam removal projects and promoting efforts to improve river restoration in New England. Her work is focused on improving river habitat connectivity in the Connecticut River Watershed. She also leads American Rivers' work on culvert and stream crossing policy and implementation both in New England and nationally. Amy has been with American

Rivers since 2009 in a position in partnership with The Nature Conservancy's Connecticut River Program leading stream connectivity efforts in the watershed. Prior to her current position Amy worked for the Massachusetts state rivers program where she worked as a project manager and outreach coordinator, working statewide to promote river protection and implementation of restoration projects. Amy holds a M.S. in Water Resources Management from the University of Wisconsin, Madison, and a B.S. Ecology and Evolutionary Biology from the University of Rochester in New York.

To reach good ecological quality of rivers by dam removal

First Author Name:
André Berne

First Author Affiliation:
Agence de l'eau SEINE-NORMANDIE

Abstract Body:

Dam removal is currently considered as the best solution for improving the ecological transparency and the sedimentary transparency of rivers. Among other advantages, these operations provide an essential ecosystemic service in terms of water quality. By removing the dam, water retention located upstream is also removed, hence offering the river a current facies that enables its flow, speed, temperature and oxygenation to be improved, in particular via the recovery of the waterway's natural invert function which generates turbulent flow zones propitious to air/water exchange. This river movement recovery also improves its self-purification and, consequently, its resilience, which are factors that improve both its biological quality and its physicochemical quality. As such, in waterways where water quality was stagnant, one can hope to achieve correct conditions as described in the Water Framework Directive. A concrete example of the achievement of correct conditions by the simple additional effect of dam removal is present on the River Orne (Enfernay and Maisons Rouge dams). The spectacular improvement of millstream perpendicular to the zone where the dam was removed would appear to demonstrate the efficiency of this measure with regard to the recovery of superficial water quality. The ecosystemic

service offered to the river is evaluated at €3.3M, representing an economy of around €2M compared to a theoretical water treatment solution. In waterways having benefited from intensive clean-up operations in the drainage basin, we can now consider that river delayering via the removal of a significant number of constructions as the sine qua non condition for achieving correct conditions. The quest for a maximum additional layering level of 30% enables the river to recover quality flow over at least 70% of its length can be considered as a preliminary

Presenting Author Bio:

Manager of Normandy unit of l'Agence de l'Eau Seine Normandie/France, Mr BERNE, Water and Forest General Engineer, is a french specialist of dam removal and hydromorphology improvement. He has erased more than one hundred dams on little rivers of Normandy, which is now one of the first region in France for migratory fishes (atlantic salmon, sea trout, lamprey, shad, etc..) and water quality. He pilots the big project of removal of Vezins dam on Selune river, which is the biggest removal in all Europe (33m high, 20km reservoir lake) for the ecological restoration of atlantic salmon of Mount St Michel Bay (presented in the last NASCO conference in St MALO/France). He has written a lot of articles in french or international scientific or juridics journals.

A dam removal in Robledo de Chavela (Madrid, Spain) and river restoration

First Author Name:

Miguel Antolín Martínez

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Presidente de la Confederación Hidrográfica del Tajo

Abstract Body:

The Robledo de Chavela dam removal can be considered a milestone in river restoration as, due to its 23 meters high, is the highest dam ever demolished in Spain and probably in all Europe. The dam was located in Cofio river (belonging to Tajo river basin), 70 km northwest from Madrid. It was built for supplying purposes during the early sixties, but few years later it became unusable, due to water quality problems

caused by livestock discharges from upstream.

On June 8th, 2012, the Tajo River Basin Authority (Confederación Hidrográfica del Tajo, CHT) detected a water leak from the drain line impossible to repair, and, consequently, launched urgent measures to avoid an extreme fish death in the reservoir and also sediment transport downstream. The CHT carried out a massive electric fishing in order to transfer fish population from the empty reservoir to downstream.

For security reasons, sediments were analyzed to confirm that heavy metal concentration, ecotoxicity and irritability were under legal limits. When dry enough, sediments were removed from the reservoir to an old meander upstream.

Slopes were reprofiled and reinforced by a breakwater wall. To prevent erosion, revegetation was accomplished by hydroseeding and native trees and bushes plantation.

On September 2014 the final crucial task was achieved: the dam removal. A highly specialized company was hired in order to reach the goal of an efficient detonation, taking into account that more than 9.000 m³ of concrete had to be reduced into small pieces. Next three months were spent in removing the concrete waste from the river. The main part of it was crushed and used to restore paths in the surroundings, and the rest was disposed in the lower parts of the river banks to prevent erosion.

Presenting Author Bio:

Mr. Miguel Antolín Martínez, Dr. Ingeniero de Caminos, Canales y Puertos (this means, pure Civil Engineer), is the current President of the Tajo River Basin Authority since March 2012. Before being elected for this position, he was in charge of the International Affairs Unit of the Directorate General for Water (Ministry of Agriculture, Food and Environment), and previously Head of Water Director Support Unit, and, therefore, more than 25 years of professional career within the public management of water.

Dam removal: enhancing or degrading ecological integrity?

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Abstract Body:

Removal of dams is increasingly being used to restore fragmented rivers and streams. The incentive is often to give migrating fish access to upstream spawning habitats, but dam removal may also bring other benefits, such as recovery of riparian vegetation and a more heterogeneous environment for aquatic invertebrates. Dam removal may also act as a disturbance on the system, releasing trapped sediments to downstream reaches.

Depending on the amount of sediments in the former reservoir this disturbance may be transient or act over a longer time period. Whether dam removal is beneficial or not to the ecosystem may therefore depend on the type of organism. We have studied the effect of dam removal on riparian vegetation and benthic invertebrates in two Swedish streams over a period of 3 and 5 years respectively, and found that riparian vegetation generally benefitted from removal. Species richness increased, and species composition became more similar to a reference situation within a three year period. In contrast, benthic invertebrates seemed to be negatively affected by dam removal. While we saw no effects on community composition of benthic invertebrates, taxon richness decreased continuously over a five year period and total densities decreased initially but showed weak signs of recovery over the five year period. Our results also indicate that the response varies between invertebrate taxa.

Presenting Author Bio:

PhD in Ecology mainly working with effects of hydropower production on riverine ecosystems and restoration and mitigation measures predominately focused on riparian ecosystems.

Weir removal in lowland streams – the ultimate tool in the fish managers tool box

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Abstract Body:

Anthropogenic changes such weir construction in rivers are common problems in many developed countries and Denmark is no exception. Through centuries, the rivers have been populated with thousands of weirs for various purposes such as irrigation, abstraction, pumping, flood control, fish farming and hydropower. The consequence has been highly fragmented river systems and vast negative effects on fish populations including extinction. For decades remedial measures have been incremental in the form of building fish passages principally constructed for upstream migrants. However, many places the consequences of weirs on fish populations reach far beyond the fish passage problems and hence the positive effect on fish populations has been limited. In the last decade we have run a number of programs targeting removal of various obstacles. In this talk we will present some of the results following weir removal and demonstrate the consequences for fish population both on a local and on a catchment scale. We suggest that removing weirs and dams do not require rocket science, is in many cases the best option, and argue that it in fact is possible many places given the right motivation and persistence.

We did it. Overview of the largest river barrier mitigation programme delivered by a non-government organisation in the UK

First Author Name:
Alistair Maltby

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The Rivers Trust

Abstract Body:

The River Improvement Fund Programme was an initiative of three phases over four years, wholly managed by The Rivers Trust and actioned by rivers trusts throughout the Country.

It delivered the largest ever river improvement programme by a non governmental organisation in England including:

146 multi fish species barriers eased, passed or removed

87 eel barriers eased, passed or tidal flap valves installed

88 riparian habitat improvements

Over 130 waterbodies with increased ecological potential

44 feasibility studies for further improvement work Resulting in over 2,800 km of rivers with improved ecological potential

Evaluation of the programme demonstrates the benefits of a community-led approach over a centralized or statutory one, including more than £2.3M of co-financing on top of the £6M provided by central government, thereby improving affordability in difficult financial times.

Presenting Author Bio:

Alistair Maltby is a fish biologist and watershed manager with over 17 years experience working with community-led organisations to deliver holistic catchment / watershed management. He is Director for the North of England of The Rivers Trust, the umbrella body for community-led river restoration in England, Wales and Northern Ireland.

SESSION B5: Nature-like fishways; design and habitat compensation

2D Modelling of nature-like fishpasses

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Abstract Body:
The passability of nature-like fishpass depends on water depth, velocity and kinetic turbulent energy. To estimate these values the 2D Saint Venant code can be an interesting tool because it can simulate a large range of geometrical configuration and also take into account the deformation of the free surface. However the flow in a fish pass can reach the limit of the model assumptions as the hydrostatic pressure. As a consequence a series of experiments on down-scale are conducted to validate the numerical results. Velocity and turbulent fields are measured by Acoustic Doppler Velocimeter (ADV) for five combinations of discharge and slope. The comparison between experiments and model shows that the numerical results are relevant for a moderate Froude number which corresponds to fishpass application. Moreover, some crucial data related to passability are extracted from the computation as the maximum velocity location.

Efficiency of a nature-like bypass channel at Rodley weir, River Aire

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Abstract Body:
Man-made physical barriers (weirs) have disrupted longitudinal connectivity in many river systems around the world for centuries. Impacts of weirs on fish communities centers on the reduced ability of fish to perform upstream migrations. To counter the potential effects these structures are having on fish communities, a number of fish pass designs have been developed to ease passage around potential barriers. To monitor the effectiveness of a recently constructed nature like bypass on the River Aire, Passive Integrated Transponder (PIT) systems were installed to observe movements of brown trout (*Salmo trutta*). The array consists of four swim through antennas, two at either end of the pass so that swimming direction could be determined. A total of 111 wild brown trout were caught, PIT tagged and released 380 m downstream of the fish pass entrance. In total 57 brown trout (51%) were detected on the most downstream loop, and of these 49 successfully entered the pass (86%). Thirty-eight of these successfully exited the pass in an upstream direction (78%). Further analysis found that a select number of fish used the pass as an area of refuge during high flows. The possible reasons for these findings are discussed in relation to flow, temperature, time of day, season and fish size. This information is important to improve our understanding of fish pass performance, thus informing future best practice guidance of fish passage designs.

Presenting Author Bio:
Jamie Dodd has always had a passion with water and spent many of his younger years fishing at his local beach. In 2010 he undertook his BSc in Marine and Freshwater biology at Hull University. Jamie is currently a second year PhD student at the Hull International Fisheries Institute (HIFI). In his

PhD Jamie is looking into the potential impact of man-made structures on the migrational movements of both anadromous and potamodromous salmonids. His work focuses on efficiency results and the micro scale behaviours of fish in and around fish passes.

Habitat compensation in a nature-like fishway

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Abstract Body:
Nature-like fishways are designed to imitate the characteristics of natural streams, thereby providing both fish passage and habitat for a variety of aquatic organisms. Due to their often limited size the fishways will never be able to fully compensate for all habitat lost due to impoundments in the main river. Nevertheless, nature-like fishways are an increasingly common fishway type and such artificial stream habitats are likely to become even more important as river rehabilitation and connectivity issues are addressed. To date, however, the potential for habitat rehabilitation in nature-like fishways has not been fully realized. To develop the concept of how to design a nature-like fishway, a 500-meter long nature-like fishway, termed the biocanal, was constructed at the Eldforsen hydroelectric facility, Sweden. It included four habitat types: riffle, pool, floodplain and braided (i.e. with islands), each replicated three times. Thus the biocanal had a more varied in-stream environment than those of conventional nature-like fishways. Studies of the colonization of macroinvertebrates in the biocanal showed that the construction of this more diverse type of nature-like fishway possesses the potential for high biodiversity. Further efforts to improve the habitat

function in the biocanal will focus on the freshwater pearl mussel (*Margaritifera margaritifera*) and its host fish, the brown trout (*Salmo trutta*).

Presenting Author Bio:

Stina is a PhD student at Karlstad University (Sweden) in the department of biology. Her work focuses on habitat compensation in nature-like fishways and host fish suitability of the freshwater pearl mussel. Stina has a MSc in Ecology from Umeå University.

The Danube Fish bypass system of Vienna/Freudenau and its importance as a lifecycle habitat

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Abstract Body:

For the fish bypass at the Danube-hydropower station Wien/Freudenau the functioning as migration facility has been classified as functional after construction in 1997. The importance of habitat support for the lifecycles of Danube fish species becomes clearly visible in times when degraded, impounded, current speed reduced section of the river are dominating the fluvial ecosystem. Central parts of impounded areas are not supporting all the needs of riverine fish: Gravel-spawning grounds, suitable flow velocity and diverse 0+ fish habitats are missing. Upper most part of impoundments, tributaries and artificial rivers, like fish bypass systems, can function as essentially needed last habitats.

The fish bypass system of Wien/Freudenau has a length of 1.6 km and a discharge of at least 1.5 m³. 2/3 of the system has been constructed as a near-natural circumvention stream and 1/3 as a nature-like pool pass.

After 15 years of operation it becomes clearly visible that fish use the bypass system as spawning ground extensively and therefore it can make an important contribution for the maintenance of several endangered species, like the nase (*Chondrostoma nasus*) and the barbel (*Barbus barbus*).

In the present study a monitoring was conducted throughout a year. Seasonal changes in abundances, species diversity and spawning events were observed. A total of 35 species colonize the bypass with temporary and spatial fluctuations.

In early spring (February and March), the indicator species of the free flowing Danube, nase and barbel, migrated into the fish pass in very high quantities. After spawning in April and May the adults disappeared and a few weeks later thousands of young-of-the-year were observed.

The present data show, that the chosen natural like solution of a bypass system serves in contrast to a hard technical construction, - additionally to its migration function - like a Danube tributary of the grayling zone. 23 species of young-of-the-year fish classes' inhabited the system in 2014. Some of them have been proved in larval stages by barcoding.

A telemetry study on marble trout (*Salmo marmoratus*) and Italian barbel (*Barbus plebejus*) at a nature-like fish ramp in an Alpine river

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Abstract Body:

Until recently research on fish migration and fish passage efficiency mainly targeted diadromous species, while there is still a significant knowledge gap on endemic potamodromous. In this study, carried out during the period October 2010-October 2011, the movements of radio-tagged marble trout (*Salmo marmoratus*; N=28) and Italian barbel (*Barbus plebejus*; N=31) along the lower course of Chiusella river and Dora Baltea river (NW Italy) were analysed during migration periods, with a particular focus on passage at a partial width nature-like fish ramp built on a 3m high weir. The monitoring, carried out through automatic stations and weekly manual tracking sessions, allowed to collect data on the behaviour of marble trout (repeated up and downstream passages, homing behaviour, use of the ramp as habitat) and on the significant impact of avian predation during winter (> 28% by cormorant (*Phalacrocorax carbo*)); on the other hand, high flow conditions in late spring affected the study on Italian barbel, preventing to catch larger spawners and creating challenging hydrodynamic conditions at the obstacle. Only the passage of the largest tagged individual (33 cm, 531 g) was recorded, while the peak in downstream migration towards the deeper reaches of Dora Baltea river was clearly identified.

Presenting Author Bio:

Claudio is an Assistant Professor in the Department of Environment, Land and Infrastructure Engineering at Politecnico di Torino, Italy. His research focuses on fish pass design and monitoring and on environmental flows evaluation through mesoscale habitat models.

Near-nature water courses at large hydropower plants as fishways and running water habitats

First Author Name:
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Engineering Consultant Dr. Gebler

Abstract Body:

Since several years near-nature water courses are installed at large hydropower stations in Germany and Switzerland. They serve as fishways and but as well as habitats, especially for rheophilic species. So far 4 of them are in use at the rivers Rhine and Aare. The largest of these bypassing water courses has a length of 1000 m, a width of 40-50 m and a discharge of 10-30 m³/s that means the dimensions of a river. These near-natural running waters are arranged with a natural river bed, including riffles and gravel banks. The function of these structures is to establish the habitat connectivity between the upstream and the downstream section of the power station but also to offer running water habitats for rheophilic species. The author is the chief executive of the engineering consultants responsible for design and construction of these river-courses.

Presenting Author Bio:

The author is working in the field of fishways and near-nature river engineering since more than 30 years. After working as scientist at the University of Karlsruhe and finishing his PhD he founded the "Engineering Consulting Dr. Gebler".

His operational area expands not only throughout Germany, but also includes neighbouring regions in Luxembourg, Switzerland, Austria, France and Poland.

Looking back on more than 500 projects he has gained an exceptional experiential wealth in the field of river engineering. By this he was able to publish several papers, manuals and also technical books. Besides, Dr. Gebler is working for several water management associations as an expert, and as well as an international expert of FAO for fishways at large hydro power plants. For more detailed information see: <http://www.ib-gebler.de>

SESSION C5: Eel Downstream Migration (II)

Downstream migration of the European eel (*Anguilla anguilla*): movement patterns and the potential impact environmental factors

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Abstract Body:
Recruitment of European eels (*Anguilla anguilla*) has declined to the extent that they have been added to the IUCN Red List of Threatened Species. Therefore, it is critical to ensure that eels complete their outward river migration in order to contribute to the available spawning stock. We conducted a four-year (2007-2011) telemetry study to understand the migratory behaviour and potential impact of environmental factors on the eel during this critical life stage.

Out of 399 female eels tagged with acoustic transmitters, only 28 % demonstrated clear downstream migratory behaviour. Fifty-five percent were detected exhibiting no downstream migration behaviour and 17 % were not detected at any monitoring station. Movement patterns of downstream-migrating (silver) eels were characterised by nocturnal activity and seasonal migration, with distinct peaks in autumn and spring.

Migration was often discontinuous and exhibited phases of active locomotion and expanded stopovers. The most important determinants of movement activity were water temperature, cumulative precipitation, and moonlight, although the significance varied by season and location in the river basin. Our results evidence a discontinuous, stepwise migration over an extended period. Furthermore, our findings indicate that migration success depends on holding duration prior to tagging, and environmental predictors with varying importance depending on the season, as well as the locations of capture, tagging and release.

Downstream migration of silver eel (*Anguilla anguilla*) in the river Meuse in the Netherlands 2008 - 2012

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Abstract Body:
Downstream migration of European silver eel (*Anguilla anguilla*) was studied in the Meuse in the Netherlands, in the period 2008-2012. Silver eel (n = 840), with implanted NEDAP transponders, were released at different locations, in the lower part of the Meuse in Belgium (Berwijn at Moelingen) and in the upper part of the Meuse in the Netherlands (Ohé en Laak). Fish were tracked by telemetry at 41 fixed NEDAP Trail detection stations distributed along the Meuse from the confluence with the Berwijn to the North sea, a distance of more than 330 km. Over the period 2008-2013 75% (n = 630) of the eels were detected. Eel numbers reaching the North sea varied between 6-10% yearly. Most eels migrated to sea by way of the Haringvliet. Silver eel migration showed much individual variation, with fish reaching the sea within several days after being released and fish postponing their downstream migration for

more than one year. The onset of migration was stimulated by increasing river discharge. Fish from different maturation classes showed no significant differences in migration speeds. Average individual migrations speed ranged from 0,3 to 1,6 m/s, indicative for at least a partly active migration (average river flow being 1 m/s). Generally migration speed slowed when fish approached sluices and weirs in the Meuse. The influence of the hydro power station (HPS) Linne on the migration was examined. Mortality of silver eel per kilometre, over the river stretch Linne – Lith (130 km) turned out to be twice as high after fish had passed the HPS (0,43% versus 0,22% passing the weir at the same location).

Presenting Author Bio:

Tim Vriese has been involved in fish migration studies since 1989. Several long term studies were done on the migration of salmonids and silver eel on the rivers Rhine and Meuse. He is co-author of a Dutch fish migration manual. Other fields of study are fish friendly turbines and pumps and the ecological effects of cooling water intakes. Currently he is working at ATKb, an environment consultancy firm.

Behaviour of seaward migrating eel at water intakes and low head hydropower

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Abstract Body:

The severe decline of the critically endangered European eel (*Anguilla*

anguilla) has in part been attributed to delayed or blocked seaward migration of escaping adults (silver eels) at river infrastructure. Eels can suffer high rates of injury and mortality at pumps and hydropower turbines and are susceptible to impingement at exclusion screens. For the few downstream guidance and passage solutions trialled for eels, effectiveness is highly variable but generally low. Archimedes screw turbines are considered one of the most 'fish-friendly' forms of hydropower. While direct damage and mortality may be lower for Archimedes than other turbines, a two year field study highlighted the influence of a low-head Archimedes facility on the behaviour and downstream passage of silver eel.

There has been a historic bias towards physical as opposed to behavioural exclusion or guidance for eel, yet there is increased understanding of the influence of hydrodynamics in the attraction and passage of fish. In a replicated experimental field study employing sub-metre acoustic positioning telemetry at a water intake, we investigated the response of actively migrating adult eel to manipulated flow fields. Eels rarely followed direct routes through the site and displayed avoidance behaviours on encountering constricted flows. Further studies investigated the influence of infrasound as a possible deterrent device within the intake. Findings offer potential to develop behavioural guidance to improve fish passage solutions and enhance traditional physical screening for eel.

Presenting Author Bio:

Dr Piper's research has included large field-based investigations with multiple stakeholders in national and international projects and he also collaborates closely with partners in relevant public bodies (Environment Agency, Cefas) and industry (Water and Power). He has worked extensively on European eel, employing telemetry techniques to address questions concerning eel migration and riverine barriers. Most recent post-doctoral research at the University of Southampton (ICER) focussed on developing behavioural guidance (infrasound and hydrodynamic manipulation) to deter adult phase European eel from deleterious areas (e.g. water intakes), and assessing the impacts of low

head hydropower on fish communities. Prior to his PhD, also at Southampton University, he managed Fisheries, Biology and Marine teams in the Environment Agency and continues to work with this organisation, translating his research findings into real world management applications to improve fish passage.

Experiments to improve passage ways for downstream migrating silver eel

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Abstract Body:
A trial was conducted with passage ways for migrating silver eel at a low head weir in a tributary to River Mörrumsån in Sweden. Behavioral traits useful for maximizing the number of eel per volume of water were sought. Six openings were made in the weir and supplied with various set-ups. One of the openings, a plain hole, served as a control. A second opening had significantly more eel passing than the control (11 versus 2; $p < 0.05$). This setup (U-chute) had a raceway extending 7m upstream of the weir. Inflow of water (and eel) took place through vertical slots on the side. Further development of this model is advocated. Two other set-ups had about the same number of eel passing (4 and 2) as the control. The first was a nature like bypass. The other, the M-chute, had a submerged raceway extending 7m upstream. Inflow took place over the sides. The last two set-ups had no eel passing through or entering, and very few eel were observed near. The first was a dead end (no water flow) and the second had a flow of water coming out of the entrance. A separate trial, involving silver eel and modified water quality, was carried out at the aquarium experimental facility at Ar, Sweden. Eel, kept in 4m² experimental fresh water fish tanks, were

offered two narrow escape ways. One opening had an inflow of brackish water, the other opening had an inflow of fresh water. Significantly more eel passed out through the opening with brackish water than the opening with fresh water (21 versus 8; $p < 0.05$). This effect was however not deemed strong enough for attracting eel to passages. It is argued there is a need for better knowledge of silver eel migration behavior during the descent to the sea.

Presenting Author Bio:
First author: Focus on development of new methods and techniques for fisheries research and management.
Second author: Focus on implementation of the Swedish Eel Management Plan.
Third author: Focus on co-ordination of Swedish eel research.

Impact of water intake for drinking water supply, on downstream eel migration in the Fremur river

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Abstract Body:
The Fremur is a small coastal river located in northern Brittany, which discharges into the English Channel near Saint Malo (2°06'W, 48°34'N). Its catchment area spread over 60 km² with a 17 km main stem. Three major dams (Pont Avet, Pont es Omnes and Bois Joli) located on the river, were previously impassable for fish, until the construction of fishpasses in 1996 (Feunteun et al., 1998). The highest one, Bois Joli dam, is 14 m high and holds a 3,9 million m³ reservoir used for drinking water supply. Downstream eels (*Anguilla anguilla*) migration is possible over the crest of the dam when overflowed as well as through the pumping pipe since 2012, following the

pumping station construction. One kilometer downstream, at Pont-es-Omnès dam, a wolf trap allows to study eel downstream migration since 1996 (Acou et al., 2008). To study the potential impact of the water intake on eel downstream migration, in March 2012, a net was installed at the exit of a pipe, receiving the washing water, coming from the first filter preventing big materials, such as fish, to go further into the pumping station.

The scientific follow-up stated in 2012 has allowed to trap more than 700 individuals belonging to 7 different species (6 of fish, 1 of crayfish). More than 170 eels were caught, including 89 during the 2012-2013 campaign. The study showed that eels use the pumping pipe independently of overflowing periods. Two periods of migration were highlighted, one in summer with a majority of yellow eels and the other one in winter with a majority of silver eels. The direct mortality was estimated between 2 and 100 %. The majority of eels showed symptoms of pathology like cutaneous erosions and bleedings.

Since January 2013, the delayed mortality is studied by mark-release-recapture. Eels were marked with blue alcyan ink using a "Dermojet" at capture in the net and there were recaptured at the wolf trap at Pont-es-Omnès dam. First results indicate a high delayed mortality. These results highlight the major impact of water intake on downstream migrating eels. They underline the need to protect or to adapt water intake especially in the current context of eel decline.

Presenting Author Bio:

This team worked since many years on the Fremur Eel program.

Behavioural patterns of migrating silver eel at a Hydro Power Station in the river Meuse

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Abstract Body:

In order to provide efficient downstream passage for migrating silver eel and to reduce mortality or obstruction rates at barriers, a better understanding of behavioural patterns for migrating silver eels is necessary. To study behavioural patterns of downstream migrating silver eels which are confronted with a hydropower station – weir – ship lock complex in the river Meuse a telemetry experiment was performed. This study used four detection stations (NedapTrail-System®) covering the river bed, two stations up and downstream the HPS, two stations up and downstream the weir and two stations in separated fishways. In all, 148 silver eels were surgically implanted with Nedap-transponders in 2010. 121 eels continued migration showing a great variety of individual behavioural patterns. The majority, 68%, of the eels passed through the turbines either immediately or after recurrence or avoidance behaviour, 15% eels migrated over the weir and it was assumed that 14% of the eels migrated using shiplocks either directly or after returning behaviour at the hydropower station complex. A great number of silver eels (36-38%) approaching the hydropower station (HPS) – weir complex, did not follow the current of the river and were firstly detected at the weir while all the water was guided through the turbines. This suggests either an active avoidance behaviour at a greater distance independent to river discharge or a passive behavioural result of eels that could not detect the main current near the complex. Other eel showed immediate passage (32%) or hesitated to pass the complex or turned around after presumably following the river flow (29-31%).

Presenting Author Bio:

I studied Biology at Wageningen University and graduated in 2008 on different fishmigration related topics. After a short career as biology teacher I started to work at IMARES in 2011 as a scientific researcher. I am involved in several projects related to fish migration en fish behaviour including the Fish Migration River research projects for pre-construction fish passage evaluation.

SESSION D5: Around the World: Fish Passage in Asia

Efficiency of the fish passages at Nam Kam River, the Mekong tributaries in Thailand

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Abstract Body:

Distribution and migration of fishes in Nam Kam River, one of the Mekong tributary in Thailand, were conducted during the migration period in 2013. Nam Kam River consists of four cascade watergates, all of which equipped with fish passage. Migration of fish from the Mekong River into the Nam Kam river system started at the onset of the rainy season around the end of May to early October.

It was found that 92 species from 21 families were observed in the fish passages. The highest number (440,015 fish) was found at the most downstream passage consisting of 83 species. Maximum number of fish was found in early rainy season with averaging 46,831 individuals per day. Fish migrated during daytime more than nighttime in term of abundance (93.03-95.80% vs 4.18-6.97%) while number of species was not significantly difference. Cyprinids was the dominant group migrated during daytime while Bagrids and Silurids were mostly migrated at nighttime. Majority of fishes were mature and ready to spawn, indicated the reproductive migration.

Distribution after migrating through fish passage using physical and genetic (microsatellites) tags were studied in two economically important species (*Hemibagrus nemurus* and *Osteochilus hasselti*). The recapture data revealed target species could migrate through a few watergates upstream at the farthest distance of 72.2 km from most downstream watergate. While the microsatellite analysis indicated that fishes could migrate, although at limited number, almost 100 km upstream. Tag recovery from physical and genetic tagging technique were very low (0.62-10.05% and 0.95% in *H. nemurus* and 0.75-0.92% and 0.58% in *O. hasselti*) as well as the effective numbers of migrants (2.7426 in *H. nemurus* and 8.2676 in *O. hasselti*). The result indicated that a series of watergates might, to some extent, obstruct the migration of fishes in Nam Kam River. Management of watergates based on the migrating period and spawning season could increase the rate of fish migration in the river.

Presenting Author Bio:
Fisheries Biologist from Department of Fisheries, Thailand (2004-present) Ph.D. student from University of Hull, United Kingdom (2013-present).

Current status of fish passages in South Korea

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Abstract Body:
Weirs are important for countries that agriculture is the primary industry due to the stable supply of water to agricultural fields. Because agriculture is still important in Korean peninsula, weirs have been constructing until now from small streams to large rivers. However, only limited fish passages were installed in weirs, and there were no managements.

As a results, streams and rivers have become highly fragmented, with fish migration being severely impeded. Thus, ministry of agriculture, food and rural affairs investigated entire fish passages in Korea in 2010-2011, and estimated current status and problems. A total of 33,718 weirs were installed (until year 2012), and this means that weirs are arithmetically located every 0.81km of the total stream length in Korea. Fish passages, however, were constructed only in 4,496 weirs (13.3% of installation rate). The weir type fish passages with Ice-Harbor type fishways (8.1%) which are favoured nowadays was showed the greatest number (36%), and the vertical slot type passages was in the second place (31%). The denil type and nature-like type

were rarely installed. Only 18.1% of installed fish passages were left whole, and urgent repair is needed for 56.7%. Fish passages of 31.3% were incorporated into the recommended slope range of Korea (1:20). Most of problems are related discharge, poor entrance, breakage and sedimentation. With these structural problems, discontinuous installation of fish passages generates poor continuity of streams. Currently, to improve stream connectivity many projects from Korean government are now conducting and preparing, and additionally development of fish passages specialized for Korean fishes are required.

Case studies of fish passages for high dams in China

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Abstract Body:
High dams created benefits for China in flood control, power capacity, navigation and irrigation. Along with the development of environmental regulations, development of fish passage structures at high dams are of high interest in China. There are hundreds of fish passage structures will be built in the near future for fish upstream migrating across high dams. We present one fish

collection system and one fish lift design for dams higher than 100m and discuss the technical challenges during design. The fish collection system consists of a floating barge, guidance net, light and bubble curtain at the bank, together with a reserved navigation route matched with bubble curtain and strobe light exclusion system which allow passage of boats but not fish. The fish lift concept consists of fish attraction channel, holding pool crowder hoist, tank hoist, with a track that transports fish for more than 100m. Both fish passage facilities were designed with the procedures including: 1) requirement by government, 2) fish population survey, 3) evaluation with respect to site hydraulics and hydrology to model the working situations for fish passage, 4) structure design for fish passage, 5) planned biological evaluation as part of the design process. Although these designs have utilized knowledge from western world and are expected to help fish conservation with positive results, a huge gap between knowledge of fish behavior and fish passage design make the success of the proposed fish passage structures uncertain, and the very limited fish population at the site also questions the necessity of fish passage. Further, no downstream passages were considered for the high dams till now.

Presenting Author Bio:

Xiaotao Shi is a professor with the China Three Gorges University. He focused on fish swimming performance quantification during upstream and downstream migration together with hydraulic analysis, aiming at adapting and developing fish passage techniques for Chinese fishes. Related research topics include fish behavior at various environment, fish passage design and methods to improve survival of fishes.

Ecological Assessment of the Siganid Fishery in Caluangan Lake and Baruyan River, Calapan City , Oriental Mindoro, Philippines

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Abstract Body:

An ecological assessment of the siganid fishery in the Caluangan Lake and Baruyan River in the City of Calapan, Oriental Mindoro, Philippines was conducted from June 2013 to May 2014. Two siganid species were identified in the study area, the mottled spinefoot, *Siganus fuscescens* (Houttuyn, 1782) and orange spotted spinefoot, *Siganus guttatus* (Bloch, 1787). The study showed that these species are good source of livelihood for fishermen and their dependents. Dissolved oxygen was found to fall within the permissible standards both during the wet and dry season sampling that gives suitable habitat for the two species of siganid to thrive to. Exceedance was observed in sodium, chlorine, sulphate as well as the total dissolved solid (TDS) which registered values way above the permissible standard. Socio-economic conditions were also determined to see the level of exploitation the surrounding community wherein the availability of other sources of livelihood prevents the exploitation of siganid and other fishery resources in the study area. This study proposed for consideration the adoption of Ecosystem based Fisheries Management to policy makers and implementers on Siganid fishery in order to attain the sustainable development of this important resource.

Presenting Author Bio:

Marius L. Panahon has a B.S. in Zoology (Emilio Aguinaldo College), a B.S. in Fisheries (Mindoro State College of Agriculture and Technology), a Masters in Environmental Governance and Management (Ateneo de Manila University) and presently taking up Ph.D. in Environmental Science at the University of the Philippines in Los Banos. He was formerly an Ecosystems Management Specialist I at DENR Fisheries Sector Program covering the areas of Region VII and currently an Aquaculturist II at the

Fisheries Management Office of the City Government of Calapan. He is the Marine Protected Area (MPA) Coordinator of the Harka Piloto Reef Fish Sanctuary which was chosen as an Outstanding MPA IN 2007. He is married to Rubilita F. Panahon and they have five children.

Fish Habitat Protection and Restoration in Angu Hydroelectric Power Station

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Abstract Body:
The construction of water conservancy and hydropower brings about the enormous economic and social benefits, but meanwhile it also changes the hydrology of original-river wetland ecosystems drastically. We built dams blocking the river, which has caused a series of circumstances, such as habitat fragmentation and so on. These conditions have had a significant impact on wetland ecosystems. How to protect in the process of development and how to develop in process of protection are the key issues that we must pay more attention and address in the construction of hydropower projects. Based on the observation data of water and sediment prototype, a one-dimensional hydrological and hydrodynamic model was built. We studied the hydrological changes in the process of power plant construction, and simulated changes of the flow state under different situations. On this basis, combining two-dimensional hydrological and hydrodynamic model, we conducted the fine simulation of the flow structure of key rivers where typical wetlands and fish spawning grounds exist. Moreover, we also analyzed the impact of

hydropower development on changes of the water level, water depth, flow field, etc., researching on habitat condition changes caused by it. Based on the above achievements, the paper puts forward a series of engineering measures including discharge of ecological flow, protection and construction of important fish habitats, river ecological restoration, node protection of important wetlands and typical design restoration.

Using a waterfall system as a natural laboratory to inform the design of fish passes in the Mekong

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Abstract Body:
The Mekong Basin features 103 long distance migratory fish species contributing 800,000 tonnes per year to the regional inland fishery. At Khone Falls in southern Laos, the Mekong River splits into multiple channels and flows through numerous waterfalls that constitute a major obstacle to fish migrations across the basin. We present here the approach and methodology of a new research project using the Khone Falls bottleneck as a natural laboratory to inform the design of fish passes in the Mekong. This project is based on systematic gathering of local ecological knowledge, combined with hydrological

measurements and river geomorphological characterization in multiple sites. The project will produce a matrix detailing, for the dominant Mekong migratory species, flow conditions and river conditions passable, preferred or not passable to fish.

This information will help design fish ladders better adapted to native fish species, thus contributing to improved mitigation of the impact of hydropower dams on food security and fish biodiversity in the Mekong Basin.

Presenting Author Bio:

Dr. Eric Baran is a tropical fisheries specialist and a Senior Scientist at WorldFish, an international research center focused on fisheries and aquaculture. Eric holds a Ph.D. in Biological Oceanography and has worked in twelve countries in Africa, South America and Asia; he is originally from France. For the past 15 years he has been working in the Mekong region, with a focus on fish ecology, impact of dams, river basin management and environmental valuation. His 50 publications on fish and Mekong fisheries are accessible at: www.worldfishcenter.org .

SESSION E5: Sturgeon Fish Passages on Large Rivers (I)

The Iron Gate dams in the Danube River and their importance for endangered sturgeons

First Author Name:
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International Association for Danube
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Abstract Body:

Danube sturgeons are highly threatened (IUCN Red List) and two out of six native species are already extinct. The Sturgeon Action Plan enforced in 2005 in the framework of the Bern Convention signed by all Danube countries, lists 72 actions for sturgeon conservation. First priority is the reopening of the Iron Gate I and II hydropower dams, as these disrupt sturgeon spawning migration from the Black Sea to the Middle and Upper Danube. The situation in the region of the Iron Gate dams is extremely complex (navigation locks, transboundary between Romania and Serbia, sturgeon fishery bans, habitat degradation), and monitoring of migrating sturgeons is just in the beginning.

Therefore, in view of limited experience, the design, construction and implementation of fish passages for sturgeons will be very difficult and demanding.

The first steps for the necessary feasibility study were done by a FAO-Mission in 2011 and a Pilot Study performed by a Dutch Consortium during 2013/14. The respective reports will be outlined by Wilco De Bruijne in the sister presentation of this special session introduction. The political background has been prepared by the International Commission for the Protection of the Danube River (ICPDR, Danube River Basin Management Plan), and the Danube Sturgeon Task Force (DSTF) is coordinating sturgeon activities in the frame of the EU Strategy for the Danube Region (Strategy/Program "Sturgeon 2020").

This special session, in particular, the Round Table discussion, is aimed at

gathering state-of-the-art knowledge on sturgeon behavior related to crossing fish passes (upstream and downstream).

Presenting Author Bio:

Senior research scientist and consultant at Eawag (1970-2005); PhD at ETH Zürich in Limnology/Hydrobiology (1974); research topics: (1) sedimentation and nutrient cycling in lakes, (2) river benthos, fish and hydromorphology; IAD-activities (1995-2015): National Representative, President, Editor Danube News; Danube sturgeon protection; critical evaluation of hydropower and navigation projects.

Fish migration at the Iron Gates

First Author Name:
Wilco de Bruijne

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ARCADIS

Abstract Body:

In the Danube river basin in Romania, 119 priority fish migration barriers were indicated. In the Danube river basin as a whole, the amount of indicated priority barriers reaches 400 – 500 barriers. The Iron Gate dams were prioritized in the ICPDR Danube river basin management plan as 'utmost priority'.

In 2011, in an assignment for Romania and Serbia (and encouraged by the ICPDR), the FAO conducted a scoping mission to explore general fish migration solutions at the Iron Gates I and II dams. The main conclusion was: provision for migration routes at the Iron Gates dams is technically feasible. Furthermore, the report stated that following steps will have to include the gathering of detailed input from already existing data and from new monitoring activities. The most critical issue will be the choice of the right location of an upstream fish passage entrance: a specific telemetry study on sturgeon is absolutely needed to decide on the location.

In 2012 a consortium of Dutch companies and a Romanian research institute (DDNI) started a project subsequent to the FAO scoping mission under the flag of the Dutch partners for water program. The project consisted of a field visit, data

collection and analysis (a.o. dam structure, bathymetry, hydrology, ecology), predesign of the most feasible fish migration solutions, cost estimate, stakeholder meeting, international expert meeting and a sturgeon telemetry study (performed by DDNI). Furthermore a roadmap for following steps was made including a planning.

This presentation will focus on the main outcomes of the FAO scoping mission and subsequent 'Partners for water' project, the project process, key questions and following steps on the roadmap.

Presenting Author Bio:

Wilco studied aquatic ecology and waterquality management at Wageningen University and Research Centra (graduated MSc). He is now consultant aquatic ecology and waterquality at ARCADIS for 6 years.

What should we know about behavior of sturgeons to provide their efficient passage?

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Abstract Body:
To provide passage of migrating sturgeons through dams, we have, first of all, to monitor and control their behavior in the water flow. To achieve this, we have to know following behavioral and ecological traits such as: rheoreaction, threshold and critical swimming velocity, swimming endurance, behavior in the flow velocity gradient, diel and seasonal patterns of spawning migrations, and vertical and

horizontal distribution of migrating sturgeons. Such information is needed to determine optimum flow velocities attracting fish to the entrance of a fish pass (FP), FP operation regime, duration of attraction of migrants, location of the entrance to FP downstream the dam, and conditions at the fish release site upstream the dam. Since 1955 to 2005, 16 FP, to enhance fish spawning migration, were built at 11 large dams in the basins of rivers Volga, Don, and Kuban. One of the main functions of the FP was to facilitate spawning migration of sturgeons - *Huso huso*, *Acipenser gueldenstaedti*, *A. stellatus*, and *A. ruthenus*. Several types of FP were built: hydraulic (1 FP) and mechanic (2) fish lifts; fish locks (10), natural (spawning) bypass channels (2), and experimental floating FP (1).

Most of them were efficient. Efficiency of some FP was as high as 67% (of the number of approached fish; river Don – Kochetovskii powerplant). The number of sturgeons that passed through the Volgogradskaya dam (river Volga) reached 60000 ind. per year (1967); 2050 ind. (Kochetovskaya dam, 1975); 2130 ind. through the Fedorovskaya dam (river Kuban, 1987). In the 1990s, the number of sturgeons in the Russian rivers decreased dramatically, mainly due to heavy poaching. This resulted in an abrupt decrease of the number of passed fish. In consequence, operation of some FP was suspended.

Presenting Author Bio:

Dr. Victor N. Mikheev. Email: vicnikmik@gmail.com. Principal researcher at the A.N. Severtsov Institute of Ecology & Evolution, Lab of Fish Behavior (Russian Academy of Sciences). Graduated from the Moscow State University, Faculty of Biology, in 1974. Currently works in the fields of fish ecology and behavior, studying trophic relations, migrations, and behavioral interactions between fish and parasites. Authored 2 books and more than 100 papers. Participated many marine and freshwater expeditions.

Salmon fishways in the Columbia River Basin and their use by white sturgeon

First Author Name:
Michael Parsley

First Author Affiliation:
Retired US Geological Survey

Abstract Body:

The Columbia River Basin is the most dammed river system in North America. Home to five species of anadromous Pacific salmon, the nine mainstem dams on the Columbia River and four on the Snake River were constructed with fishways to enable salmon to return upstream to natal spawning areas. Most of these dams were constructed with two fishways; one adjacent to each riverbank. The fishways have overflow weirs with submerged orifices and some vertical slot structures. Fish lifts constructed at Bonneville Dam in the 1940s were used to pass white sturgeon upstream but their use was discontinued in the 1950s because the lifts were ineffective for passing adult salmon. Fish counting stations were constructed in all fishways. White sturgeon, a resident migratory species native to the Columbia Basin, was not mandated to be counted until 2006 despite knowledge of their presence in fishways dating back to the 1940s. However, due to their charismatic appearance and relative scarcity in fishways, the people counting the fish voluntarily enumerated them and often estimated their size and noted direction of movement within the fishways. Daily passage of white sturgeon from 1998 through present are now available in digital format and I used the data to address specific questions regarding upstream passage by white sturgeon. Mean lengths and peak of timing of white sturgeon counted suggests that current upstream passage is not related to a spawning migration.

Differences in white sturgeon lengths and differences in timing of counts between fishways at individual dams suggest that physical or hydraulic conditions influencing approach, attraction, entry, and ultimately passage differ among sites. These findings suggest that further study could provide information on ways to improve upstream passage of white sturgeon.

Presenting Author Bio:

During his career with the U.S. Geological Survey, Mr. Parsley oversaw field and laboratory studies that provided insight on the effects of dams and hydropower system operations on several species of North

American sturgeons. Most of his team's work focused on white sturgeon in the Columbia River Basin, where most dams have fishways designed for upstream passage of salmon and steelhead. In 2007, they published a paper on the upstream and downstream movements of white sturgeon at The Dalles Dam, a large hydroelectric dam with two fishways. In his presentation today, he uses counts of white sturgeon at eight mainstem dams to address several questions regarding upstream passage.

Upstream Passage of Sturgeons at Dams: Behavior of Sturgeons at a Fish Lift and in a Prototype Ladder

First Author Name:
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ECO Dept., UMass; BK-Riverfish, LLC

Abstract Body:

Attraction of sturgeons to fishway entrances is poorly studied but observations on adult Shortnose Sturgeon, *Acipenser brevirostrum*, entering one of two fish lifts at Holyoke Dam, Connecticut River, MA, USA, indicate the benthic sturgeons need a bottom entrance with a submerged orifice if the water is deep. Sturgeons can pass upstream in nature-like or ramp fishways, or in technical fishways, like fish lifts, but not so good in traditional fish ladders. Keys to passing sturgeons in fish lifts is 1) attracting fish to the entrance by induced currents, 2) operating the lift during the seasonal (and daily diel period) of migration, 3) cycling the crowder trap within the time period fish will remain at the barrier without departing, and 4) designing the appropriate lift hopper. Adults have a moderate swimming ability and can ascend fish ladders, but they ascend best when the fish ladder design enables them to continuously swim upstream.

Unfortunately, most fish ladders (e.g., pool & weir, vertical slot) have cross walls that prevent sturgeons from continuously swimming upstream: an important aspect of their swimming style. Also, observations in an artificial ladder showed a series of ascents and descents before fish reached the top of the ladder. This suggests that any ladder for sturgeons should allow fish to descend without injury and loss of upstream

ascent drive. Experiments with several species of sturgeons in a prototype side-baffle ladder allowed fish to swim continuously during ascent and did not harm them during descent. Fish moved freely up- and downstream like they might use a semi-natural channel.

Plans are to install the prototype at a dam in 2015 or 2016 to field test the design.

Presenting Author Bio:

PhD - 1972, Fisheries Biology; College of Fisheries, Univ. of Washington, Seattle
Coop Fish Res. Unit (FWS) @ UMass, Amherst for 12 yrs; Conte Anad. Fish.

Res. Center (FWS & USGS), Turners Falls, MA for 18 yrs.

36 years of research on life history behaviour of diadromous and freshwater migratory fish, particularly sturgeons, and up- and downstream fish passage at dams in N. America, China, Romania, and Brazil.

Considerations and Alternatives for Safe Downstream Passage of Juvenile and Adult Sturgeon at Hydro Projects

First Author Name:

Steve Amaral

First Author Affiliation:

Alden Research Laboratory, Inc.

Abstract Body:

Fish passing downstream through hydro turbines may be subject to mortality rates between 5 and 30%, depending on species, fish size, and turbine design and operation. Juvenile and adult sturgeons may encounter multiple hydro projects during seasonal downstream movements and, consequently, some populations can be susceptible to potentially high rates of turbine passage and mortality. Although most downstream fish passage technologies have been evaluated with a wide variety of freshwater and diadromous fishes, relatively few studies have been conducted with sturgeon species. Turbine passage mortality typically is mitigated through the use of physical screening devices that reduce entrainment and guide fish to alternative downstream passage routes. Several lab and field studies have investigated guidance and exclusion of sturgeon exposed to various configurations of narrow-spaced bar racks and louvers, with effectiveness typically

being dependent on bar spacing, structure angle to flow, and approach velocity. Bypass design and location are also important to passing

sturgeon safely downstream. Laboratory data suggest bypass entrance

velocities should be about 1.5 m/s or greater to effectively attract and pass sturgeon. For fish that pass through turbines, there is evidence that sturgeon may be less susceptible to injury and mortality than many teleost species. This is likely due to their tough integument, lack of scales, and cartilaginous skeleton, all of which probably contribute to lower rates of blade strike mortality. A review of recent studies examining downstream passage alternatives for sturgeon will be presented, as well as assessments of total project survival that account for passage route selection and associated mortality rates. With this information, the need for and feasibility of downstream passage facilities for sturgeon can be evaluated and used to develop appropriate mitigation measures.

Presenting Author Bio:

Steve Amaral is a Principal Fisheries Biologist with Alden Research Laboratory, Inc., located in Holden, Massachusetts. He has B.S. and M.S. degrees in fisheries biology, both from the University of Massachusetts. For more than 20 years, Steve has been extensively involved in the design, evaluation, and application of fish passage and protection technologies at all types of water intakes. He has participated in laboratory and field testing with various screening technologies, angled bar racks and louvers, and behavioral guidance systems. In addition to upstream and downstream passage, Steve's hydropower experience includes instream flow assessments and turbine passage survival evaluations for conventional and hydrokinetic projects. He has lead investigations of injury mechanisms experienced by fish passing through turbines and has assisted with the development of theoretical models for predicting turbine passage survival. Much of Steve's fish passage experience has included studies with endangered or threatened species, including American eel, shortnose and lake sturgeon, and Atlantic salmon.

SESSION A6: Fish behaviour and fishway monitoring

Five years monitoring of the original "stairs pipe" fish pass assess the complete reconnection and natural function of a nursery tributary for its main river

First Author Name:
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Abstract Body:

The sedentary trout population dynamic of a main river and its tributary has been studied in the Ardenne (Belgium) for more than fifty five years. It shows a population division between the nursery brook dominated by the juveniles and the river by the adults. Every winter, several hundreds of spawners migrate to the brook to reproduce and when the offspring fingerlings are 1 or 2 years old, they swim down to the river for a quicker growth. This ensures the river population sustainability.

Close to this well documented system, another one is disturbed by an obstacle preventing any spawning run. The result is an isolated brook population made of all age class with an evident lack of numerous juveniles. The obstacle consists in a fall added to a sloped culvert. Two fish traps downstream to the fall showed very few emigrating fingerlings and much less spawners attempting to jump the obstacle than at the well connected brook.

In 2008 an original fish pass was built to bypass the obstacle. It is a "stairs pipe" made of standard particular pipe elements provided with an inclined baffle. Alternating the position of these elements creates a sinuous flow that breaks the water velocity. Secondly it creates every two meters a small jump and an intermediate rest place with a slow backwater current. So this 24m long fish pass can be very easily crossed.

The reconnection results have been monitored for five years by migrating fish trapping and population inventories. It

showed the tributary natural function rapid recovery. The migrating spawners came rapidly nearly as numerous in the reconnected brook as in the naturally connected one. The brook population structure changed also significantly with a relative increase of the juvenile fraction. Consequently, the tributary contribution to the main river recruitment was also significantly boosted.

Telemetric survey of upstream and downstream migrating species at the river Elbe, Germany

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Abstract Body:

The detection of movement patterns of species in rivers can be realised by acoustic telemetry. From 2012 till 2013 a survey on migrating species by means of telemetry was conducted in the river Elbe focussing on following questions: How do successful upstream migrating fish behave after swimming through a fish pass? To what extend is a direct downstream migration taking place? The investigation area is located 30 km upstream the city of Hamburg in the 400 m width headwater of the weir Geesthacht. The migration barrier is equipped with a new double slot pass at the north bank and a natural like channel (since 1996) at the south. 6 anadromous (n=161) and 10 potamodromous (n=127) species were tagged with an acoustic transmitter after passing the fish ways successfully. Additionally a group of tagged Atlantic salmon smolts (n=76) were released 8 km upstream the weir. 21 hydrophones were installed along the river banks over a section of 4 km upstream the weir to detect the movement patterns of the released specimens. Very good redetection quotes were achieved: 68% of anadromous as well as 65% of potamodromous species and 95% of salmon smolts were redetected.

Several typical behaviour patterns have been observed: No matter, if the tagged fish were released at the head of the old or the new fish pass, the upstream migrating anadromous specimens tend to follow the current flow to pass the investigation area very fast and in beeline. Also the salmon smolts migrated immediately in just 4 hours throughout the headwater and pass the weir. Not even local turbulences e.g. caused by a pumped storage plant could affect this movement patterns. In contrast potamodromous fish show a remarkable unsteady cruising behaviour and just one-third continued their upstream migration along the same river bank where they had been released.

Presenting Author Bio:

Juliane Klan, born in 25.08.1986 in Templin, is an expert of (Marine) biology. Employed at the Institute of Applied Ecology in Marschacht, Germany since January 2014, Juliane Klan is engaged with the protection of fish species, within the scope of the fish monitoring at River Elbe. Amongst others she is commissioned with the monitoring of upstream migrating fish species at the fish pass in Geesthacht and at the water inlet of coal-fired powerplant "Moorburg" in Hamburg. Apart from that Juliane Klan is involved in projects of fish tracking, by means of Telemetry and HDX transponder technology. She holds a Bachelor of Science in Biology (Berlin University 2010) and graduated in Marine Biology at the University of Rostock in 2012.

Using GIS to Evaluate Fish Passage

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Abstract Body:

Behavioral studies have been conducted over the last several years to assess

downstream passage of juvenile salmonids, upstream passage of shad and reservoir movement of white sturgeon at hydroelectric facilities in the United States. Acoustic transmitters were surgically implanted into run-of-river fish and detection arrays were configured to track acoustically tagged fish. GIS analysis of fish approach and passage has provided valuable information to hydropower engineers who were seeking alternatives to operational configurations that would increase passage rates. For juvenile salmonid studies, GIS spatial analyses have included the evaluation of passage route efficiency, relative percent passage densities, normalized bin densities, approach elevations and top-spill non-selection. Passage route efficiency was measured by the proportion of smolts that selected a particular route of passage (powerhouse, top-spill or spillway). Relative percent passage densities and normalized bin densities highlighted zones of use in the forebay. Both passage route efficiency and relative percent passage were correlated to operational configurations. Approach elevations were analyzed for smolt positions within 300 feet of the dam. Top-spill non-selection presented three-dimensional positions of smolts that had approached within 300 feet of the top-spill bypass structure but did not pass. All GIS analyses were examined for trends between years and species and have led to operational configuration modifications to provide increased successful smolt passage. The GIS analyses used during these behavioral studies will be presented.

Presenting Author Bio:

Rolland (Rod) O'Connor, M.Sc., is a Senior Fishery Biologist/Project Manager with a diverse background in fish passage evaluations and telemetry-based fish behavior studies. Rod is proficient with telemetry tools including active and passive tag technologies. Rod specializes in synthesizing telemetry data with other factors such as migration timing, environmental conditions, and dam operations to address challenging study questions. In recent years Rod has acted as Project Manager in field studies evaluating improvements to juvenile salmonid passage through prototype passage structures at lower Snake River hydroelectric dams operated by the U.S. Army Corps of

Engineers. He has also managed studies investigating predator-prey interactions between juvenile steelhead and piscivorous fishes in a mid-Columbia River reservoir. Rod is currently the Project Manager for the Pacific Lamprey Management Plan implementation team covering two mainstem hydroelectric dams in the mid-Columbia River.

Fish behaviour analysis in a vertical slot fishway

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Abstract Body:

The improvement of devices that allow the upstream and downstream migration of fish through hydraulic constructions in rivers is nowadays a real priority to maintain the continuity of the biodiversity. Among lot of constructions, the vertical slot fishways (VSF) are commonly used and are effective in ensuring unhindered passage of the large sizes fish. A typical problem is that, first, fishes have to find the entrance of the fishway and, when they have found it, small sized fish can encountered difficulties to progress due to the inappropriate flow conditions. This comment is highly linked to the fish locomotion modes that depend to the species in regard with turbulence (kinetic energy, Reynolds stresses, vorticity, strain, eddy length scales) and the instantaneous flow features. In general, fish tend to avoid flows that have unpredictable, wide fluctuations in velocity that interfere with swimming trajectories. Unfortunately, those conditions based on fish swimming capabilities could not be anticipated by the commonly-used criteria to design VSF. At consequence, a better understanding of the relationship between fish swimming behaviour and accurate hydraulic conditions in a VSF is necessary.

This study investigated the swimming behaviour of small-sized chubs, ($8 \leq TL < 12$ cm), under experimental VSFs flow conditions. All the fish movements between pools were video-recorded and analyse with view point of fish movements between pools, stabling zones, transit time and trajectories. Flow turbulence and instantaneous evolution of the flow were analysed using PIV and ADV datas and were related with fish swimming behaviour. The influence of turbulence on the swimming behaviour was assessed for original VSFs and modified VSFs by addition of one or three cylinders. The results show that flow in existing vertical slot fishways can be adapted with the addition of vertical cylinders inside each pool.

Presenting Author Bio:

Professor David is involved in Ecohydraulics since 2002. His team works with the French Agency (ONEMA) to improve upstream and downstream migration. Experimental, numerical and field measurements are conducted and associated with biological observations.

Timing, frequency and environmental conditions associated with mainstem-tributary movement by a lowland river fish, golden perch

First Author Name:

Wayne Koster

Other Authors:

2. David Dawson

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2. Department of Environment, Land, Water & Planning

Abstract Body:

Tributary and mainstem connections represent important corridors for the movement of fish and other biota throughout river networks. We investigated the timing, frequency and environmental conditions associated with movements by adult golden perch (*Macquaria ambigua*) between the mainstem of the mid-Murray River and a tributary, the Goulburn River, in south-eastern Australia, using acoustic telemetry over four years. Golden perch moved freely between mainstem and tributary habitats. The results of the study indicate that a

spatially and temporally complex relationship between adult golden perch movement, river discharge and water temperature plays a key role in connecting mainstem and tributary populations of the species. The relatively common occurrence of movement across the mainstem–tributary junction suggests that this geographic feature does not function as an impermeable behavioural or demographic boundary between populations in the two rivers. This finding highlights the fact that fish populations do not necessarily conform to artificially constrained management units, and demonstrates the need to consider the spatial, behavioural and demographic interdependencies of aquatic fauna across riverscapes. Although they are often complex, the behavioural mechanisms and associated environmental conditions that influence connectivity across mainstem–tributary interfaces need to be understood and accounted for during development of models that underpin management actions for riverine fishes.

Presenting Author Bio:

Wayne Koster is a scientist (fish ecology) at the Arthur Rylah Institute for Environmental Research with over 10 years' experience in fisheries research and management. The focus of much of Wayne's recent work directly relates to the movement and migration of threatened native fish, and responses to conservation initiatives such as environmental flows. Wayne has an extensive knowledge of the ecology and habitat requirements of Australian freshwater fish and is currently leading projects to evaluate the effects of environmental flows on native fish movement and reproduction in various inland and coastal rivers in south-eastern Australia.

Chub (*Squalius cephalus*) and catfish (*Silurus glanis*) migration at a barrier in the River Demer (Belgium)

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Research Institute for Nature and Forest

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2. David Buysse

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Abstract Body:

Longitudinal and lateral connectivity of rivers is necessary for fish to successfully fulfill their life cycle. Three hydraulic constructions prevent fish migrating from the sea to the upstream part of the river Demer. In support of the plan to enhance fish migration along the third barrier, upstream migration of chub and catfish was studied during the spring and summer of 2014 using acoustic telemetry (Vemco technology: V13 transmitters, VR2W data loggers). Beside the barrier, the potential of a small tributary as a natural bypass was studied. Only large chub and catfish succeeded in migrating upstream along the barrier after many trials, indicating a very small chance for fish to pass this barrier. Although the attractiveness of the tributary was smaller, it was more efficient than the barrier, suggesting its potential as a natural bypass channel to upstream spawning habitat in the river Demer. Research on the relation with discharge might further support the local water managers in enhancing the attractiveness of the tributary and its potential as a natural bypass for upstream migration.

Presenting Author Bio:

Since Marche 2014, Ine is freshwater fish biologist at the Research Institute for Nature and Forest in Brussels (Belgium). From 2010 to 2014 she studied Northern pike migration and the spatio-temporal modelling of pike populations during her PhD at the faculty of Bioscience Engineering of the Ghent University. Ine has experience in evaluating fish migration using radio- and acoustic telemetry.

SESSION B6: Fishway design

Seeking better fishways: the Pump Fishway Project

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Abstract Body:
A surprising hiatus affects fish research and management. Those of us working in fish passage strive to move fish past barriers. Aquaculturists, on the other hand, move fish around fish farms safely and effectively. Marrying these two approaches presents an exciting opportunity for fishway development. Millions of fish-passage barriers remain in rivers globally, together with many under-performing and costly fishway investments, resulting in declining biodiversity and production of freshwater fish. Better approaches to fishway design are urgently needed to aid in halting this worldwide loss of connectivity

Multidisciplinary work at UNSW Australia aims to refine and test a pump fishway. This novel concept integrates technologies from fish passage and aquaculture to improve fishway performance and reduce costs. Fishways knowledge is being combined with pumping techniques routinely used in aquaculture to safely transport large biomasses of fish from across a broad size range. The pump fishway uses a helical fishway section to provide sufficient

elevation for fish to be gravitated into a transfer chamber, which is then pressurized with water piped from the reservoir. This flow carries fish up a rising transfer pipe and a small auxiliary pump finally delivers fish into the reservoir.

A pump fishway offers many potential benefits: effective upstream passage for migrant fish communities; lightweight, modular construction with few moving parts; applicability to diverse sites and barriers >1.5 m high; energy-independence using hydraulic power from the reservoir to drive the system; continuous operation with brief transfer cycles; and potential barge-mounted use providing mobility, flood protection and fewer constraints due to tailwater levels. Large savings on capital and operating costs are predicted. Research and development are planned to optimise and validate the pump fishway design, using physical and computational hydraulic modelling and animal trials with wild, migrating fish.

Presenting Author Bio:
John Harris is a fisheries scientist and river ecologist working in research and management of Australian freshwater fishes. Following employment as a research leader in government and academic fields working in fish passage, aquatic conservation, invasive species, environmental flows and freshwater fisheries, he now holds an adjunct academic position at UNSW Australia and operates a private consultancy. Fish passage remains a key research interest.

The baffle-brush-fishpass - a New Concept for non-selective fishpasses

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Abstract Body:

The baffle-brush-fishway combines the properties of a superactive baffle (Larinier) fishpass with the features of the brush-furnished fishway. Both types mark the extremes of the hydraulic spectrum in fishpasses. The baffle fishway exposes a high turbulence flow with a mean velocity around 1,1 m/s while the brush-type fishway provides a multiple-structured migration corridor with low velocities. A transition zone provides a continuous crossover of flow properties. Thus, any fish can choose a migration corridor which meets its demands and abilities.

The presentation explains the main features of this type and addresses basic hydraulic calculations such as rating curve, friction factor and design procedure.

Presenting Author Bio:

Head of the the Hydraulics Laboratory and Testing Facilities in the Department of Civil and Environmental Engineering, Institute of Water, Waste and Environment

Hydraulic design of an innovative baffle-brush type fish pass

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Abstract Body:

The flow characteristics (depth, velocity, energy dissipation) of a new baffle-brush type fish pass were investigated experimentally in a 2 m wide rectangular flume which has a bed slope of 4% for discharges ranging between 100-550 L/s. In all experiments quasi-uniform and subcritical flow conditions, Froude number ranging between 0.17-0.23, were observed. The Darcy-Weisbach friction factor was negatively correlated with the relative

submergence of the baffle. The turbulence intensities were ranged between %38-79 in the baffle zone and %13-31 in the brush zone. The hydraulic test results showed that this type of fish pass can produce adequate flow depth and favorable local flow velocities for the design discharge of 0.2 m²/s (relative submergence of brushes=1.03). The hydraulic test results reveal that baffle-brush fish pass fulfill the requirements of an efficient fish passage by providing tranquil flows and sufficient flow depths for different fish species. Consequently, the following design procedure can be used for the proposed baffle-brush fish pass: (i) required flow depth can be specified for the target fish species, (ii) the friction factor can be estimated based on the relative submergence of baffle, and (iii) for the given bed slope, average flow velocity and discharge values can be computed from Darcy-Weisbach formula. The main advantage of the proposed hydraulic design is that we can scale-up all the parts of this type in order to adjust it to almost any demand based on the model test results.

Presenting Author Bio:

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 published more than 40 research papers and his work was cited over 200 times. He has been conducting research on hydropower, environmental hydraulics, and sustainability. He developed an Environmental Risk Index for Small Hydropower Plants.

Archimedes type passage creates an important new fish migration route at pump station Halfweg (Rijnland Water Authority; Netherlands)

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Abstract Body:

Pump station Halfweg is situated west of Amsterdam. It is an important discharge station at the borders of the Rijnland Water Authority and the North Sea canal. The region of the water authority is mostly situated below sea level and surrounded by dunes and dikes. The function of the pump station is to remove excess fresh water from the water authority region and to prevent "salinization". Intrusion of salt water from the canal is prevented by a combination of valves and shutters at the pump station. The valves and shutters are only opened during water discharge. As a result for decades the inward migration of fish was not possible and the fish could not reach spawning and hatching areas.

In 2012 on the fresh water side of the pump station an innovative fish passage was completed. An Archimedes type pump was used. It pumps fresh water into a container at regular intervals each day. The water level in the container is 25 centimetres higher than the average water level in the water authority region and about 5 centimetres higher than the level of the canal.

Furthermore, the container is connected to a one metre diameter 30 metre long pipe, which discharges in the canal. Pumping results in a fresh water discharge in the brackish canal zone, that attracts migratory fish. The velocity of the discharge is about 0,1 m/s. Most migratory fish are capable of swimming against this current. Fish arriving in the container are given the opportunity to escape through a small opening to the water authority region. It is also possible to close the opening in the pipe with valves, to protect the Rijnland region.

During a 6 week monitoring period in the spring of 2013 more than 130.000 fish were counted in a fine maze net attached to the

passage. Most counted were elvers and 3 hatched stickels. Large amounts of elvers were counted in

2014 too; in one week more than 50.000 individuals. The results clearly show the necessity of passages for migrating fish species. Long term monitoring may follow the trends at this location.

Presenting Author Bio:

Since 2003 working at Rijnland Water Authority, principally coordination of hydrobiological research and monitoring. Previously working as researcher at Netherlands Institute of Ecology (KNAW-NIOO-CEME) and Universities of Amsterdam and Groningen.

Design and special constructions of fishway pilot sites on German Federal Waterways

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Abstract Body:

Current scientific knowledge does not cover all aspects of designing fishways on large German Federal Waterways. Therefore, the German Federal Institute of Hydrology (BfG) and the German Federal Waterways Engineering and Research Institute (BAW) together with the responsible German Water and Shipping Authority (WSV) address research questions in a R&D program, focusing on the link between hydraulics and fish behavior. The extensive R&D schedule includes the investigation of necessary auxiliary discharge, the optimum entrance location in the tail water and several other aspects of fishway entrance design (e. g. connection to river bed, design of shut-off devices) as well as the evaluation of different fishway types.

The above questions are particularly important where fishways compete with

hydro-power plants in terms of attraction flow and available discharge. They can only be addressed adequately by the in situ evaluation of hydraulic parameters and fish behavior. Therefore, six fishway pilot sites are planned at barrages with hydro-power on major Federal Waterways.

Two aspects complicate the planning in particular: In order to investigate the effects of variable auxiliary discharge (from base flow up to 5 % of nominal discharge) large and varying amounts of water have to be added to the lowermost pools of the fishway. For these pools, special constructions are necessary to handle the amount of discharge while maintaining the passability for fish. Furthermore, the investigation of different entrance locations requires a sophisticated layout of the channels and pools which connect the entrances to the fishway. In order to pre-investigate details of the special constructions hydraulically, the BAW operates physical and numerical models.

An overview of the research program at the pilot sites, the challenges in the planning process and the accompanying hydraulic models are subject of the presentation.

Presenting Author Bio:

Diploma Degree (Dipl.-Ing.) of Hochschule Karlsruhe Doctorate Degree (Dr.-Ing.) of University of Braunschweig since 2012 at Waterways and Environment Section of BAW.

Hydraulic Research on Fish Passage Design at Lock & Weir sites – Flanders Hydraulics Research

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2. Peter Viaene

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Abstract Body:

Both European and Belgian legislations aim at restoring and enhancing the ecological strength of the water systems. Besides improvement of water quality and protection

through legislation, restoration of free fish migration on the rivers and main waterways. To solve the problem of the disruption of longitudinal habitat connectivity by man-made obstacles such as locks and weirs, fish passages are constructed.

In close cooperation with the Institute for Nature and Forest Research (INBO) of the Flemish Government (hydraulic) research on fish passage design at weir-lock sites on Flemish rivers has been done since 1995 at Flanders Hydraulic Research (FHR). The research is done via scale model tests, field measurements and literature study. To determine the effectivity of a fish passage both passability and attractiveness are assessed. The passability requires limitations to the maximum velocity and minimal depth along the fish passage. The attractiveness is defined as the extent to which fish can find the entrance of the fish passage. To obtain maximum attractiveness an attraction flow at the passage entrance is applied.

The presentation gives an overview of the FHR research. Regarding the passability current results and research questions relating both nature like fish passages as bypass channels and more technical solutions as V-shaped fish ladders and vertical slot passages are addressed. Also previous research on swimming and leaping capacities that has been done with living fish is presented. In recent years several scale model tests have been done regarding the attractiveness of fish passages downstream of weirs applying a perpendicular attraction flow. Current research focusses on the comparison of perpendicular with parallel attraction flows and on sharp bends in V-shaped fish ladders.

Presenting Author:

Klaas Pieter VISSER is a hydraulic engineer with 7 years of experience in hydraulic research and consultancy. He has worked in civil engineering projects in the Netherlands, Singapore and Belgium. Since 2012 he is working at Flanders Hydraulics Research in Antwerp, Belgium. The main topics of his research are the hydrodynamics around and hydrodynamic forces on structures such as dikes, weirs and fish passages. Research is done through scale model tests, field measurements and literature study.

Peter VIAENE has been working as a bio engineer at Flanders Hydraulics Research in

Antwerp, Belgium since 1998. In cooperation with research institutes like the Institute for Nature and Forest Research (INBO) and different Flemish universities he has worked in several projects. Main focus has been on scale model based research on fish passage hydraulics and ecologically sound management of aquatic vegetation.

SESSION C6: Eel and lamprey passage

The Eel Passage Research Centre - A Bi-National Collaborative

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Abstract Body:
American eel is among the many diadromous species that must contend with hydropower projects during migration between freshwater and marine habitats. Provision of upstream passage for juveniles is relatively straightforward and effective for this species; however, downstream passage of pre-reproductive adults presents a significant challenge, especially at large facilities on rivers with heavy debris loads. The Electric Power Research Institute (EPRI) organized and leads the Eel Passage Research Center (EPRC), a bi-national, long-term, collaboratively-funded research program to address this challenge. The research focus is on identifying and developing behavioral stimulus technologies to guide downstream migrating adult eels to collection points for capture and transfer around operating hydropower projects. Research is guided by a 15-member technical committee comprising eel experts from hydropower companies and federal (US and Canadian), state, and provincial resource management agencies. The Center was formed in 2013, with initial funding through 2017. This presentation describes the scope and structure of the EPRC, our collaborative process for research funding and management, and our activities to date.

Presenting Author Bio:

Dr. Jacobson is a Senior Technical Leader in EPRI's Waterpower Program, which encompasses conventional hydropower as well as marine and hydrokinetic technologies. His professional work over the past 25 years has focused on environmental assessment in aquatic ecosystems. Prior to joining EPRI in September, 2009, he worked in the environmental consulting arena, most recently for 13 years as the founder and principal scientist of Langhei Ecology, LLC. Dr. Jacobson's specialty is design, analysis, and interpretation of monitoring and assessment programs to support environmental decision-making. Since 1998, Dr. Jacobson has been a faculty member of the Johns Hopkins University, Krieger School of Arts and Sciences, where he teaches a graduate course on ecological assessment. 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.

Does yellow eel prefer old pool and weir or new vertical slot fish pass during their upstream migration?

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Abstract Body:
The hydroelectric dam of Lixhe in the River Meuse, 323km upstream from the North Sea at the entry of Belgium near the frontier with the Netherlands is equipped with two basin fish-passes: – the old pool-and-weir configuration (OFP) operates at low discharge (0.13m³/s) and – the new vertical-

slot configuration (NFP) operating at high discharge (1m³/s) with attraction flow (1.5m³/s). However, the utilization rate of these fish-passes by the incoming yellow eels remains unknown, because the trap of NFP is not adapted to retain anguillids and small species. Yet, such knowledge is crucial to improve the inland colonization of the species and to increase our understanding of fish-pass utilization given its particular swimming mode. In season 2013, eels caught two times a week using a cone-trap pool in the OFP and net traps in the NFP, were tagged and released the same day 0.3km downstream (n = 396eels). The utilization of OFP and NFP was studied using automatic RFID transponder detection antennas placed in upstream basins of the fish-passes, during years 2013 and 2014. Results revealed that the OFP was the preferred migration route of eels (eel numbers, OFP: NFP, 2013= 88:51 and 2014= 41:16, χ^2 -test, $p < 0.0001$), which was also used earlier in season. Eels displayed fidelity to their catch fish-passes (>70% of the detected eels, annually). Detection rate was high in the year of eel tagging (2013: 35.1%) before decreasing in the following year (2014: 14.4%). Eels used these fish-passes the night from 22:00 to 04:00, at 14-26°C, river flow <200m³/s and whenever waxing and waning phases of moonlight. Our results provide insight into the utilization of fish-passes by migrating eels. The study suggests further reflection before removing the old fish-pass in large rivers and to think about the eel attractiveness and comfort when the construction of a new fish pass is planned.

Presenting Author Bio:

Nzau Matondo Billy is a PhD senior researcher at the University of Liège. He works on eel stock estimation on the River Meuse and implementation of eel restocking tests in Wallonia (Belgium).

The eel ladders at Beauharnois Power station, Canada

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Abstract Body:

The first anthropogenic obstacle encountered by juvenile American eel (*Anguilla rostrata*) in the St. Lawrence River (Canada) during their upstream migration from the Sargasso Sea, is a large hydro dam. The facility is located at Beauharnois, downstream of Lake Ontario, the largest and final growth habitat of this river system. Following preliminary tests from 1994 to 2001, the dam was equipped with a first eel ladder in 2002 on the left bank followed by a second on the right bank in 2004. Eel counts dropped from 1994 to 1998, and then increased from 1998 to 2011. In 2012 and 2013 a sharp decline of numbers was observed while 2014 presents some hope for a return to higher numbers. A strong inverse relationship ($r^2 = 0.83$) was observed between annual counts and mean annual length. In addition, an annual age-length key developed using otolith readings from 2004, 2009, 2011 and 2013 allows us to assign an age to every length-class recorded during these years. In 2004, we observed an age structure distributed from age-1 to age-21, where 83.9 % of specimens were within age-3 and age-6, and a mean age of 5.2 years (s.e. = 2.2). In 2009, the mean age had decreased to 4.1 years (s.e. = 1.8) while the age distribution had narrowed to between age-2 and age-11, with 80.0% of the specimens between 2 and 5 years old, in 2011 the mean age was 4, 4 (age-2 to age 13) and 4,8 in 2013 (age-2 to age-10). This later result reflects the decline of arrival of young eels at the Beauharnois ladders in 2012 and 2013.

Presenting Author Bio:

After some 15 years as a free-lance Limnologist, Mr. Jean Caumartin has joined Hydro-Québec in 2000 as an Environment advisor. He is currently involved on cross-boundaries projects dealing with fish of the St-Lawrence River, mainly American eels and American shad. He has Master degree in Biology, specialized in limnology since 1986.

Efficiency of a vertically oriented bristle pass for upstream moving European eel (*Anguilla anguilla*) and river lamprey (*Lampetra fluviatilis*) at an experimental Crump weir

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Abstract Body:
Globally, populations of diadromous anguilliform fish, such as eel and lamprey, have experienced substantial declines, partly as a result of habitat fragmentation caused by river infrastructure. In the UK, a new configuration of bristle pass (side-mounted and vertically oriented) has been developed to help upstream moving European eel (*Anguilla anguilla*) negotiate low-head structural barriers such as gauging weirs. However, the efficiency of this type of anguilliform pass remains untested, despite regional implementation and recommendation of nationwide deployment in England and Wales. This study investigated the behaviour of European eel and river lamprey (*Lampetra fluviatilis*) as they attempted to pass an unmodified (control), or modified (treatment - with bristle passes installed) Crump weir, under experimental conditions. The experiment was repeated under three hydraulic regimes (low, medium and high velocity) that represent a range of conditions frequently encountered at Crump weirs in the field. Passage and delay were quantified and the influence of hydraulic regime and treatment assessed. Both species were highly motivated to explore their surroundings and move upstream during the trials. Bristle passes helped European eel and river lamprey pass the Crump weir, although interspecific variation in efficiency was evident. Passage metrics and behavioral

reasons for interspecific differences are presented and discussed, as is the need for further research on design optimisation.

Presenting Author Bio:

Jim Kerr undertook an integrated Masters in Oceanography at the University of Southampton between 2004 and 2008. After graduating he worked for a small marine environmental consultancy (Seastar Survey Ltd.) undertaking a range of work including EIAs for the oil and gas industry and acoustic noise pollution monitoring for offshore wind farm projects. He then switched to focus of freshwater aquatic ecology and is currently in the final stages of undertaking of a PhD focussing on fish passage and the behavioural response of fish to complex hydraulics.

Efficiency of a horizontally and vertically oriented studded fish pass substrate for upstream moving European eel (*Anguilla anguilla*) and river lamprey (*Lampetra fluviatilis*)

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Abstract Body:
For diadromous anguilliform fish, such as eel (*Anguilla spp.*) and lamprey (*Petromyzon spp.* and *Lampetra spp.*), conventional fishways function poorly. Often this is a reflection of their alternate life history strategies and/or poor swimming performance in comparison to subcaragiform species, for which fishways are more frequently designed. Unique behavioural strategies adopted by anguilliform fish during upstream migration (such as climbing) provide an opportunity for the development of novel, species specific

solutions. For eel, synthetic bristle board passes have been developed and widely implemented. More recently, boss or studded substrates (commonly referred to as eel or lamprey tiles in the UK) have been installed oriented either horizontally (with upward facing studs) or vertically (and side mounted with studs facing the channel wall) at numerous low-head barriers. Despite implementation in the field, here we will present results from the first controlled study on the efficiency of eel/lamprey tiles. Using a large open channel flume we were able to quantify passage success, passage efficiency and observe the behaviour of yellow phase European eel (*Anguilla anguilla*) and upstream migrant adult river lamprey (*Lampetra fluviatilis*) as they encountered a model crump weir. The weir was either unmodified or modified with horizontally or vertically oriented tiles. The addition of the tiles improved passage; however efficiencies remained low in some instances, particularly for lamprey. Potential causes for poor passage are discussed, as is the need for further research on design optimisation, which if conducted may enable eel/lamprey tiles to significantly improve the connectivity of rivers fragmented by anthropogenic barriers.

Presenting Author Bio:

Since completing a BSc in Environmental Science at the University of Southampton in 2007, my work has focused on mitigating anthropogenic impacts to freshwater environments. Initially this was while working for a river restoration company, and, more recently, through a PhD and Postdoctoral Researcher positions. My experimental research has assessed fish behaviour with the aim of better understanding factors that may limit fish passage performance and to determine the impact of a novel low-head hydropower technology on fish survival. More recently I have quantified the passage efficiency of anguilliform specific fish passes, while field based research has investigated the distribution, movement and activity of brown trout (*Salmo trutta*) in a southern English chalk stream using electro-fishing and radio telemetry.

Experiences of the eel-protective power plant management in the Weser river system

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Statkraft Markets GmbH

Abstract Body:

Legal and political requirements expect all sectors in society to take river ecosystem health and biodiversity into consideration. Statkraft, international leader in hydropower and Europe's largest generator of renewable energy has implemented an early-warning system in combination with a fish-friendly turbine management for all its run-of-river hydropower plants located along the Weser river system.

The European eel (*A. anguilla*) stock is highly endangered and faces multiple stressors such as pollution, overfishing, lack of habitat as well ecological discontinuity through run-of-river hydropower stations and weirs, especially during migrating season (Aug-Feb). When migrating, there is a risk for silver eel getting injured by intake rakes and turbine blades. The eel-friendly turbine passage is currently considered to be the best practice in protecting migrating silver eel by reducing injuries during turbine passage and by significantly increasing the total survival rate. The eel-protective power plant management addresses one critical life phase for the endangered silver eel and is a sustainable, economic as well ecologic long term solution significantly increasing the number of eel leaving European freshwaters, which is, from a management perspective, likely to be the most effective route to improving eel stock. Experiences and results of 3 years operation mode will be presented.

Presenting Author Bio:

Dr. Sonja Stendera is an aquatic ecologist with international research experience in freshwater ecology. She is now the environmental coordinator at Statkraft in Germany responsible for implementing the WFD and fish protection measures at their run-of-river hydropower plants.

SESSION D6: Policy & Management of Fishways on a National Stage

Fishway Offsets - significant opportunities challenged by management realities

First Author Name:
Matthew Gordos

First Author Affiliation:
Fisheries New South Wales

Other Authors:
2. Craig Copeland

Other Authors Affiliations:
2. Fisheries New South Wales

Abstract Body:
Water NSW is the primary bulk water supplier in New South Wales, Australia, managing water resources through the operation of over 300 dams, weirs and regulators. In the early 2000's, dam safety upgrade works were identified at five (5) large dams owned by Water NSW's to bring them in line with contemporary best practice. The dam safety upgrade works triggered the requirement for Water NSW to construct fishways at the dams under the NSW Fisheries Management Act 1994. Following the development of concept designs and costings for Keepit Dam, Water NSW estimated in 2009 that high level fishways at the five dams would approximate \$285 M, a figure viewed as cost prohibitive to the State government and irrigators who had a 50:50 cost share arrangement. Fisheries NSW subsequently worked collaboratively with Water NSW to develop the Dam Safety Upgrade Fishway Offsets Program, whereby fishways would be installed at thirteen (13) high priority weirs located downstream of the original dam compliance sites in order to achieve a greater ecological benefit at a significantly reduced cost of \$45 M. Despite the collaborative nature of the agreement, by 2015 only one fishway has been constructed and another weir removed, with the remaining Fishway Offsets Program being placed on indefinite hold due primarily to the doubling of fishway construction costs

and a change in political sentiment. This presentation (1) details lessons learned regarding management and political considerations that ultimately resulted in program deferment, (2) highlights the ecological and economic opportunities offered by fishway offsets, (3) summarizes guiding principles for the assessment and selection of potential fishway offset sites, and (4) proposes a decision-making framework for future fishway offset proposals.

Presenting Author Bio:

Matthew Gordos manages the NSW Fish Passage Program on behalf of the Aquatic Habitat Rehabilitation Unit within Fisheries NSW. The NSW Fish Passage Program has resulted in over 500 barriers being remediated in the State, improving fish access to over 10,000 kms of 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.

The fish migration strategy on the border rivers Morava and Dyje – international cooperation

First Author Name:
David Veselý

First Author Affiliation:
Povodí Moravy, s.p.

Abstract Body:

The Morava River and the Thaya River forms the permeating axis of the Danube migrant fish species on the territory of the Czech Republic. Both rivers are a significant European migration routes. For this reason, these rivers are subject of intensive investment activities, conceptual studies and strategic migration plans. In both cases, these are border rivers, so there also takes place intensive cross-border international cooperation. There will be described the whole range of ongoing activities in our oral presentation. Then we will focused on detail of the project of ensuring migration of fish on the Thaya River in the National Park Podyjí, which is processed in a Czech-Austrian cooperation and on the project addressing migration permeability of the border stretch of the river Morava, which is solved by joint

Czech-Slovak project. We believe that the international dimension of this issue represents a significant contribution of both projects.

Presenting Author Bio:

Author works for Morava river authority. He is responsible for revitalization of rivers and their flood plain, nature-like flood defence and last but not least for fish migration.

Management and Research - Integrated Swedish Work on Best Available Technique

First Author Name:
Niklas Egriell

First Author Affiliation:
Swedish Agency for Marine and Water Management

Other Authors:
2. Support by Dr Olle Calles

Other Authors Affiliations:
2. University of Karlstad

Abstract Body:

The presentation will give a view of the Swedish integrated work on finding the best available technique due to fish passages. This process includes a dialogue between managers, researchers and companies. The aim is to find the best techniques world wide and produce guidelines that can be used by companies, authorities and others in Sweden and maybe other countries (Norway is represented in the reference-group), working on developing the hydropower in an environmentally good manner. The presentation will give a wide brief of the difficulties and solutions due to legal requirements and implementations, targets on passage efficiency, prioritization etc.

French R&D program on « eel and dams » related to EU Regulation 1100/2007

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2. Philippe Baran
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Abstract Body:

The European eel stock collapsed in the 1980's and is still declining gradually. The main causes of this decline are known: fishing, water and habitat quality, river fragmentation and hydropower plants (HPP) impacts. The European Union (EU) council established a management plan in 2004 and a regulation was initiated (European Regulation CE n°1100/2007) in September 2007 to improve the recovery of the European eel stock. To reach restoration goals, France is engaged in a management plan to act on each of the factors suspected to cause the decline of the species. Concerning the effects of river fragmentation and HPP, a research and development program was initiated in 2009 with several partners. This program, managed by a committee made up of ONEMA, IRSTEA, EDF and other power utilities, has resulted in the development and testing of technical solutions. Fourteen research and development actions have been conducted during 3 years (some of them are still ongoing) and focussed on 2 main themes: blockage of juveniles during their upstream migration and mortalities of adults (silver eel) in the turbines during their downstream migration. By example, the efficiency of different upstream passage devices (i.e., brush type eel pass and other types of passes) have been evaluated. Fish friendly intake criteria have been defined and turbine management experiences have been conducted. Moreover, tools available for the diagnosis of the HPP impacts, turbine mortality and escapement evaluation have been tested and performed. This presentation shows the main results of this program and some operational solutions that have been conducted since.

Restoration of the Haringvliet

First Author Name:
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WWF-NL

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Abstract Body:

The Haringvliet estuary, just south of Rotterdam, used to connect the North Sea to the Rhine and Meuse rivers, until it was closed for water safety reasons by the Haringvliet dam in 1970. With the closure, the dynamic tidal ecosystem turned into a stagnant freshwater lake. Fish such as salmon and eel could no longer move between river and sea and largely disappeared from the rivers.

In 2011 the Dutch government approved a plan to open partly the sluices in the Haringvliet dam to allow salt water to enter a part of the estuary and open up a route for migratory fish to reach their spawning grounds upstream. When this happens in 2018, matters will improve for fish migration. However, much more effort is needed to restore the natural estuarine dynamics and bring back life, ecological and economical, to the delta.

January 2015, WWF-Netherlands, Natuurmonumenten, Sportvisserij Nederland, ARK Natuurontwikkeling, Staatbosbeheer and Vogelbescherming Nederland were awarded a 13.5 million Euro grant by the Dutch Post Code Lottery to realise an ambitious restoration of the tidal landscape of the Haringvliet.

The programme will aim for restoring the tidal landscape of channels, shoals and sandbanks to host salmon and trout, as well as dolphins, porpoises and water birds. Special attention is given to the European sturgeon, which disappeared from the rivers as a result of pollution and overfishing. A rearing station and reintroduction programme will bring back this majestic fish. There will be special attention to reducing the threats of professional fisheries in the Haringvliet estuary and around the dam in specific. Options are to change to different

fishing methodologies and to develop fish free zones around the dam.

The Haringvliet delta is not only in need of an ecological boost, but also an economic one. Public access to restored nature is part of the wider plan.

This approach will provide lots of opportunity for sustainable economic development in the region.

Presenting Author Bio:

Esther Blom is an ecologist and works for WWF-NL since 10 years.

She works on projects both in the Netherlands as well as internationally, e.g. in China.

Present Situation and Actions on Downstream Fish Passage in Germany

First Author Name:
Dr. Christian Göhl

First Author Affiliation:
RMD-Consult GmbH

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Abstract Body:

Due to the high diversity of rivers in Germany, either dewatering to the Atlantic or Black Sea, and the vast diversity of fish species, there is different importance and stages of fish protection matters. Since the Federal Water Act was passed in 2009 the necessity for fish protection at diverting facilities and the need for fish passage devices is embedded in the law.

According to new regulations in recent years, a lot of activities have been carried out in the laboratory research, field tests, implementation and monitoring. A broad discussion of all stakeholders about needs, requirements, state of knowledge and experiences took place under the roof of Environmental Federal Office (UBA).

DWA (German Association for Water, Wastewater and Waste e.V.) is the German representative of the specialist in the field of water management and is in charge of preparing the up-to-date standards with its specialist committees.

The working group on fish protection and downstream fish passage facilities published a corresponding paper in 2005. At the

beginning of 2015 DWA has taken new action to adopt and update the paper according to present knowledge and publish a technical standard for fish protection and downstream passages in Germany by 2017.

This presentation will give an overview of the legal situation in Germany as well as current activities and technical solutions in practice and research.

The spokesperson of DWA will outline current items of discussions and objectives for the DWA Group.

Presenting Author Bio:

Since 2005 RMD-Consult GmbH, Head of Civil Engineering Department, Deputy Managing Director

2004 Doctorate Degree, Thesis: Bypass facilities for downstream passage of silver eels at hydro power plants 1998-2004

Technische Universität München, Scientific employee, department and laboratory for hydraulics and water resources engineering

1998 Diploma in Civil Engineering

SESSION E6: Panel discussion: Sturgeon Fish Passages on Large Rivers (II)

Monitoring strategy of sturgeon behaviour to ensure functionality of future fish pass: the Iron Gate 2 case

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Abstract Body:

Preliminary study on sturgeon behaviour funded by the Dutch Partners for Water Programme and the ICPDR Secretariat (2014) has proven that beluga and stellate sturgeons still arrive at Iron Gate 2 dams (Danube R Km 862.8). High water current and impossibility to access Serbian reach of the Danube in the tailrace of Iron Gate 2 HEP (330 m wide) has prevented us from conducting triangulation with the mobile receiver to detect position of the sites where the beluga sturgeon male tended to congregate.

The preparatory project funded by the European Investment Bank Luxemburg

(2014 - 2015) has adopted a monitoring strategy to achieve the required resolution to positioning the fish pass entrance(s). The strategy is based on four components: (i) detailed 3D bathymetry of the bottom of the river in the area of the tailrace in Romanian and Serbian territorial waters, (ii) water flow velocity profiles recorded at intervals of 100 m, (iii) combined acoustic and radio telemetry tests to achieve the required resolution needed to determine preferred positions in the river of adult sturgeons arriving downstream the dam, and (iv) integration of behavioural data with genetic analysis to distinguish phylogeny of tagged sturgeons in relation to migration seasons and known population segments.

Telemetry tests at Iron Gate 2 dams will be conducted by teams from Romania and Serbia under the guidance of a Norwegian expert. Results of this preparatory project will be incorporated in the planning of a three year large scale study of the behaviour of sturgeons and other migratory fish at Iron Gate dams and reservoirs.

Presenting Author Bio:

Radu is founder (1994) and leader of the Sturgeon Research Group of DDNI Tulcea, involved in numerous sturgeon related projects on the Lower Danube River, Romania.

SESSION A7: Telemetry for Fish Passage Studies - a Look into the Toolbox

Use of Telemetry for Ecological Fish Surveys in Europe

First Author Name:
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Abstract Body:

In contrast to the US, Canada, and Scandinavian Countries there are few and infrequent ecological studies on fish conducted in Europe which use telemetry systems such as hydro-acoustic, radio, or PIT technology. The reason for the infrequent use of these technologies is mostly the high cost of the equipment and lack of experienced staff to operate it. Within the framework of this introductory talk there will be an exemplary selection of recently conducted telemetry studies in Europe that demonstrate the application possibilities of these technologies and resultant findings. Due to the amended European Animal Welfare Act (2014) there exist diverse requirements for actual field work to consider, especially in protocols tagging of lamprey and other fish. The general lack of experience using telemetry technology in Europe makes it necessary to rely on international knowledge for selecting the most suitable technology for a particular research question, and established standards for handling and tagging of specimens to assure normal behaviour and avoid behavioural anomalies. This reliance on previous work completed around the world is fundamental in gaining reliable and significant results from future telemetry studies.

Telemetry Techniques

First Author Name:
Steve Anglea

First Author Affiliation:
Biomark

Abstract Body:

Telemetry techniques have been applied to the complex science of fish passage for over 40 years. Over the past decade there has been tremendous growth in the fish telemetry market with new vendors and new products coming online every year. Researchers often wade through a myriad of study needs and telemetry possibilities in the early stages of planning which often include: the geographic study area, water conditions (ambient noise, entrained air), system cost, tag size, fish weight to tag ratio, tag life, tag broadcast frequency, detection range, binary or 3D data, collaboration with other studies, data management and data processing.

Sorting through the various products in search of a telemetry tool for a specific project application can be a daunting task. Fortunately, in just about every instance, there are telemetry solutions which may be applied to help understand fish movements in a passage environment (bypass, fish ladder, river, etc...). Fish telemetry can be broken down into a few categories from basic to complex: Radio Frequency Identification Tags (RFID/PIT), radio tags and acoustic tags. Each technology has benefits and limitations. RFID tags, for example, are very small (as small as 8 mm long and can be implanted with a needle) and have a relatively limited detection range. Radio tags have a longer range of detection but tags are also larger and have an external antenna. Acoustic tags have the longest ranges and offer 3D capabilities but tags are larger and often more expensive. In many instances, a combination of technologies may be utilized to meet research needs (i.e. tagging fish with both an RFID and acoustic tag). This presentation will provide an overview of current telemetry technologies and a comparison of the benefits and limitations of each.

Presenting Author Bio:

Steve Anglea received a B.S. degree in Zoology from the University of Wisconsin-Madison in 1990 and a M.S. degree in Fisheries Resources from the University of Idaho in 1996. He spent his early years working as a biologist snorkeling streams in Montana and Idaho looking for bull trout. From 1996-2002 he was a

Scientist/Engineer at the Pacific Northwest National Lab in Richland, Washington where his primary responsibility was managing hydroacoustic evaluations of the Surface Bypass Collector and Removable Spillway Weir at the U.S. Army Corps of Engineer's Lower Granite Dam. Steve moved to Boise, Idaho to work at Biomark in 2002 where he is currently the Director of Technical and Applied Services. He has utilized this position to participate in the development new readers and antenna systems for fish biologist in the United States, Japan, Ireland, United Kingdom, and Europe.

Telemetry Data and Database Management

First Author Name:
Cindy Fitzgerald

First Author Affiliation:
Blue Leaf Environmental

Abstract Body:

One of the most overlooked but critical component of telemetry studies is database management. Database management is the cornerstone to providing accurate and creditable data for analysis. In the last decade it has become a necessary element in fisheries research as different telemetry technologies and study designs require different database needs. Researchers can quickly become overwhelmed by the sheer volume and/or complexity of data without an appropriate system of management to organize, store and make vital data accessible in real-time. Some of the tools available for data management include the Microsoft SQL Server with front-end data access through Microsoft Access or WebFOCUS. These programs offer many important functions including the ability to query specific components of data sets, generate reports by pushbutton, run repeatable programming processes and validate data in an accurate and expeditious way. They also reduce the potential for human error by the organization and automation of the process and allows for robust quality control and assurance of data sets. Microsoft Access databases can be easily utilized in the field for data entry and pushbutton data validation and reporting. Microsoft SQL Server is a more complex system typically used for larger data sets

and requires a more skilled manager for proper usage.

Presenting Author Bio:

Cindy Fitzgerald is a Database Manager with 15 years of experience, over half of which have been involved in biotelemetry evaluations assessing both upstream and downstream movement of fish at hydroelectric facilities. Cindy has been responsible for database design and programming, software development and analysis, and managing data and information technology systems as it relates to project objectives. Cindy has worked with scientists in all facets of data collection, processing and management. Her areas of expertise include quality control and assurance of large fisheries data sets through SQL Server and Microsoft Access and summarized data analysis reports (annual acoustic telemetry data sets that have exceeded 100 million records).

Processing and Analysis of Telemetry Data in Fisheries Management

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First Author Affiliation:
Anchor QEA

Other Authors:
2. Sam Haffey
3. Dalton Hance
4. Corey Wright

Other Authors Affiliations:
2. Anchor QEA
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4. Blue Leaf Environmental

Abstract Body:

Advancing technology has facilitated widespread application of electronic devices to monitor fish behavior, often resulting in cumbersome data sets and difficulty interpreting results. Consequently, successful telemetry evaluations are often a result of (1) a well-planned study design, (2) accurate and efficient data management, and (3) appropriate statistical approaches to inform the research question. We describe several case studies with different

technologies, species, and objectives to highlight the importance of data management and analysis. These examples include passage and behavior evaluations of salmon at various life stages, lamprey behavior, and sturgeon supplementation using active and passive telemetry, multiple data streams, and diverse statistical approaches. The successes and shortcomings in the Pacific Northwest can inform telemetry evaluations in both connected and impounded river systems around the globe.

Presenting Author Bio:

Mr. Murauskas has worked in fisheries for 16 years, contributing to a range of passage evaluations including shads, temperate basses, lampreys, trout, and salmon. He recently led the only combined adult and juvenile salmon passage evaluations in the U.S. Pacific Northwest and recalculation of hatchery mitigation for five of North America's largest publicly-owned hydroelectric projects.

A Case Study Highlighting Telemetry Tools: Are Bypass Systems at Wanapum and Priest Rapids Dams Increasing Downstream Smolt Survival on the Columbia River?

First Author Name:

Leah Sullivan

First Author Affiliation:

Blue Leaf Environmental

Other Authors:

2. Curt Dotson
3. Mark Timko

Other Authors Affiliations:

2. Public Utility District of Grant County
3. Blue Leaf Environmental

Abstract Body:

In the Pacific Northwest, downstream migration of juvenile salmon on the Columbia River has been impeded since 1933 by the construction of 14 hydropower facilities. Volitional passage of juvenile fish through turbines at these facilities has resulted in direct mortality and indirect mortality from the effects of dams on the surrounding environment. For over three decades, improving fish passage has been a

high priority on the mid-Columbia River by the Public Utility District of Grant County. Two unique bypass systems have been designed, built, and installed over the past six years to improve fish passage at Wanapum Dam (2008) and the Priest Rapids Dam (2014). Since 2008, fish passage efficiency studies using acoustic and passive integrated transponder (PIT) systems have shown annual variability at both dams. At Wanapum Dam, up to 77% of the juvenile steelhead passed through the bypass system, which is equal to a 66% reduction in turbine passage; the average between 2008 and 2010 was 71%. At Priest Rapids Dam, results from

2014 have demonstrated that a total of 69% of juvenile steelhead passed through the top-spill bypass and spillway, which was a 19% increase in the average non-turbine passage from previous estimates (2008-2010). This case study will be presented to highlight the telemetry tools that were used to evaluate the spring migrants that used downstream passage alternatives in the mid-Columbia River during these studies. The results, fish passage behavior, guidance efficiency, and survival at both dams and the associated reservoirs before and after the installation of both bypass systems, will be discussed.

Presenting Author Bio:

Leah Sullivan, M.Sc., has more than 15 years of experience, and has conducted small and large scale biotelemetry fisheries studies. She specializes in the application, personnel management, and analysis/technical reporting of such studies, including the use of acoustic, radio and PIT tag technologies. Leah has developed study plans and budgets, implemented, and overseen studies and data analysis on various migratory species of downstream and upstream migration, timing, and distribution as it is related to hydroelectric projects; project involvement has ranged worldwide, including the Pacific Northwest, U.S. East Coast, New Zealand, and Germany. Leah has experience in gastric and surgical tagging of fishes and is abreast of the most current SOP's regarding fish handling and tagging procedures; she has overseen all aspects of large and small scale surgical fish tagging operations.

Migrational behaviour of pit-tagged fish at Geesthacht wier, River Elbe, Germany

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Abstract Body:

Nearby the town of Geesthacht, 35 km upstream of Hamburg, exist the only one migration barrier for fish on the German side of the Elbe. This weir was built in 1960 to regulate the tidal influence and to obtain a constant water level upstream. Since 1998 fish passage is provided by a natural-like bypass channel on the left side of the river. On August 1st 2010 Europe's biggest fish pass, designed as a vertical double slot pass, was put into operation on the other stream side. Ever since a fully extended fish ecological long-term monitoring was established at that location. An essential part of this monitoring is the use of HDX-Technology (= Half Duplex) to assess fish migration on short and long Scale. In this context up to 10.000 specimens of anadromous and potamodromous species per annum, e. g.

Atlantic salmon (*Salmo salar*), river lamprey (*Lampetra fluviatilis*), burbot (*Lota lota*) and ide (*Leuciscus idus*) are individually tagged with PIT-Tags (= Passive Integrated Transponder) and released at both river banks up to 3 km downstream the tailwater of the weir. Redetection of upstream migrating tagged individuals is facilitated by frame antennas, which are positioned within the corridors of both fish passes. 7 antennas in the old and 23 in the new fish pass, observe automatically and continuously as well as time-, site- and individual-specific the migratory behaviour. Due to this complex setup at the monitoring site and an above-average amount of marked individuals it is possible to get detailed and unique information about fish behavioural patterns in the tailwater of the weir and in different

fish pass types as well as the period of time needed for the passage of fishways. The results that have been determined will be presented.

Presenting Author:

Nicola Mast is a professional of Landscape architecture and is employed at the Institute of applied ecology since 2010. From June 2013 Nicola Mast is co-commissioned with the management of the branch office Elbe. Surveys of fisheries at the pumped-storage hydropower plant as well as long term fish ecology monitoring at the weir Geesthacht are part of her obligations. Apart from this Ms. Mast also conducted studies on migration patterns by means of acoustic Telemetry and HDX Pit Tag Transponder Technology. Furthermore she investigated the fish stock of streams in the state of Hesse within the scope of the Water Framework Directive 2000/60/EG. Ms. Mast holds a diploma of engineering in landscape architecture from the University of Weihenstephan, where she graduated in 2009.

SESSION B7: FITFISH: Current information needs for effective fish passage management

COST action FA1304: Swimming of fish and implications for migration and aquaculture (FITFISH)

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Universitat de Barcelona (IBUB)

Abstract Body:
The study of swimming of fish is essential for our understanding of the interplay between migration, growth and reproduction in wild fish but also has considerable interest for fish in aquaculture. The main objective of the COST Action FITFISH is to develop a research network in which fish swimming in the wild and in aquaculture is studied for the first time under a multidisciplinary perspective. FITFISH will provide the ground for technological breakthroughs (e.g. more accurate monitoring of migrant fish; design of exercise-“friendly” fish farming facilities), for establishing swimming as an essential factor determining welfare and for demonstrating that swimming can benefit quality production. FITFISH will add value to independent, nationally funded research activities by providing the means to exchange information, promote industrial activities and influence policies at a European level in a new common forum. Activities in FITFISH also include the training and exchange of early stage researchers in the area. For more information: www.fitfish.eu.

Presenting Author:
Dr. Ir. Arjan P. Palstra is a physiologist with a passion for fish and expertise on exercise physiology, biology of reproduction and the use of molecular tools for fish research. His research area is interdisciplinary, in-between aquaculture and the natural environment, in-between fundamental and applied science, in-between IMARES and Wageningen University.

Current information needs for effective fish passage management: prioritization and recent developments

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Abstract Body:
Migratory fish species form an essential part of the ecological quality of surface waters. The strong human influence on many water bodies in Europe has had detrimental effects on populations of migratory fish species, which have declined or even disappeared in many cases. Measures to restore migration often have, until now, a strong ad hoc character. Therefore there is need for a profound, integrative scientific approach, leading to a framework for analysing migration and the design of effective measures. We will present an agenda for the exchange and integration of knowledge among scientists and experts and for the development of a research agenda aimed at generating new knowledge in the fields of 1) monitoring fish behaviour in real-life situations, using a range of well-known and high-tech techniques; 2) experimental approaches in which the effect of disturbing cues on behaviour and physiology of individual fishes is investigated, and 3) modelling the effects of mitigating measures on population dynamics.

Presenting Author Bio:

Leo Nagelkerke is lecturer in Fish Biology and Fisheries at Wageningen University and mainly interested in changes in fish communities under pressure and food-web interactions

Efficiency and suitability of the fish passages in River Ceyhan, Turkey

First Author Name:

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Abstract Body:

The efficiency of the 2 different fish passages in River Ceyhan, Turkey were investigated by trap catches, external tags, PIT telemetry and radio telemetry. Fish were caught by electrofishing downstream of the fish passage. They were marked with tags and released downstream of the fish passages.

Automatic PIT-tag logging station and a trap were positioned at the upstream exit of the fish passage. Radio tagged fish were also tracked by a receiver and antenna, manually.

The pool type fish passages was ineffective because none of the fish were found in the trap and none of the 25 radio tagged fish were passed. As for the vertical slot fish passage, a total of 495 *Capoeta angorae* and 280 *Alburnus kotschyi* were caught into the trap. Migration movements took place between May 01 and July 21. Thirteen individuals (10.7%) of the 122 external tagged *C. angorae* and 24 individuals (15.4%) from the 156 PIT tagged *C. angorae* passed. Similarly, 18 individuals (75%) among the 24 radio tagged fish passed. These different

passing rates was because of tagged fish sizes ($p < 0.05$). The mean length of the *C. angorae* passing through was 19.4 cm (11.0-39.7 cm) and the mean length of the *A. kotschyi* was 15.6 cm (10.1-19.8 cm). Tagged fish sizes varied from 13 to 26.5 cm (19.8 ± 2.75) for the external tagged fish, from 11.1 to 28.3 cm (16.6 ± 3.6) for the PIT tagged fish and from 24.5 to 46.4 cm (31.3 ± 5.85) for the radio tagged fish. However, the size of the fish passing through were 20.5 ± 1.72 cm (18.6-24.0 cm) for external tagged fish, 22.0 ± 3.6 cm (13.7-28.3 cm) for the PIT tagged fish and 31.5 ± 6.17 cm (25.5-46.4 cm) for the radio tagged fish. There is a strong relationship between the sex of the migratory *C. angorae* and their migration time (day) ($R^2 = 0.998$).

On the performance of a new upstream and downstream passage facility for diadromous fish species

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Abstract Body:

The River Ätran is an important river for diadromous fish species on the Swedish westcoast. Wild populations of wild Atlantic

salmon, brown trout, European eel and sea lamprey enter the river for spawning and growth. The conditions for migratory fish species are improving in the river since rehabilitation efforts now address the needs of all diadromous species and life-stages, and not only upstream moving salmonids. This presentation presents results from before and after the construction of a new two-way passage facility at the Herting hydroelectric plant (HEP) near the river mouth.

The old facility consisted of a Denil fishway for upstream passage and spill gates for downstream passage. The total passage efficiencies (TPE) differed among species and life-stages, with 70-90% being recorded for salmon spawners, smolts and kelts. The corresponding TPE for juvenile eels was 10-50%, 70% for silver eels and 0% for sea lamprey spawners.

The new facility consists of a large nature-like fishway for upstream passage and a low-sloping 30° β -rack and a full-depth bypass for downstream passage. Evaluation of the new facility is in progress, and preliminary results indicate a high passage survival of about 90% for salmon smolts and spawners. Most silver eels managed to pass successfully (97%), but the HEP was only operating for part of the study period; TPE for silver eels and sea lamprey will be evaluated during 2015.

Presenting Author Bio:

Olle Calles is an associate professor in fish ecology at Karlstad University, Sweden. He has a PhD in biology from 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.

Restoration of longitudinal connectivity of the Danube River by the construction of free passages for migratory fish species at the Iron Gates dams

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Abstract Body:

The first impassable obstacles for the fish migration along the River Danube from the Black Sea are represented by the Iron Gates I and II hydroelectrical dams, constructed in 1972 and 1984 on 943 and 863 river kilometers, respectively. Construction of fish passages on these dams would make more than 800 river kilometers upstream reopened for fish migrations.

The Iron Gates dams are jointly operated by Romania and Serbia and they represent the

largest hydropower dam and reservoir system along the Danube River basin. Among migratory fish species affected by these dams are three critically endangered sturgeon species and Pontic shad (*Alosa immaculata*) as anadromous species, catadromous European eel (*Anguilla anguilla*) and more than 10 potamodromous fish species. Differences in time of upstream and downstream migrations have to be taken into account while considering the provision for free passage through the dams, as well as total lengths of upstream migrants, especially of species such as beluga sturgeon (*Huso huso*) that can reach total length of more than 3 m. Preliminary fish passage feasibility study could involve investigation of local hydraulic conditions at different discharges and operating conditions of dams, as well as investigation of fish behavior when they approach dams during migrations by fish tracking, telemetry, and Didson or Aris camera. Romania and Serbia could develop research teams for continual monitoring of fish behavior in the vicinity of dams, as well as in the reservoir between the two dams, based on the best experiences from other countries. Common work of biologists, ecologists, hydrologists and civil engineers is necessary regarding data collection, review of existing data, as well as for evaluation of the fish passage alternatives. Involvement of governmental agencies, local authorities, hydropower managers, researchers and NGO's from both countries is one of the prerequisites for successful completion of fish passages.

Presenting Author:

Mirjana is research professor in Institute for Biological Research University of Belgrade, Serbia. She carries out research on conservation biology, ecotoxicology, population ecology, and conservation and management of sturgeon species. She was involved in scoping mission for first preliminary assessment of the feasibility for providing free passage to migratory species at Iron Gate I and II dams (Danube, Romania and Serbia).

All you need is love: adequate information for effective fish passage?

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Abstract Body:

Obstacles like weirs, watermills and locks are a barrier for migratory fish in our watercourses. The fact that specific fish species cannot reach their optimal spawning habitat, can have severe consequences for the survival of these species. Although much numerous fish passes have been designed to solve this problem, these fish passes don't always work optimal. More insight into fish behavior is needed to improve fish pass efficiency, and acoustic telemetry allows such detailed observation of spatio-temporal migration patterns. We present novel findings on fish behavior at anthropogenic structures based on acoustic telemetry. The impact of several constructions like sluices, weirs, pumping stations and small-scale hydropower plants will be assessed and potential solutions to enhance fish migration at these structures will be discussed. This approach will allow to identify crucial information needs for effective fish passage management and reveals a promising range of opportunities for fish passage research.

Presenting Author Bio:

Ans Mouton obtained his degree in Environmental Engineering at Ghent University in 2004. Between October 2004 and October 2008, he was a PhD student at the Department of Applied Ecology and Environmental Biology of the Faculty of Bioscience Engineering of Ghent University under the supervision of Prof. dr. ir. Peter Goethals. His research was supported by Prof. dr.

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As a BOF grant holder he developed species distribution models for fish and invertebrates in rivers. He taught various courses and practical exercises, while he also tutored several Master theses. Ans Mouton presented his work on several international conferences during platform and poster presentations.

In 2006 he was awarded the Best Student Paper and Presentation Award on the iEMSs Biennial Congress (Burlington, USA). He is the author of several peer-reviewed publications in international journals and cooperated with research institutes and universities worldwide.

Since October 2008, Ans Mouton works at the Research Institute for Nature and Forest (INBO) as research scientist Management Aquatic Species and Ecosystems. He was the project leader of different Flemish research projects and participates in several European research projects, such as the COST 626 European Aquatic Modelling Network programme and the Interreg IVB programme 'Living North Sea'.

SESSION C7: Lamprey upstream migration

Migration of river lamprey in the fragmented river Scheldt, Belgium

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Abstract Body:
The disruption of longitudinal and lateral connectivity of rivers has led to ecological catastrophes such as the extinction of several diadromous fish species. River lamprey is an important indicator species for the integrity of ecosystems and connectivity within and between catchment areas. In the highly fragmented River Scheldt basin first restoration actions are undertaken, such as the building of nature-like bypasses. In 2011 and 2012 forty-one adult river lamprey were followed during their upstream migration in the tidal and/or non-tidal part of the River Scheldt and its tributaries using acoustic telemetry (Vemco technology: V7 and V8 transmitters; VR2 and VR2W data loggers). The migration patterns in the river catchment and their behaviour at a tidal barrier, lock-weir complexes and fish bypasses (passage timing and delay) show that the disrupted water management of the river and in consequence of its barriers and bypasses are the key to (un)successful spawning migration in the catchment.

Presenting Author Bio:
David is a freshwater fish biologist in the Aquatic Management group at the Research Institute for Nature and Forest in Brussels

(Belgium). He has more than 10 years of experience in fish migration studies with radio-, PIT- and acoustic telemetry, fish pass evaluations and fish mortality/passage studies at pumping stations.

Passage efficiency and behaviour of adult sea lamprey in a vertical-slot fishway

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Abstract Body:
Dams and weirs are known to have major impacts on migratory fish such as the sea lamprey *Petromyzon marinus* L., but these deleterious effects can be mitigated by the

construction of efficient fishways. The Açude-Ponte dam at Coimbra represented the upstream limit of sea lamprey's distribution in River Mondego until 2011, when a vertical-slot fishway was installed. Since then, several methodologies including visual counts and bio-telemetry techniques were used to monitor its efficiency. In 2014, a total of 221 adult lampreys were tagged with PIT tags to assess the efficiency of the fishway. During the 2015 spawning season, additional 200 lampreys will be tagged to assess the interannual variability of the fishway efficiency. From 28 lampreys tagged with conventional radio transmitters and released downstream of the weir, eight (ca. 30%) successfully negotiated the fishway, reaching the upstream spawning areas in the main river stretch and tributaries. Data obtained from three lampreys tagged with EMG transmitters give a first glance of the fine-scale behavior and muscular effort required during fishway negotiation. Finally, visual counts identified the upstream passage of nearly 8,000 lampreys during the 2013 and 22,000 during 2014 spawning seasons. A statistical model developed with this data clearly shows that the weir discharges significantly influence the migratory behavior in the vicinity of the fishway, limiting its efficiency during high discharge periods.

Presenting Author Bio:

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. At the present time is an Invited Assistant Professor at the University of Lisbon and develops its research among the MARE - Marine and Environmental Sciences Centre. The domain of specialization is ichthyology namely with the study of diadromous species. Present research dedicated to the study of fish migrations.

'Dodgy' barriers: conservation implications and mitigation outcomes for sea lamprey in Irish SACs

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Abstract Body:

Anthropogenic structures in rivers can impede fish passage. In Ireland, weirs were commonly installed on major and minor rivers to harness water power to operate machinery. Many such structures are now derelict. Many had fish passage facilities installed, the target species being Atlantic salmon (*Salmo salar* L.) and brown trout (*Salmo trutta* L.). A combination of Water Framework Directive and Habitats Directive provides a lens to critically examine anthropogenic barriers and their possible impacts on fish species of conservation significance, particularly in channels designated as Special Area of Conservation (SAC) for anadromous species. In Ireland, these species include sea lamprey (*Petromyzon marinus* L.), Twaite shad (*Alosa fallax* L.) and Atlantic salmon. Surveys have identified substantial clustering of sea lamprey nesting sites below the most downstream major weirs on the Irish SACs and limited upstream penetration, as recorded in catchment-wide larval sea lamprey distribution. Ireland has a conservation management objective of achieving unimpeded access to 75% of the main stem channel length for spawning anadromous lamprey migration. The potential for achieving this target was examined in two SAC rivers – the Mulkear (Lower River Shannon SAC) and the Munster Blackwater SAC. Barrier passability or porosity was examined using the SNIFFER barrier tool and information on the status of sea lamprey was generated from spawning site surveys and from catchment-wide electric fishing surveys of larval lamprey. Implementation of barrier

management strategies was associated with substantial increase in numbers and degree of dispersal of *Petromyzon* redds on the Mulkear. The two major Blackwater weirs are scheduled for modification and scope for enhanced dispersal of migrating adult sea lamprey is examined in the context of the design of proposed modification and of available sea lamprey larval records in the Blackwater catchment.

Presenting Author Bio:

Lead scientist on Inland Fisheries Ireland's (IFI) investigations on Annex II Habitats Directive fish species (lamprey, shad and whitefish (pollan)) and Red Data Book Fish (char and smelt). Leads strategies in IFI to examine connectivity and anadromous fish; to improve hydromorphology (under WFD) in arterially-drained rivers; oversees works and monitors impacts of strategies on fish community and on riparian zone.

Can migrating lampreys be effectively guided into fish passage devices using semiochemicals? Evidence from studies in the Laurentian Great Lakes

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Abstract Body:

Fish passage devices often fail for either of two reasons: (1) individuals fail to encounter and recognize the passage device, or (2) fail to successfully negotiate the device once encountered. In the Laurentian Great Lakes the sea lamprey *Petromyzon marinus* is an invasive pest, threatening the persistence of important commercial and recreational

fisheries. For ten years we have been examining the sea lamprey migration and the roles that semiochemicals play in guiding movements, the selection of habitats, and mating behavior. Here, we present evidence from numerous field experiments designed to reveal the extent to which attractive and repulsive conspecific odors may be used to guide migrating lampreys into watersheds, river channels, and devices associated with dams. The evidence strongly suggests that lampreys may be effectively guided to fish passage entrances (and away from dangerous areas, such as water intake structures) through the manipulation of chemical information. We discuss the implications of these findings for achieving improved lamprey conservation.

Presenting Author Bio:

Michael Wagner is an associate professor at Michigan State University where he studies the behavior of native and invasive fishes. His recent work has focused on the movement ecology of the sea lamprey, especially where chemical information plays a role in guiding search behavior and the selection of habitats and mates during the lamprey's annual reproductive migration. The lab is heavily involved in the creation and testing of novel invasive species control strategies guided by insights from large-scale field experiments in behavioral biology.

An EvaEel Ladders as Traps or Passage Devices for Migrating Sea Lampreys

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Abstract Body:

We tested if eel ladders with the right spacing of pegs on slanted ramps can selectively trap migrating sea lampreys. We

compared entry of adult sea lampreys into eel ladder-style traps (ELST) with capture by funnel traps during three seasons in two Michigan rivers. Both funnel traps and ELST caught several thousand lampreys, but only the ELST perfectly retained trapped animals and had zero by-catch of finfish. Mark-recapture experiments revealed significant trap happiness of ELST-caught lampreys. In one river, the ELST catch was strongly biased toward females. At the same site, the ELST caught lampreys with lower average weight and a lower female GSI. We analyzed via PIT tags and video observations of hundreds of nocturnal approaches and attempts to swim up the exposed part of the ramp. The rate of completion of climbs varied considerably between sites and years. Most of the failed attempts were aborted near the base of the ramp; those attempts appeared to be caused more often by a decision to turn around than a lack of stamina to swim all the way up. Manipulations of ramp angle and attraction/ ramp flow resulted in varying rates of attempt and completion: steeper ramp angle and more attraction flow lead to more successful passage over the ramp.

We showed that eel ladder-style traps can selectively catch (or pass over obstacles) adult migrating sea lampreys. While we can't explain the reason for the trap biases we observed, our observations underline that fish passage devices or traps that rely on complex behavior of the target animal will likely select for a subset of the target population. After further fine-tuning of the ramp parameters and flow, modified eel ladders could become a valuable tool for management of adult lampreys.

Presenting Author Bio:

Ulrich Reinhardt received his doctorate from the University of British Columbia. Since 2000, he works at Eastern Michigan University. His expertise is in fish behavior, especially that of juvenile salmon and adult sea lampreys.

Efficacy of an unmodified and modified super active baffle fish pass for European river lamprey (*Lampetra fluviatilis*)

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Abstract Body:

Achieving good upstream passage of lampreys, a threatened group of serpentine fishes, remains a problem. The ability of European river lamprey (*Lampetra fluviatilis*) to pass a Crump weir using a 15% gradient Larinier superactive baffle fish pass during their upstream spawning migration was tested. This type of fish pass has become widespread in Europe in the last two decades, but its efficiency for river lamprey is unknown.

River lamprey were PIT tagged (n=350) PIT, a subsample were acoustic tagged (n=31), and all were released downstream in batches in Oct-Dec 2013.

Telemetry arrays were installed in the pass (PIT) and river (acoustic) and ran throughout the migration period. Attraction efficiency into the fishway (estimated at 90.1%) was good and half of lampreys entered within 24 h of release, but only one lamprey successfully ascended the pass (0.3% passage efficiency), despite many entering repeatedly. Out of 29 acoustic tagged lamprey that visited the weir, four (13.8%) passed the weir directly. The fishway was unsuitable for river lamprey over a wide

range of flows. The pass was modified by addition of vertically mounted peg-and-slot tiles, interrogated at the entrance and exit by PIT telemetry and retested in winter 2014-15. There was an increase in passage success. Preliminarily, out of 197 river lamprey PIT tagged Oct-Dec 2014, 184 (93.4%) were logged at the fishway entrance. 74 (40.2%) entered the tiles at the downstream end, of which 14 (18.9%) swam up through the tiles successfully. Twelve lamprey (6.5% passage efficiency) were logged at the upstream exit of the pass. Reduced flow velocity in combination with increased availability of resting habitat within the tiles may increase the passage efficiency of this type of fish pass for river lamprey. Although increased, passage efficiency, after placement of the tiles, is still considered far from optimal.

Presenting Author Bio:

Jeroen Tummers is a final year Ph.D. researcher at Durham University, UK. His research interests are in the field of river restoration ecology, including the efficacy of fish passage and habitat restoration techniques.

SESSION D7: Pool Type Fishways

Efficiency of two different types of fishway, Ice-harbor and complex type, installed in the Gongju weir, South Korea

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Abstract Body:
As weirs block the longitudinal connectivity of stream, fishway is normally installed to overcome blockage of migration and movement of aquatic organisms. Recently, three large weirs with fishways were constructed for efficient use of water in the Geum River which is one of the major rivers in South Korea. In this study, we monitored two types of fishway, Ice-harbor and complex type, installed at both ends of the Gongju weir in the Geum River using traps and PIT telemetry for three years (2012 – 2014). The complex type fishway consists of ice-harbor type and nature-like type fishway. The results showed that each species used fishway at different time, and it was related with ecological characteristics of each species. Attraction rate was higher at the Ice-Harbor type (8.9%) than complex type (4.2%). Passing rate was also higher at Ice-Harbor type (45.1%) than complex type

(10.8%). Higher attraction rate of the ice-harbor type may relate with large amount of water release from hydropower generator just beside of the Ice-harbor type. There were quite big difference between the passing rate of the Ice-harbor type and complex type. The complex type fishway is three times longer than Ice-Harbor type, and this could be one of the factors that affect passing rate.

Fishway with two entrance locations

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Abstract Body:
In recent years, in the Iberian Peninsula, many fish passes have been built and improved. To ensure the proper operation of these, it is essential to carry out an evaluation and subsequent monitoring, considering both biologic and hydraulic aspects. We analyze the performance of Iberian barbel –*Luciobarbus bocagei* (Steindachner, 1864)– in a technical fishway: pool and weir, with bottom orifice. It is located in the Josefina hydropower plant (Duero River, Valladolid, Spain). Fish ladder has two fish entrances: one in the turbine outlet channel and another in the natural river course. Both the most relevant hydraulic values (flow, velocity, volumetric energy dissipation) and biological parameters (movement pattern, attraction, entry and passage) were measured.

Biological assessment was conducted in the spawning season using PIT tag technology. The main influence on upstream movement was river discharge. There were no preferences between path selection; and ascent success and transit time were similar between two entrances.. Results highlight the importance of two access points for improve entrance and decrease migration delay.

Presenting Author Bio:
PhD. Forestry Engineer. Hydraulics Professor at University of Valladolid.
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Is CFD an efficient tool to develop pool type fishways?

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Abstract Body:
Rivers longitudinal connectivity is compromised by man-made obstacles, such as dams and weirs, which affect fish movements, leading to populations decrease and genetic deterioration. Properly designed fishways re-establish connectivity, allowing for fish migration. The aim of our work is to contribute to a more fast and efficient development of pool-type fishways using hydrodynamic modelling, based on fish behaviour experiments.

Modelling free surface flows in hydraulic structures with complex geometry, like pool-type fishways, with aerated and complex flow patterns, represents a significant research challenge. Knowledge already acquired in an experimental full scale indoor pool-type fishway in previous studies is used. A 1:2.5 scaled fishway of this facility was built and used to characterize velocity and turbulence in a pool-type fishway with

cross-walls equipped with bottom orifices. An offset orifice configuration was used with consecutive orifices positioned on opposite sides of the cross-walls, creating a sinusoidal flow path.

The measurements of velocity fields were made using Particle Image Velocimetry (PIV) and Acoustic Doppler Velocimetry (ADV). Velocity maps were obtained at several positions, for planes parallel to the bottom and parallel to the sidewalls. Parameters that influence fishways efficiency like velocity fields, turbulent kinetic energy and Reynolds shear stresses were determined.

A 3D computational fluid dynamics (CFD) model of the fishway was developed using a commercial software FLOW-3D. Velocity fields, turbulent kinetic energy and Reynolds shear stresses were compared with the ones determined from PIV measurements and ADV measurements and results deviations between experimental and numerical data were analyzed.

The use of FLOW 3D to simulate mean velocity patterns and flow turbulence in pool-type fishways and its use as design tool for new fishway geometries are discussed.

Presenting Author Bio:
Ana Quaresma is a PhD student at Instituto Superior Técnico (IST), Universidade de Lisboa. Her PhD thesis is on developing pool-type fishways based on physical and numerical modelling of flows. Her research interests focus primarily on ecohydraulics and fluvial hydraulics. Before engaging in the PhD she also worked in consulting companies in hydraulics and ecohydraulics studies.

The most evaluated fishway in Spain: A new lesson every year

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Abstract Body:

Salto de San Fernando" hydropower plant is placed at River Tormes, just upstream of Santa Teresa reservoir (Salamanca, Spain). The dam is 13 m high and it has a pool and weir with bottom orifice fish ladder to let potamodromous fish (*Iberian barbel* – *Luciobarbus bocagei*–, Northern straight-mouth nase –*Pseudochondrostoma duriense*– and brown trout –*Salmo trutta*–) overcome the obstacle. This fish ladder is being monitored since 2012: daily trapping and counting fish that reach the last pool; fish passage video recording through orifices and spillways; tagging fish (PIT, T-bar and others) and studying passage metrics (location, entrance, passage time, performance). Results have been analyzed as a function of physical –discharge, temperature, atmospheric pressure– and biological variables –species, sex, size, competition–. Downstream migration is also analyzed to locate fish routes and understand fish behavior. After every research, passage improvement options are detected, accomplished and assessed on next migration season. At this moment, this overall approach has quintupled fish ladder efficiency and it offers lot of information about Iberian fish behavior and their preference under different hydraulic conditions.

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PhD. Forestry Engineer. Hydraulics Professor at University of Valladolid. Principal of the research group GEA (Group of Applied Ecohydraulics). Specialist in fishways design and evaluation.

Optimization of efficiency of step-pool fish-pass channel

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Abstract Body:

Seven years monitoring of the operation of a step-pool fish-pass channel was conducted at the hydropower plant on the River Neisse, Poland. Initial observations, after fishway construction showed that the fish can't pass it. The reason was the high water velocity and the highly turbulent nature of water flow. Also the attraction flow was too slow.

Accordingly, measures to improve fish-pass efficiency were undertaken.

Initially the water velocity was reduced by throttling of inflow by one third. After this a few fish were found in the trap placed at the exit of the fishway. As a next step the thalweg in the lower part of fishway channel was raised by stone layer and 3 additional steps were constructed. Also other parts of the channel bottom were elevated with stones, to reduce slope at some steps. Additionally the openings on each fishway chute were narrowed, in order to further reduce water velocity and to create a sinuous pattern of water flow. These changes lead to a significant reduction of average water velocity. The observations after these modifications showed significant increase of fish-pass efficiency reaching 1.5 fish per hour. Last modification applied was to narrow the attraction flow stream with stones.

This resulted in substantial increase of fish-pass efficiency – up to 5.8 fish per hour.

Presenting Author Bio:

Dr. Paweł Prus is biologist and ecologist educated on the Warsaw University, Poland. He study hydrobiology, inland waters ecology and fisheries. He is involved in development of fish-based tools for river ecological status assessment and methods for fish-pass monitoring. He also study the

ecological relationships between benthic invertebrates and fish, what was a theme of his PhD thesis completed in 2011. He is an assistant at S. Sakowicz Inland Fisheries Institute since 2003.

Entrance arrangement of fishways – interaction of entrance location, turbine flow and attraction flow

First Author Name:
Wolfgang Kampke

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Abstract Body:

Besides passability the attraction of a fishway at the tailwater of a barrier with a hydropower plant is the most important criteria to ensure that a fishway is fully functional.

The relevant national and international guidelines and regulations give recommendations regarding the position of the entrance or multiple entrances, the entrance geometry, the substrate connection and the attraction flow.

Fishways currently planned at federal waterways in Germany, as well as existing structures have various types of entrance arrangements. Mainly three different types can be found that differ significantly in the entrance configuration but comply with the recommendations regarding attraction given by the current guidelines and regulations.

To assess and compare the three different entrance configurations at several relevant hydraulic boundary conditions physical model tests in a 1:10 scale model of a barrier with a hydropower plant were performed. The resulting flow conditions in the tailwater were measured in detail with a 3D ADV probe, related to the behavior and swimming abilities of the relevant fish species and evaluated regarding the formation of a suitable migratory corridor with a significant attraction flow.

Presenting Author Bio:

Wolfgang Kampke is a Civil Engineer with the Federal Waterways Engineering and Research Institute of Germany. After graduating from the University of Karlsruhe in 2002, he worked as research associate at the Institute of Water and River Basin

Management of the Karlsruhe Institute of Technology (KIT).

Wolfgang's work experience includes fundamental and applied research on river restoration, fish passage design, fish behavioral monitoring, physical modeling and hydropower.

He is a doctoral candidate at the Karlsruhe Institute of Technology under the supervision of Prof. Franz Nestmann, KIT and Prof. Peter Goodwin, University of Idaho and his doctoral research focuses on flow parameters, with turbulence in particular, and their influence on the swimming behavior of fish.

In 2011 he joined the Federal Waterways Engineering and Research Institute where he is consulting the Federal Water and Shipping Administration in designing fish migration structures. He is also involved in setting up a multi-disciplinary research program on ecological connectivity and fish migration at Federal Waterways.

**SESSION E7:
Workshop: International
Networking (Hosted by
World Fish Migration
Platform)**

WORKSHOP lead by
J. Royte, J. van Herk, H. Wanningen, L.
Wildman

SESSION A8: Telemetry studies around the world

Passage of Redband Trout at Irrigation Diversion Dams in the Donner und Blitzen River, Oregon

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Abstract Body:
We evaluated passage delays of migratory redband trout (*Oncorhynchus mykiss gairdneri*) at three diversion dams on the Donner und Blitzen River, Oregon. Two of these dams have Denil fish ladders and the third one has a jump-pool ladder. Our study objectives were: 1) to compare redband trout delays among the three dams, 2) to determine whether trout experienced greater passage delay in entering the fish ladders or in ascending after the initial entry, and 3) to identify relationships between passage likelihood and water temperature, discharge, daylight, and fish fork length. An array of Passive Interrogation Transponder (PIT) antennas detected tagged trout, first, when they approached each dam, subsequently when they entered its ladder, and finally when they reached the upper end of that ladder. Therefore, data on ladder entry time, ladder ascending time, and total passage time for individual trout were obtained. Statistical methods for survival analysis were used because they handled both censored data and time-dependent covariates. The results showed that trout were 7 times more likely to pass the jump-pool ladder during the day than during the night, but none of the other parameters were significantly associated with the likelihood of passage. Trout passage varied significantly between each of the dams. The expected median passage time was 0.07 days at one of the Denil fish ladders, 2.1 days at the jump-pool ladder, and 20.4 days at the other

Denil ladder. At all three passage installations, a greater proportion of the total passage time involved ladder entry than ladder ascending. Entry time ranged from 14.6 to 71.5 times longer than ascending time among the three ladders. Our results revealed highly variable passage likelihood and time depending on ladder design, location and attraction flows.

Presenting Author:
Dr. Guillermo Giannico is an Associate Professor and Extension Fisheries Specialist in the Department of Fisheries and Wildlife at Oregon State University, Oregon. He has been conducting research on salmonid ecology and freshwater habitat utilization for over 20 years. In his role as Extension Fisheries Specialist, Dr. Giannico provides information, educational material, training courses and technical assistance to personnel from government agencies, watershed councils, NGOs, fishers, foresters, farmers and the general public on topics such as fish and aquatic ecology, land use impacts on freshwater systems and watershed restoration and planning.

Fishway permeability for two Neotropical long distance migratory species

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Abstract Body:
The effectiveness of fishways should consider the senses of fish movements, both

downstream and upstream, if we really want to have them as a tool to minimize the dam impacts. In this study we evaluated the effectiveness of the fishway of the Hydropower Plant “Engenheiro Sergio Motta” (Porto Primavera dam), Upper Paraná River, southeastern Brazil, during 627 days between December, 2012 and August, 2014. We tagged 995 fish with PIT-tags 23mm, distributed in 628 *Prochilodus lineatus* and 367 *Leporinus obtusidens*. The fish were released both downstream (416 *P. lineatus* and 58 *L.*

obtusidens) and upstream of the dam (212 *P. lineatus* and 309 *L. obtusidens*).

A total of 145 (34.8%) *P. lineatus* tagged downstream concluded the passage and 25 (17.2%) of those passed back. The average time of the upstream movement were 201.4 days, with a minimum of 01h 07min and a maximum of 448 days. Of the 58 *L. obtusidens* released in downstream, 19 individuals (32.8%) ascent the fishway and of these there were no subsequent downstream movements. From 212 *P. lineatus* tagged upstream, 34 (16%) descent the fishway, with a mean of 148.8 days, minimum of 1hr 54min and maximum of 421.5 days. As for the 309 *L. obtusidens* released upstream, 21 individuals (6.8%) descent the fishway, with average time spent 36.6 days, the minimum and maximum time was, respectively, 7.6 and 448 days. The permeability of fish ladder is essential for maintenance of migratory species, especially long distance, providing connectivity between different areas of life (feeding and breeding), in order to maintain the fitness of these target species and its consequent conservation.

Presenting Author Bio:

Sergio Makrakis, Associate Professor and Researcher at Western Paraná State University – Unioeste, Brazil. He is an expert in assessment of impacts on fish populations, fish migration and monitoring fishways. Partnerships with ITAIPU Binacional with assessment and monitoring of the Canal da Piracema, the biggest fishway in the world. Companhia Energetica de São Paulo (CESP) and NEOENERGIA in assessing impacts on fish and monitoring fishways. Also, he realizes assessments of the impacts of boating activities on fish in the Iguaçu National Park-PNI. He has the partnership with the University of Valladolid,

Department of Hydraulics and Hydrology, with which he is also participating in the Life+ Segura Riverlink project sponsored by the European Union as Advisory Board.

A multi-faceted approach for evaluating fishway performance in south-eastern Australia

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Abstract Body:

In the coastal rivers of south-eastern Australia 70% of fish migrate at some stage between the rivers and estuary to complete their life cycle, predominantly as catadromous and amphidromous migrations. A major threat to diadromous fishes in this region is the construction of artificial barriers, such as dams, weirs and road crossings. Traditionally, fishways in Australia were based on those designed to pass salmonids, thus limiting fish passage for the comparatively poorly swimming Australian native species. However, in the past few decades fishway design has been refined to accommodate native species' swimming ability and wide range of body sizes (40-1000mm). Ongoing monitoring programs have facilitated the refinement of modern fishway design to ensure successful passage of the target community.

The Hawkesbury-Nepean and Shoalhaven rivers are the second and fifth largest regulated coastal river systems within the state of New South Wales. Barriers in these systems were retrofitted with either vertical-

slot or high-dam fishways completed over the last six years, together with new environmental flows. Sampling techniques for fishway evaluation on these rivers includes monitoring fish communities above and below the barrier; PIT tagging to assess timing of migration through fishways; and fishway entrance and exit trapping to assess the success of the fishway at passing individual species. Modern sampling techniques such as genetics and stable isotope analysis (SIA) are also being used on historically fragmented habitats to detect changes in population genetic structure and trophic shifts. Finally, analysis of fish movement (derived via acoustic telemetry) in response to environmental variables is providing detailed information on potential migration cues and flow regimes required to stimulate fish movement. This multi-faceted research approach not only provides empirical and real-time data for evaluating the performance of fishways in improving fish passage, but also informs operational managers on their efficiency and assists engineers in refining future fishway design.

Presenting Author Bio:

Chris Walsh is a research scientist with the NSW Department of Primary Industries in south-eastern Australia. His current research interests include freshwater and estuarine fish ecology, in particular, fish behaviour and their response to environmental flows.

An evaluation of fishway passage for Alewife (*Alosa pseudoharengus*)

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Abstract Body:

Alewives (*Alosa pseudoharengus*) are anadromous fish that often encounter fishways when migrating upstream to their spawning habitat. In partnership with Ducks Unlimited Canada, we are quantifying attraction efficiency, passage efficiency and time of movement of alewife through fishways. To do this we tagged 790 fish with Passive Integrated Transponders (PIT) and tracked their movement through two Denil style fishways. Overall attraction efficiency to fishways was 44%, but passage efficiency was $\geq 74\%$.

Tagged fish were most active at dawn and dusk. Tagged alewife detected at the base of the fishway were significantly longer than undetected individuals, and may have been experienced migrants. Our data suggest that quantification of the number of migrants that are motivated to attempt passage of fishways has implications for measures of true fishway attraction and passage efficiency for defining “effective fishways”.

Presenting Author Bio:

MJWS is a Tier II Canada Research Chair in the Ecology of Coastal Environments, and an Associate Professor in the Biology Department at Acadia University.

Small scale efficiency of downstream bypasses and large scale effects of hydropower production for fish populations: An advanced experimental design using radio telemetry

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Abstract Body:

Different technological solutions are currently in use to improve downstream fish passage. However, there is no standardized method of assessing their efficiency. At the same time, negative effects on fish populations caused by river damming are seldom taken into account. Here, an advanced radio telemetry set-up is presented, which provides a standardized method to assess both large scale effects of river damming and small scale efficiency of downstream fish pass solutions. This method divides the river into different sections up- and downstream of the power plant, i.e. i) natural section, ii) reservoir section, iii) power plant section and iv) downstream section. Fixed antenna stations mark the beginning and end of each section, whilst all potential migration corridors at the power plant are also covered by antennas. Antennas are tuned and, if necessary, custom made for each site, providing the ability to adapt the system to most hydropower settings. In addition, manual tracking from the river bank or boat is used to provide higher data resolution and differentiate between live and dead, but drifting fish. Simultaneously to the monitoring of biological data, power production and losses associated with the operation of the bypasses are also documented. Using this design, mortality and migration speed can be compared between natural and impounded river sections. Further, migration route choice can be documented for each fish, thus providing an assessment of bypass efficiency. Using this novel approach, different downstream bypass solutions can be compared, both in terms of their efficiency as well as the system specific large scale effects of river damming, whilst assessing the overall cost to hydropower production.

South African FISHTAC programme: radio telemetry techniques for real time manual and remote, fish behaviour and environmental variable monitoring in southern African inland aquatic ecosystems

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Abstract Body:

Radio telemetry techniques have been used to characterise fish behavioural ecology aspects in aquatic ecosystems to contribute to the evaluation of the ecological consequences of changes in environmental variable states. The South African inland fish tracking programme (FISHTAC) has been established to promote the development of and use of fish movement variables within water resource management in southern Africa. FISHTAC includes an established four phase framework including: Inception phase, Planning phase, Analyses phase and Outcomes phase which if implemented correctly, as demonstrated in the FISHTAC manual, should allow users to implement a fish behavioural study using radio telemetry techniques with minimal error. FISHTAC promotes the use of radio telemetry tracking systems developed and tested by Wireless Wildlife (WW) in South Africa to track fish tagged with small transceivers (tags) in riverine and lake ecosystems manually and remotely in real time. The WW telemetry system uses a digital format and a single frequency. It incorporates a data management system which allows for real time remote monitoring, facilitates communications between transceivers which allows operators to switch from remote to manual modes for example and provides data management and storage capabilities. A feature of FISHTAC includes the ability to incorporate peripheral sensory components into tags. These include depth, temperature and movement sensors (accelerometer) and storage capabilities which can be monitored manually and remotely in real time. The approach also includes triangulation techniques to locate tagged fish remotely. The FISHTAC system is reliable, easy to implement and

capable of addressing a range of ecosystem management and conservation questions. FISHTRAC can contribute to the; awareness of the value of characterising the biology and ecology of fishes and the ecosystems they live in, conservation and management of ecosystems, and the development of telemetry monitoring techniques in South Africa.

Presenting Author Bio:

Gordon is an established aquatic ecologist with specialisation in ecological risk assessments, freshwater and estuarine ichthyology, environmental water requirements and water resource management.

His extensive scientific profile includes the development of and application of regional scale ecological risk assessments techniques throughout Africa.

This includes the development of the PROBFLO ecological water requirement approach and application of the approach for the second phase of the Lesotho Highlands Water Transfer Study. Gordon is also a co-developer of a programme established to promote the use of fish movement in water resource management in southern Africa. Gordon has extensive experience as a water resource manager and contributed to the establishment of various protection measures in numerous catchments in southern and central Africa. Gordon is also an ichthyologist and for more than a decade has been researching aspects of fish biology and ecology and the use of fish as ecological indicators throughout Africa to manage fisheries and the ecosystem in which they occur. Gordon manages the Aquatic Ecosystem Research programme at the School of Life Sciences of the University of KwaZulu-Natal. He collaborates with numerous international scientists on various international projects and programmes including an international Regional Scale Risk Assessment collaboration and a fish behavioural ecology collaboration.

SESSION B8: Fish Biomechanics, behavior & physiology in challenging environments (I)

The representation of three-dimensional space in fish

First Author Name:
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Abstract Body:

To navigate around their local environment, animals must recognise their own position with respect to their goal. This task can be completed successfully if they have a representation of space in their brain, built upon learning and remembering environmental features. This representation can be thought of as a neural map. Previous research has focused on how animals navigate horizontally, however most must also move vertically. This is exemplified by flying or swimming animals, which move with six degrees of freedom (unlike surface constrained animals that move with three). By using behavioural experimental and theoretical approaches, we study both the sensory basis of 3D navigation in fish and also how the information gained from the environment is learned and remembered. We show that the vertical and horizontal components of space are stored separately in the fishes' representation of space, which simplifies the problem of encoding complex information in the brain, and that the vertical axis contains particularly salient spatial cues, including hydrostatic pressure.

We also demonstrate that fish that swim freely through a volume of water are able to accurately learn and remember 3D metric information – that is, distance and direction. Our work suggests that the spatial information obtained by a fish's sensory systems is pulled together into a supramodal representation of space that is similar to the place cells in the hippocampus of mammals. We also suggest the putative neurones that encode space in fish fire with a spherical

distribution, allowing the animals to navigate effectively in three-dimensions.

Presenting Author Bio:

I received a PhD from the University Oxford (Department of Zoology) in 1998 on the social basis of pigeon navigation before taking up a 1year post-doctorate position in UNAM, Mexico. I returned to Oxford as an independent Junior Research Fellow of Keble College where I started to work on spatial cognition, focussing particularly on the use of the lateral line in blind Mexican cave fish. This developed into a larger project on navigation in fishes for which I was supported by a Royal Society Research Fellowship and a L'Oreal Women in Science Fellowship. I became a tenured Associate Professor in Zoology at Oxford in 2009 conjoined with a Tutorial Fellowship at St John's College. The main theme of my research concerns the study of spatial cognition. My group and I use fish as model systems to understand how animals perceive, learn and remember spatial information from their local environment, and how they use this information to orient efficiently. Our work not only has a fundamental importance to animals' survival and success, but also acts as a model for the study of sensory ecology, learning and memory.

The acoustic world of fish: Sound ways to investigate migratory bottlenecks

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Abstract Body:

Many fish species migrate through freshwater river systems related to seasonal or life cycle changes in habitat requirements. Human activities have negatively affected migratory fish populations in many ways.

Especially dams and dikes built for the protection of human populations against flooding often prevent exchange between water bodies. In many places at weirs, locks, or hydropower stations water flow is not only fully or partially blocked, but artificial water flow through pumping systems often yields an alternative passage way with high risk of mortality. Only recently, people are becoming fully aware of the importance of sound to fish survival, reproduction, and well-being. Given the fact that many waters have low visibility, hearing is often the dominant channel available to fish for gathering information about their underwater surroundings. Although cues related to water flow, salinity, or temperature may all be important, underwater sounds can also play a critical role in dispersal decisions of migrating fish. Soundscape orientation, acoustic communication, but also noise pollution can influence navigation abilities and synchronization of migration. Current insights about attraction and deterrence in the field of soundscape orientation and acoustic communication in fish are reviewed in the context of migratory bottlenecks.

Presenting Author Bio:

Specialized in field studies related to the acoustic ecology of birds and fish with outdoor and indoor studies on fundamental and applied aspects. Published over 65 papers in peer-reviewed journals; current h-index 25. Extensive teaching experience at BSc, MSc and PhD-level in: Animal Communication, Signal Evolution, Behavioural Disturbance and Experimental Design.

An Integrative Strategy for Understanding Fish Behavior at Hydropower Forebays

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Abstract Body:

In the last decade, CFD with agent-based models has emerged as a useful methodology to design and evaluate fishway efficiency. However, despite using sophisticated modeling approaches, actual fishway performance varies widely. For certain species, expensive operational or structural changes of the bypasses are needed after biological information became available. Understanding the behavior of targeted fish species is therefore essential in locating and designing fishway entrances. This study presents a methodology that integrates biology and engineering to link fish behavior to hydrodynamics using an inverse problem approach. Chinook and steelhead swim paths were measured in the forebay of Rocky Reach and Priest Rapids dams. 3D CFD simulations of hydropower forebays were performed to model and fully understand the hydraulics of the system. Fish thrust magnitude and orientation, calculated by combining measured and modeled data at every measured fish location, were used to characterize fish swimming behavior at the forebay. Probabilistic distributions for fish thrust magnitude and direction were generated to capture the inherent stochasticity of animal behavior and will be presented and discussed.

Presenting Author Bio:

Dr. Marcela Politano is a Research Engineer at IIHR-Hydroscience & Engineering, University of Iowa, USA. She has expertise in numerical modeling of the hydrodynamics and water quality in rivers, tailraces, reservoirs and fish passage facilities. During the past 10 years, she has supervised over 30 projects for the power industry. She has been the project manager of numerical studies directed at reduction of TDG downstream of numerous hydroelectric projects in the USA.

Three dimensional swimming-fatigue model to predict passage of Asian carp at a lock and dam

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Abstract Body:
There is an acute need to better understand and predict fish swimming activity around lock and dam structures so that their flows can be set to block undesirable invasive species while permitting desirable native species to pass. For example, while the lock and dam system in the Upper Mississippi River presently appears to serve as the primary check to the upstream movement of invasive Asian carps (*Hypophthalmichthys spp.*), we do not yet understand how effective it is or how it might be improved. Our project seeks to identify changes in gate operation that might inhibit passage of Asian carp while having minimal impacts on native fish passage.

To accomplish this, we developed a swimming-fatigue and optimal path selection model to predict the likelihood of upstream passage of fish through three-dimensional turbulent flows. This model extends conventional swimming-fatigue time models to accommodate three-dimensional movements and

selects swimming trajectories following paths of least energetic cost.

Turbulent fluctuations, which are neglected in conventional one-dimensional passage models, are incorporated by changing local velocities according to the level of fluctuations calculated from accompanying computational fluid dynamics models. Likelihood of passage is then estimated

using Monte Carlo simulations which randomly selects model fish with unique swimming capabilities. In this talk we will discuss preliminary model results and how these findings can be used to manipulate gate operation and flow for management purposes. (Funded by the Minnesota Environmental and Natural Resources Trust Fund).

Presenting Author Bio:
Dr. Zielinski is a Postdoctoral Research Associate at the University of Minnesota Aquatic Invasive Species Research Center. He is a civil engineer specializing in ecohydraulics, fluid mechanics/dynamics, and computational modeling. Much of his work has focused on developing acoustic deterrents and velocity barriers for invasive carp.

Changes in fish passage metrics following the co-location of a low-head hydropower turbine with an existing fish pass; revealed by an acoustic tracking study of migratory salmonids

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Abstract Body:

Co-location of hydropower turbine outfalls with fish pass entrances has been suggested as current best practice to optimise the attraction flows for the fish pass and to mitigate the perceived negative impacts of small run-of-river hydropower schemes. To test this a five year acoustic tracking study was instigated to monitor the installation of a low-head Archimedes screw turbine alongside an existing pool-traverse fish pass on Ruswarp Weir, at the tidal limit of the River Esk (England). The study tracked the behaviour of salmon and sea trout as they approached the weir and fish pass and determined the overall passage rate (% of tagged fish ascending the weir by any route), the attraction efficiency (% of tagged fish entering the pool below the fish pass) and the fish pass efficiency (% of tagged fish detected in the pool below the fish pass that ascended the weir via the pass). Over the five years (3 years pre and 2 years post) 138 sea trout and 18 salmon were tracked using acoustic tags with arrays of fixed and mobile hydrophones to determine large-scale behaviour in the tideway and in the approach to the fish pass (a pool-traverse pass, replaced by a Larinier pass during construction of the turbine). The study showed that following the co-location of the turbine and the construction of the Larinier pass there was a significant increase in the attraction efficiency (35% to 69%) and the overall passage rate (35% to 53%) but a significant reduction in fish pass efficiency (100% to 69%) for sea trout. These results support the concept of co-locating outfalls to increase attraction efficiency whilst at the same time raise concerns that this also reduced the fish pass efficiency; perhaps causing a distraction and delay to migrants, with an associated increased risk of predation.

Presenting Author Bio:

Jim's 20 year career in fisheries began using acoustic and radio telemetry to monitor fish movement in impounded rivers. An early adopter and champion of split-beam acoustics and imaging sonar for fisheries monitoring, he has developed monitoring tools and techniques for fish passes and has a long association with technology based fish monitoring methods.

Awarded the Winston Churchill Medal from HM Queen for international work on fish

monitoring, he is a former Editor of FISH magazine and Vice-chair and Fellow of the Institute of Fisheries Management. Jim now manages a team of technical specialists and is responsible, among other things, for providing a fish passage advisory service for the Environment Agency and their delivery partners.

Swimming behaviour of beluga and stellate sturgeons during their migration in the Lower Danube River

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Abstract Body:

The Lower Danube River (LDR) still supports three naturally self-sustaining species of anadromous sturgeons. Beluga sturgeons (*Huso huso*) and stellate sturgeons (*A. stellatus*) are still common while Russian sturgeons (*Acipenser gueldenstaedti*) became very rare. Studying their swimming behaviour is essential for understanding (i) the impact of construction works aiming to improve conditions for navigation; (ii) sturgeon behaviour in relation to Iron Gate hydropower and navigation systems; (iii) behaviour of young sturgeons during downstream migration towards the Black Sea. A significant number of wild adult sturgeons (N= 103; 39 beluga, 1 Russian and 63 stellate) was implanted with acoustic transmitters, with depth and temperature sensors, and their movements were tracked using arrays of submerged automatic receivers installed in the LDR (R Km 60 – 863) during 2009 – 2014. For some of these fish additional swimming depth data were obtained by manual tracking. Wild born

young of the year (YOY) beluga sturgeons (N=27) were captured in the LDR (R Km 123), implanted with acoustic transmitters and released during routine monitoring (June 2010). YOY beluga sturgeons of hatchery origin (N=33) were implanted with acoustic transmitters and stocked in the LDR at R Km 300 and R Km 102 (August 2010). Their movements were tracked and recorded by arrays of submerged acoustic receivers installed on the main Danube (R Km 101) and the three branches of the delta. This paper analyses for the first time on the LDR consistent data (over 70,000 recordings) on swimming speed (upstream and downstream) and swimming depth behaviour of adult sturgeons (beluga and stellate), during spring and autumn migration season, and YOY beluga sturgeons of wild and hatchery origin.

Presenting Author Bio:

Marian Paraschiv is member (2002) of Sturgeon Research Group involved in monitoring YOY sturgeons tagged with different techniques

SESSION C8: Downstream Passage (I)

An Analysis of Partial-Depth, Impermeable Guidance Structures for Downstream Fish Passage at Hydroelectric Facilities

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Abstract Body:

Impermeable guidance structures (or guide walls) are used to improve passage efficiency of out-migrating anadromous fish species. Their purpose is to guide the fish to a bypass (i.e. a sluice gate, weir, or pipe) allowing the fish to circumvent the turbine intakes and safely pass downstream. This paper details a series of experiments (nine total) performed at the USGS Conte Anadromous Fish Research Center located in Turners Falls, MA and a series of computational fluid dynamics models (24 total). The goal of the analysis was to measure the velocity components (x, y, and z) immediately upstream of the guide wall under a wide range of guide wall depths and angles to flow for a specified flow rate typical of a power canal. Multiple metrics are developed that attempt to determine whether or not a fish will 1) encounter swim speeds greater than that of the fish is capable, 2) follow a negative rheotactic behavior and swim below the guide wall, and/or 3) be entrained by the downward flow and pass below the guide wall. The presentation will discuss the history of guide walls in fish passage, introduce both the physical and computational model set-ups, and present the findings of the study.

Presenting Author Bio:

Kevin Mulligan is a Ph.D. candidate in the Environmental and Water Resources Engineering (EWRE) Department at the University of Massachusetts Amherst and a Hydro Research Foundation Fellow. His Doctoral Dissertation focuses on guidance structures for downstream fish passage. In particular, he is studying the design parameters of partial-depth, floating, impermeable guidance structures using both

computational fluid dynamics (CFD) and physical modeling efforts. In conjunction to his graduate studies, he has served on multiple positions (including the Organizing Committee and the Coordination Team) for the International Conference on River Connectivity and Best Practices and Innovations (the Fish Passage Conference Series) since its inception in 2011. He received his Master of Science Degree in Environmental and Water Resources Engineering with a specialization in Fish Passage Engineering in 2013. In 2009, he received his Bachelor of Science degree in Civil Engineering and became an Engineer in Training (E.I.T.).

Downstream migration of fishes at large hydropower facilities: fish behavior and guiding efficiency for angled bar racks and louvers

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Abstract Body:

In Switzerland hydropower production contributes roughly 60% to the electricity supply. However for the protection of fishes almost no downstream migration facilities yet exist. Until 2030 all hydropower facilities have to provide a safe downstream

migration corridor for fishes. In Europe some technological solutions exist to enable downstream migration at small hydropower plants, but no analogous solutions exist for larger hydropower facilities. Guidance efficiency of five fish species (barbel, spirling, brown trout, eel and grayling) was tested in a laboratory flume with modified bar racks and louvers angled at 30 and 15 degree to the approaching flow (0.3-0.9 m/s). The bar spacings were 5 and 11 cm. The test fishes were collected from wild river populations using electrofishing techniques.

A total of 34 different configurations were evaluated. For selected experiments we additionally used a bottom overlay in order to increase the guiding efficiency. All the experiments were documented with video recordings. A detailed analysis of the flow is presented by the companion paper by Albayrak et al. (2015). The main angle of the guiding array (15 or 30 degree) did not have a significant effect on the guidance efficiency.

Apart from the spiralin the increase in flow velocity did not affect the successful bypass passage. The guidance efficiency was

- higher for bar racks and louvers with clear spacings of 5 cm, compared to 11 cm
- higher for bar racks than for louvers (tested with barbel and spiralin)
- considerably higher with a bottom overlay, notably for grayling.

Our studies showed that angled bar racks have a striking potential for diverting European fish species away from turbine intakes. However additional lab and field studies (at a pilot hydropower plant) are needed and more fish species have to be tested.

Presenting Author Bio:

studies in biology at ETH Zurich, Ph D in fish science at ETH, postdoc at the University of British Columbia, Vancouver B.C., Canada, Senior scientist at Eawag, lecturer at ETH Zurich, since 2015
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Development of criteria for the design and dimensioning of fish-friendly intakes for small hydropower plant

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Abstract Body:

To conciliate the hydroelectric production and the restoration and protection plans of migratory species, in particular salmon (*Salmo salar*), sea trout (*Salmo trutta*) and eel (*Anguilla anguilla*), and more generally the longitudinal continuity for fish species, it is necessary to avoid or at least reduce damages to fish passing through turbines. The best way to reduce fish mortality would be to install fish-friendly turbines, but it is not a cost-effective solution on existing installations and in the present state of the art their use is very limited in terms of head and discharge ranges.

Transforming conventional intakes into so-called "fish-friendly" ones is therefore considered as one of the most acceptable solutions.

We present here the development of criteria for the design and dimensioning of fish-friendly intakes for small hydropower plants in France (up to ≈ 100 m³/s until now). These criteria were established from the feedback following the evaluation of existing downstream bypasses in France and abroad, and from hydraulic studies on down-scale models. Fish-friendly intakes comprise a trashrack designed to guide fish towards its downstream end and to the entrances of bypasses, through which fish safely reach the tailwater.

Criteria concern (1) the clear space between bars to avoid the passage of fish through the trashrack and via turbines, (2) the inclination or angulation of the rack to guide fish towards the bypasses located at its downstream end, (3) the normal velocity through the rack to avoid fish impingement, and (4) the number, positions, dimensions, and discharge of bypasses to collect the fish. New formulae have also been proposed

to evaluate head-losses for inclined or angled trashracks with low bar-spacing.

Requirements for the traceability of bypasses for downstream migrating fish - Ethohydraulic insights

First Author Name:
Dennis Appelhoff

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Institute for applied ecology

Abstract Body:

There is a strong demand to build new fish ways due to amended regulations in conservation and restoration regarding the longitudinal passableness of rivers. The upstream migration of anadromous species, like Salmon is well investigated and technical standards for efficient fish passes exist. However, for the downstream movement of diadromous and potamodromous species little knowledge is available. Therefore it is necessary to enhance our understanding for the orientation and behavioural pattern of fish, facing migration barriers, to determine the requirements for a traceable bypass.

Prerequisite for a proper efficiency is a good traceability, which means that the fish do not lose time to find the entrance and accept the bypass as an alternative migration corridor. This is a complicated task because the specific species behaviour has to be taken in account. To investigate the downstream migrating behaviour of fish, a reproducible set up is needed in which the fish can be observed directly, the installed bypasses and peripheral components can be changed easily, while important operating values, like discharge and velocities can be controlled. Nevertheless such a laboratory set up has to have a situational similarity with the real situation in the field (in front of a hydropower plant), so that the results are transferable and applicable. This specific field of Ethology in a through-flow model flume is called Ethohydraulic. The used model flume is completely glazed, 30 m long, 2 m wide, 1 m deep and has the capacity for up to 1 m³/s process water. The study investigates the effect of different bypass shapes, sizes and positions on the traceability and acceptance for fish. Additionally the different alignments of screens and the approach velocity in front of a bypass in competition to a water outlet are

tested with salmon smolts, silver eel and potamodromous fish so far.

River Mill Dam Downstream Migrant Integrated Collector and Bypass

First Author Name:
Peter Christensen, PE

First Author Affiliation:
R2 Resource Consultants, Inc.

Abstract Body:

The River Mill Dam Hydroelectric Development is part of the Clackamas River Hydroelectric Project in northwest Oregon, USA owned and operated by Portland General Electric (PGE). A downstream migrant fish collector and bypass facility was installed on the dam in 2012. The dam was constructed in 1911, and although a fish ladder was included at the time, and upstream passage of anadromous and resident fish has always been provided, downstream passage was only possible through the turbines or over the spillway until the collector and bypass was added. The collector is unique in that attraction water used to entice the fish into the collector is provided by the integration of one of the original five turbine/generators into the collector. This eliminates the need for pumps or the spilling of water to drive the attraction flow, and results in very cost-effective operation. The majority of the attraction flow is screened away from the fish and passes directly through the turbine. The orientation of the collector entrance is also designed to work in conjunction with the powerhouse trashracks in front of the remaining four turbine/generator units to lead the fish toward the entrance. The fish bypass facilities include a sampling station that automatically sorts fish by size and a bypass pipe to the tailrace that combines smoothly at high velocity with a second bypass pipe from another dam upstream. The project has been extremely successful, and has safely collected and bypassed numbers of fish far in excess of its original design capacity in both of the first two years of operation. This presentation will provide an overview of the project, the hydraulic design involved in the unique turbine integration and fish attraction characteristics, and the impressive biological results from the initial years of operation.

Presenting Author Bio:

Peter Christensen, PE is a senior Civil Engineer and Fish Biologist with R2 Resource Consultants in Redmond, Washington, USA. He has 30 years of experience providing engineering design and scientific research to the hydroelectric and water resource industries related to fish protection and restoration. Peter has worked closely with Portland General Electric engineers and biologists on a wide range of fish restoration design projects for the Clackamas River Hydro Project, and led the design of the River Mill Downstream Migrant Collector and Bypass from its concept development through managing the final design and providing construction support.

Turbulent Flow Field Around Angled Bar Racks

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Abstract Body:

VAW of ETH Zurich conducts research on louvers and angled bar racks, so-called 'fish guidance structures' (FGS) for run-of-river hydropower applications. The purpose of the system is to improve the sustainable and efficient usage of hydropower by providing safe downstream fish guidance past the hydropower intake, guidance towards a fish-bypass collection system, and minimizing

negative economic impacts. The FGSs create complex two- and three-dimensional flow structures at different scales in the water column near them and the bypass, which can be sensed and behaviorally avoided by approaching fish. This paper presents the results of an experimental investigation on bar racks with and without a solid bottom overlay angled at 15° and 30° to the approach flow in a laboratory flume.

The bars or slats were angled 45° against the flow direction. The bar spacing, thickness, and length were 0.05 m, 0.01 m and 0.10 m, respectively.

The mean approach flow velocity and flow depth were 0.60 m/s and 0.9 m/s, respectively. Profiles of longitudinal and transversal flow velocity components and turbulence characteristics in the water column were measured upstream, downstream, and around the structures using 2D-Laser Doppler

Anemometer at 1 kHz. The results of the experiments will be presented and discussed in relation to fish guidance efficiency of the investigated bar rack configurations obtained from live-fish experiments. In the companion paper by Peter et al. 2015, the results of live-fish experiments carried out in the same flume for the same and different bar rack, and flow configurations will be presented.

Presenting Author:

Dr. Ismail Albayrak received his M.Sc. in Hydraulic Engineering from Istanbul Technical University in 2003 and obtained his Ph.D. in the field of environmental hydraulics at the Federal Institute of Technology in Lausanne (EPFL) in 2008. He worked for three years in a project on flow-plant interactions at the University of Aberdeen. Since 2011 he has been working as a senior researcher at the Laboratory of Hydraulics, Hydrology and Glaciology (VAW) of ETH Zurich.

SESSION E8: Measuring the success of fish passages: from impact assessments to a virtual ecology approach

**A decision analysis to guide the use of
barriers and fishways for sea lamprey
control in the Laurentian Great Lakes**

First Author Name:
Robert McLaughlin

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Abstract Body:
Decision analysis was carried out to assess barrier and fishway options used to control Sea Lamprey (*Petromyzon marinus*) in the Laurentian Great Lakes. Tensions between use of in-stream barriers to control sea lamprey, and dam removal and provisioning of fishways to reduce habitat fragmentation of native fishes, are arising over a broad geographic scale of ecological and economic significance. Management objectives, barrier and fishway options, and key uncertainties influencing the expected performance of the options were specified in workshops with resource managers. Data syntheses and mathematical models were conducted to project proportional changes in population growth rates of sea lamprey and migratory non-target fishes for each option. Over a variety of circumstances, a permanent barrier with a trap-and-sort fishway best balanced sea lamprey control and non-target effects, but other options ranked higher in specific circumstances. Performance of the management options was sensitive to how fishery managers weight sea lamprey control versus non-target effects. Adaptive management could be used to reduce uncertainty in the performance of different barrier and fishway options.

Presenting Author Bio:

I hold a Partnership in Ecosystem Research and Management Scientist position created between the University of Guelph and the Great Lakes Fishery Commission, a binational agency supporting fisheries management in the Laurentian Great Lakes. My research examines how the behaviour of individual animals affects the biology of populations, communities, and biodiversity, and applies this knowledge to assist fisheries managers. Ongoing research themes include (i) resolving trade-offs between enhancing and reducing connectivity for native and invasive fishes at multiple spatial and conceptual scales; (ii) using behavioural concepts to improve trapping success and control of invasive species; (iii) testing the role of behaviour in the development and evolution of population divergence in fishes, e.g., resource polymorphism and partial migration; and, (iv) understanding mechanisms behind the resilience of stream fish assemblages in agricultural landscapes.

Before we rush into the field

First Author Name:
E.E. van Loon

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University of Amsterdam

Abstract Body:
The aim of this talk is to explain and demonstrate that a 'virtual ecology' approach (i.e. using a model to generate an ecological reality rather than field observations) can be very useful to evaluate an ecological monitoring plan. Three aspects are highlighted. First, the principal steps involved in a virtual ecology approach to monitoring are laid out, using examples on fish passage monitoring. Secondly, it is argued how theoretical model specification as well as its implementation (both necessary to start a virtual ecology analysis) are merits rather than weaknesses of the approach, which help to understand and interpret subsequent field observations. And thirdly, it is shown that implementing a virtual ecology analysis to evaluate fish passage monitoring is not computationally intensive nor theoretically demanding. Hence, it can be done with rather modest means and involve e.g.

field ecologists as well as decision makers to specify system properties and constraints. Presenting Author Bio (short paragraph only - no bulleting or other special characters): I am interested in developing and applying statistical methods that help to understand and analyse ecological systems. Currently I am focusing on the analysis of animal tracking data as well as the reconstruction of population dynamics based on observations of non-marked individuals.

Can we measure cumulative effects of hydro-power on the passage of up- and downstream migrating fish? Development of a cumulative effects model framework

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2. Simon Palmer
3. David Fraser

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Abstract Body:
The Environment Agency provides guidance for run-of-river hydropower schemes in England, but concerns about small effects from multiple single schemes led to a project to determine how these can be assessed and to test an approach on migratory fish populations.

We developed a model to assess the impact of multiple hydropower schemes. The model forecasts catchment-scale cumulative effects using three elements: hydropower scheme, spatial fish population and fish life cycle.

The scheme element includes effects that are important to migratory fish and those that can be quantified. These are: 1) impediment to up- and downstream migration; 2) alleviation of up- and downstream impediment (e.g. fish pass installation); 3) impingement and entrainment; 4) habitat loss to freshwater stages (via a depleted reach). The model can be modified to include other effects if new research is able to provide better

quantification, for example on migration delay causes by barriers.

The spatial population element was developed by applying reference juvenile density values to the wetted area of the river network using Atlantic salmon as a demonstration species. The scheme effects element was then applied to the spatial population element, enabling the salmon population upstream of the scheme, and (via the life-cycle element) returning adults to be quantified and associated scheme benefits / dis-benefits to be applied. The sequential evaluation of multiple schemes in this way allowed assessment of cumulative effects.

A number of hypothetical scenarios confirm that cumulative effects (positive, neutral or negative) were possible. The extent of effects was dependant on scheme location, the combined net benefit / dis-benefit of all schemes and the population status. The model results are sensitive to the precision and accuracy with which we are able to quantify barrier passability to fish and fish pass efficiencies, both of which can be hard to quantify with confidence.

Presenting Author Bio:

Iain has over eight years of experience of fish passage research and assessment. In 2011 he joined APEM Limited after completing his PhD at the University of Southampton concerning 'The response of eel, lamprey and brown trout to conditions associated with barriers to up- and downstream movement under experimental conditions in a flume'. During his PhD he undertook research within large open channel flumes to assess the response of fish to the physical and hydraulic conditions associated with in river infrastructure, e.g. gauging and orifice weirs, and fish screens. Whilst at APEM, Iain has been involved with the majority of projects concerning fish passage, including recent development of a tool to assess the cumulative effects of hydropower schemes on fish, assessment of the potential effects (blade strike, sound, visual etc.) of novel hydro-power technologies on fish movement, and fish pass feasibility studies of literally 100's of structures within the UK (ranging from gauging weirs to pumping stations).

Not just for adults! Evaluating the efficacy of multiple fish passage designs at low-head barriers for the upstream

movement of juvenile and adult trout *Salmo trutta*.

First Author Name:
Michael Forty

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Durham University

Other Authors:
2. Jack Spees
3. Martyn Lucas

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Abstract Body:

Connectivity in salmonid-streams is vital for juvenile as well as adult trout, yet most upstream passage studies consider only larger adults. Upstream passage of juvenile and adult *Salmo trutta* at individual and cumulative low-head (< 3 m) barriers on two tributaries of the River Ribble (NW England) was investigated using PIT telemetry during summer/autumn 2013 and 2014. The efficiency of a low-cost baffle fish pass (Servais, 2006) was evaluated for the first time, along with two more traditional pool-weir passes, an embedded rock ramp and two culverts. We used a combination of naturally migrating *S. trutta* and novel in-nature displacement experiments, where resident fish were displaced from above to below structures and their homing instinct utilised to instigate their ascent of the structure. Each structure was evaluated using several metrics measuring the passage efficiency (PE) and delays incurred before successful passage (time and number of attempts). We show that instigating ascent of a structure through downstream displacement can be successful with up to 91% of displaced fish attempting to pass. Passage efficiencies of up to 82% for the low-cost baffle design were observed, which was comparable to the pool-weir design (up to 84%) and better than the embedded rock ramp (71%). The two culverts had contrasting impacts, with the shorter control (within predicted swim performance) Culvert 1 representing a man-made structure which had little impact on passage efficiency (96% - 100%) and delay metrics compared to Culvert 2 (PE = 41%). Logistic regression demonstrated a strong

body-length effect on passage success at passes, with shorter individuals (< 91–132 mm depending on the structure) having a less than 50% probability of successful passage. The study demonstrates the efficacy of three fish passage designs at low-head barriers and the variation in delay that can be incurred even between similarly designed passes.

Presenting Author:

Michael Forty is a final year Ph.D. researcher at Durham University, UK. His research interests are in the field of river restoration ecology, including the efficacy of fish passage and habitat restoration techniques. He previously completed his M.Sc. in River Environmental Management and and B.Sc. in Geography at the University of Birmingham.

Fish migration possibilities in the Netherlands; state of the art (barriers, solutions, monitoring)

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Abstract Body:

Measures to restore fish migration is gaining a major boost in the Netherlands since the Water Framework Directive, Benelux Regulation and Eel Directive are operational. Water managers, responsible for a good ecological status, are working hard to reach free fish migration in their waters.

Currently, 1.124 measures are realized at barriers like weirs, pumping stations, sluices and culverts. 2.745 barriers are identified. Since 2000, there is a strong development of measures and new techniques.

These results are based on a study “The Netherlands living with Fish Migration”, that was started in 2008. Target of this study was the evaluation of the progress in approach of measures and to gather information on improvement of fish migration in the Netherlands. Within this project a database was created with the prioritized barriers and measures for fish migration. This data is supplied by the water managers. Every four years water managers are asked for an update and an evaluation is carried out.

In this presentation the results are discussed, with focus on type of barrier, solutions and intensity of monitoring carried out by the water managers. Also an overview of planning, with respect to WFD targets, is given. A map is created of for migratory fish accessible inland waters in up- and downstream direction. Database and maps are good medium for exchanging knowledge between water managers and other stakeholders.

Presenting Author Bio:

Martin Kroes is a consultant working on fish and fish migration issues. He has approx. 20 years of experience in fish related topics and worked on monitoring of fish ways and fish migration studies, best practices manuals, design of fish ways and policy for implementing fish migration in water management. Since the end of 2014 he started his own company.

Efficiency measurements as tool in evaluating fishways

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Abstract Body:

The awareness of the importance of free fish migration in the Netherlands is reflected in the increasing number of fishways that has been built in the past decade. The intention is that all the bottlenecks will be solved before 2027.

Equally important as the realization of fishways, is the evaluation of the design. In other words, are all species and size classes that want to pass, truly able to pass the structure. The challenge in this type of research is to avoid interference of the measuring tools with the fish migrants. The conventional monitoring fyke, does not meet this requirement. Migration is obstructed and the gear is highly selective for small fish. Emerging electronic techniques offer this opportunity and makes it possible to watch fish migration behaviour on the road through the fishway. The use of a resistivity Fish Counter will be illustrated by means of a case study.

The counter detects the swimming direction and size of the passing fish.

Species identification is achieved by the application of a camera, triggered by the passing fish. The placement of a counter station at both sides of the fishway, gives the unique opportunity to determine the efficiency in terms of the ratio between the number of fish entering the downstream side and the number of fish exiting at the upstream side. An example will be given of a fishway that originally was reviewed as a good functioning construction.

However, measurements of the efficiency showed that only a small part of the fish community was able to pass. The results also uncovered the weak spot in the design. This was not regarded as a failure, but as an opportunity to make use of the hidden potential of this fishway. It also contributed to the improvement of this type of design in general.

Presenting Author Bio:

Jan is a fisheries biologist for more than 25 year. The focus is on fish migration, fishway design and fish stock assessments with special interest in modern techniques. He started in 2005 with a private company, VisAdvies BV. This company concentrated further on applications like Acoustic telemetry PIT telemetry, sonar (fish stock assessment), fish counters etc..

SESSION A9: The impacts of land use and watershed conditions

Rangewide river herring recovery: a habitat perspective

First Author Name:
Alison Bowden

First Author Affiliation:
The Nature Conservancy

Abstract Body:

River herring (alewife and blueback herring) are anadromous alosines that play important ecological roles and historically comprised major U.S. fisheries. Stocks are at historically low levels Atlantic coast-wide, which lead to a status review to determine if listing as Threatened species was warranted. In August 2013 National Marine Fisheries Service declined to list the species, but initiated a coastwide conservation planning process to fill some of the research gaps, address uncertainty in the data, and revisit the status of both species with new information. The Plan will identify important conservation efforts that can be implemented to help restore river herring throughout their entire range from Canada to Florida, track the implementation of these efforts, identify research needed to fill in critical data gaps, and monitor the progress of restoring these important species. Interdisciplinary working groups focused on habitat, climate change, fisheries management, genetics, stock status, species interactions, and ecosystem integration. This session will explore the findings to date of the Habitat working group including threats, strategies, research priorities, and current cooperative research related to habitat drivers of river herring status such as connectivity, landuse, water quality and water quantity. Since river herring occupy a wide range of ecosystems along the entire East Coast of North America, identifying and addressing significant threats to river herring may provide important benefits to other diadromous and riverine species.

Presenting Author Bio:
Alison Bowden is Freshwater Program Director with The Nature Conservancy in

Massachusetts. Her work focuses on developing and implementing innovative science and policy tools to protect and restore rivers, as well as linking freshwater and marine conservation for migratory fish. She works on a wide range of policy issues including transportation, environmental permitting, water resource management and fisheries management. She is 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.

Green Infrastructure and Blue Habitat: the impacts of watershed conditions and stormwater management on river health and fish passage

First Author Name:
Cathy Bozek

First Author Affiliation:
The Nature Conservancy

Abstract Body:

Actions and land use in the watershed impact river habitat quality and fish migration. Stormwater runoff from developed land often carries high sediment loads that obstruct rivers, and excess nutrients that promote dense vegetation blooms, leading to conditions that severely hinder fish passage. Research shows that watershed impervious cover is a strong indicator of fluvial fish community health. Expanding directly-connected impervious surface in the watershed increases these impacts, while improved stormwater management can reduce the impacts and benefit the river system.

Green infrastructure, including both site-specific best management practices and landscape level conservation and restoration of natural lands, provides critical functions that reduce the impacts of stormwater runoff. In Massachusetts, The Nature Conservancy and our partners are restoring passage for river herring, American eel, and other species by removing dams and improving road-stream crossings, and we are also working to improve stormwater management and watershed land use decisions to benefit fish movement and give fish populations the best chance to thrive in their new habitat. We are encouraging implementation of green infrastructure

through demonstration projects, outreach, and support of legislation and policy. This talk will explore the impacts of watershed conditions and stormwater management on fish migration and river habitat, the management choices that can be successful in improving connectivity and river health, and the benefits of a holistic approach to fish passage restoration.

Presenting Author Bio:

Cathy is an aquatic ecologist at The Nature Conservancy in Massachusetts. Her work focuses on dam removal projects, green infrastructure and stormwater management, and partnership-based watershed restoration and management. Cathy has a M.S. in Water Resource Management from the University of New Hampshire and a B.A. in Geology from Colgate University.

Beyond Dams: Restoration of river herring in key watersheds along the Atlantic Coast of the USA

First Author Name:

Mari-Beth DeLucia

First Author Affiliation:

The Nature Conservancy

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2. Alison Bowden

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2. The Nature Conservancy

Abstract Body:

Dams have been, and still are, a major limiting factor in the restoration of anadromous river herring (alewife and blueback herring) in many river systems along the Atlantic Coast of the United States. In other areas, however, factors such as water quality, predation, and other types of habitat alteration may be a far greater threat to the restoration of these species than dams. An increase in impervious surfaces due to land conversion in the Chesapeake Bay and Puget Sound has been linked to decreased recruitment success in river herring and Pacific salmon, respectively. A prioritization of threats and restoration needs related to habitat for river herring was undertaken in a number of watersheds along the Atlantic Coast including the Chesapeake Bay, the

Connecticut, Delaware, and Hudson rivers as well as the Santee-Cooper watershed. Recruitment declines from stormwater runoff, habitat loss and altered prey/predator regimes were common themes across the coast and may be limiting recovery overall. Developing strategies to address these threats will be critical to successful restoration of these species.

Presenting Author Bio:

Mari-Beth DeLucia is a Fisheries/Aquatic Ecologist with the The Nature Conservancy. She has over 15 years of professional conservation experience in freshwater, marine and migratory fish conservation and holds B.S. in Biology from Southern Connecticut State University and a M.S. in Natural Resource management from Central Washington University.

Maintaining Agency capacity for ongoing and future road-stream crossing challenges

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Abstract Body:

The USDA Forest Service is dedicated to managing the habitat, watersheds and terrestrial and aquatic organisms that live and migrate through the National Forest lands and waters throughout the United States, Alaska, Hawaii and Puerto Rico. To achieve our mission and advance sound stewardship of all natural and manmade resources, we work closely with tribes, local, state and federal agencies, our stakeholders, and partners to find science-based solutions to complex ecological issues. Within our National Forests there is a large transportation network that is vital to communities and the economy, and this network also includes many road-stream crossings, which include culverts and bridges, that allow our roads to pass over streams and rivers.

The Forest Service understands the importance of establishing policies, procedures, technical capabilities, and expertise to assist resource managers to maximize the use of constrained resources to solve ecological and flood resiliency road-stream crossing issues. This presentation will describe how government agencies can create, develop and establish a management system that will provide effective expertise and guidance to solve simple-to-complex road-stream crossing decisions. Multidiscipline virtual aquatic organism passage teams can provide rapid and efficient expertise to support resource managers with technical assistance, regulatory interpretation, design solutions, decision making methodologies, and training to build and maintain agency capacity.

Presenting Author Bio:

Kurt is the assistant director of engineering with oversight and policy development responsibilities for technology and geospatial services.

He has been serving in this capacity for the last 11 years working on a diverse range of technology issues such as the aquatic organism passage, remote sensing, and other engineering technology services. He received a masters of science in civil and environmental engineering at Utah state university and undergraduate degrees in hydrology and biology.

To Fill or Not to Fill stream simulation and embedded aquatic organism passage structures

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USDA Forest Service

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Abstract Body:

Throughout North America stream simulation and embedded / recessed culverts are used to facilitate the passage of aquatic organisms thru road stream crossings. Although the concept of nature-like streambeds inside these structures is widely embraced, the design methodology and construction practice varies widely between state and federal agencies. Much debate has occurred with one specific requirement, whether or not to place stream bed material inside these structures. Not placing bed material inside structures assumes on going sediment transport processes will fill the structure's interior with streambed materials. This is assumed to be a cost saving measure from both a design and implementation standpoint. Recent research, monitoring, and historic installations provide evidence that not placing streambed material can produce deleterious effects to the stream and aquatic habitat, cause low flow barriers, may not retain bed material, and potentially cause long term structural failure. Conversely in some channel types or site condition infilling may not be necessary and produce satisfactory results.

Casual mechanism of success and failure, stream impacts, and design considerations will be discussed along with recommendations for site specific conditions where infilling structures is required or allowing structures to fill naturally would be successful.

Presenting Author Bio:

Bob is the watershed restoration geologist for the Eastern region of the US Forest service and a principal of the Washington Office Virtual AOP design team. He has been a practicing AOP and stream restoration design for 30 years in Alaska and across the National Forest system. He was the 2014 recipient of the Career Achievement Award for Distinguished Service in Fish Passage at the International conference on engineering and ecohydrology for fish passage.

Fishmigration issues in a river in transition

First Author Name:
Iwan de Vries

Abstract Body:

The Vecht River is a low land river that has its origin in Germany, then crosses the border and runs through the Netherlands, ending in the IJsselmeer where eventually the new fishmigration river should make the connection with the sea. The river has been chanalized in the last century; meanders have been chopped off, weirs have been placed, natural banks have been replaced by non native rocks and fishways were added in the 1980's. Since a few years now the waterboard has slowly started to undo the damage that has been done to the natural system.

Big questions are where to start a process like this; can we go back to how it was all the way, and what should the new dimensions of the Vecht be? New meanders should replace the old fishways, but are they ideally situated for optimal fish migration? And of course we need dead wood in our system once again, but our weirs don't function with large pieces of wood banging against the structures.

We are facing new demands like sluices for recreational boating A wild water canoeing track and other uses of the river. And even if we are doing everything right we should be aware that our organisation only covers one part of the river and that for that reason we should be working together with our partners to connect the source to the sea.

This presentation will try to take you along our journey in restoring the river. We will show you the choices we've made, some of the successes we have had and also some mistakes we have made so far. We invite you to not only listen to what we have done so far, but also to help us in making the right choices by asking us the right questions.....

Presenting Author Bio:

Iwan de Vries used to work in automation until he changed his career and started to work for the waterboard in 2006. Since then he is, among other things, an advisor in the design of waterways and fishways. Iwan

also teaches the design of fishways to other professionals.

SESSION B9: Fish Biomechanics, behavior & physiology in challenging environments (II)

Size matters even for the ubiquitous fish speed metric of BL/s

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Abstract Body:
The use of BL/s, i.e. body lengths per second (dimensions of s⁻¹), to express relative swim speeds for fish is very common. The physiological literature demonstrates the following: a) fish length is a strong predictor of swimming performance; b) longer fish achieve higher absolute swim speeds (dimensions of m/s) than shorter ones, at least for the same species; c) when swim speeds are expressed in BL/s, shorter fish have higher relative speeds than longer ones. Therefore, it is difficult to estimate swim speeds of large fish from small fish and vice versa, when using these absolute or relative swim speed metrics. It is important to recognize that regressions with data from small fish (e.g. juveniles) expressed in BL/s, would lead to overestimates of absolute swim speeds for large fish. It also follows that BL/s regressions with data from large fish, would lead to underestimates of absolute swim speeds for small fish. Yet, costs and complexity often lead to considerable data sets for small fish and limited tests with large fish, even though swim speed estimates are frequently needed for large fish. Regression strength for the same data sets, is higher when using dimensionless swim speed expressions, rather than BL/s. Such ecohydraulic analyses, demonstrate swimming performance similarity between

small and large fish and provide better absolute swim speed estimates. Furthermore, ecohydraulic analyses point to efficient strategies for testing length classes, particularly when swim speeds for considerable numbers of sizes and species are needed.

Presenting Author Bio:

Christos (Chris) Katopodis is a Professional Civil Engineer, International Consultant, Adjunct Professor (1995-2014) and President of Katopodis Ecohydraulics Ltd. The company develops integrated and innovative solutions which transcend relevant disciplines by bridging water related engineering and ecology, or ecohydraulics. Katopodis Ecohydraulics Ltd.

brings worldwide experience and provides consulting services, including: a) expert advice on planning and design to address and mitigate environmental concerns, protect, pass or exclude fish, provide E-flow regimes (i.e. ecological, in-stream or environmental flows), assess or advance new technologies, develop guidelines, and enhance or restore habitat and river health; b) advice on regulatory issues, environmental assessments and mitigation options, particularly for fish and fish habitat; c) workshops and short training courses.

Influence of biometric parameters, flow condition and water temperature on Iberian fish sprinting behavior: volitionally swimming performance

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Abstract Body:

Knowing the swimming ability of fish is important to detect movement limitations through hydraulic structures: fish passes weirs and slots, gauging stations, culverts, bridges foundations and other. All these obstacles are collectively referred to "velocity barriers". Fish behavior will determine the passage of these structures through combination of fish swimming performance and motivation. Once the fish decides to enter the barrier, must swim faster than the speed of the flow to advance. Thus, the swimming performance depends on the fish speed and fatigue time.

To estimate these values, we experimented in an open channel flow with fish samples of different size, swimming volitionally against several high-velocity flows and water temperature range. The movement of fish was controlled by PIT telemetry systems and video record. The information obtained (fish speed, ascend time and distance traveled) was processed using survival analysis techniques and the results can be applied to practical problem solving velocity barriers.

We have worked with two species of Iberian fish: Iberian barbel (*Luciobarbus bocagei*) and Northern straight-mouth nase (*Pseudochondrostoma duriense*). The biometrics parameters, flow velocity and water temperature have a significant influence in fish behavior. Endurance and swimming ability of these species do not differ greatly between them and is much higher than the values which are obtained using other methods as respirometers. The results challenge established fish passage guidelines, suggesting that in some cases these species are capable of passing much higher velocities than was previously believed.

Presenting Author Bio:

Forestry Engineer. PhD Student specializing in swimming behavior of Iberian fish. I am member of GEA (Ecohydraulics Applied

Group) where we provide specialized scientific and technical assistance in the field of water resources, fishing uses and their associated ecosystems (fishways, ecological flows, river restoration, hydraulic simulation, software development, training, etc.)

Movements of a potamodromous cyprinid past an experimental weir with variable height and plunge pool depth

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Abstract Body:

Fragmentation of river networks has been pointed out as one of the most serious threats to the sustainability of fish populations. Although far more numerous than dams, the impact of small weirs on fish movements have received much less attention. The presence of these barriers alters the water depth and velocity patterns and creates vertical drops that change the hydraulic environment, leading to connectivity losses with negative consequences to the persistence of fish communities. This study aims to evaluate the passage performance of a potamodromous cyprinid, the Iberian barbel (*Luciobarbus bocagei*) when encountering small weirs of varying heights associated

with variable plunge pool depths. A factorial design consisting of 16 configurations (4 replicates each), was carried out in an experimental flume with schools of 5 fish for each test (mean total length = 18.7cm ± 3.3 cm) at a flow discharge of 50 L.s⁻¹. Different combinations of plunge pool depths (z=10, 20, 30, and 50 cm) and heights of the jump (h=5, 10, 15, and 25 cm; distance from the plunge pool surface to the top of the weir crest) were tested. Both variables and their interaction term (z x h) were significantly correlated with the number of successful weir negotiations by fish (PerMANOVA, p< 0.01). The highest number of passages (n=50) occurred for a combination of z=20 cm h=10 cm, and the lowest (n=1) for a combination of z=10 cm h=25 cm. Results showed that increased passage does not necessarily occur at higher water depths in association with lower height of the jump. Thus, successful negotiation seems to be a more complex phenomenon where both variables interact to set the most effective hydraulic conditions for fish. These outcomes are useful to define design criteria for the requalification of small barriers to improve fish passage and habitat connectivity.

Presenting Author Bio:

Susana Amaral is a PhD student on River Management and Restoration at Instituto Superior de Agronomia, University of Lisbon. Her research areas include river restoration, freshwater fish ecology and conservation, fish passage engineering, and ecohydraulics. She is interested in issues regarding the restoration of longitudinal connectivity of rivers and in the enhancement of fish passage through instream obstacles, with emphasis on the effects of turbulence on fish behaviour, swimming ability and jumping performance.

How fish use and process flow information

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Abstract Body:

Fish use the mechanosensory lateral line and the acoustic system for the processing

of hydrodynamic information. With their lateral line fish perceive the amplitude, direction and frequency content of water motions relative to their body and tail fin surface as well as local pressure gradients across their head and trunk. With the acoustic system fish detect the particle displacement component and the pressure amplitude of a sound wave. Both, the lateral line and acoustic system, play an important role in many fish behaviors, including schooling, predator avoidance, intraspecific communication and prey detection. With the acoustic system fish not only can discriminate multiple sound sources but in addition can determine the direction and distance to these sources. Rheophilic fish even use lateral line (and acoustic?) information to save energy while swimming in turbulent flow. The smallest sensory unit of the lateral line is the neuromast. The lateral line neuromasts occur freestanding on the surface of a fish or they are embedded in lateral line canals. Inner ear receptors relevant for the processing of sound information are the hair cells of the utricle, sacculus and lagena. Hydrodynamic stimuli are received and transduced into neuronal signals by the lateral line neuromasts and the inner ear receptors. Lateral line and acoustic information is conveyed by afferent nerve fibres to the fish's brain and processed by higher order neurons in distinct nuclei. In my talk I will introduce the peripheral morphology of the lateral line and acoustic system of fish, describe behavioral and physiological work, thereby focusing on recent studies that have investigated how fish behave in unsteady flow, what kind of sensory information is provided by the flow and how fish use and process this information.

Presenting Author Bio:

Wissenschaftliche Laufbahn

1978-1985 Studium der Biologie (Diplom) an der Eberhard-Karls-Universität Tübingen

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Promotion im Fach Biologie an der

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(BMFT) 1993-1994 Wiss. Mitarbeiter am
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Mitarbeiter am Institut für Zoologie der
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Bonn 1996 Gastwissenschaftler am Parmly
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Fach Zoologie an der Mathematisch-
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Professur für Neuroethologie am Institut für
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SESSION C9: Downstream Passage (II)

HDX-Monitoring in the Wupper, a study of fish-migration

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Abstract Body:

The river Wupper is one of the priority-waters catchment areas for anadromous and potamodromous fish in the German federal state North Rhine-Westfalia. The survey took place at a small hydropower facility named "Auer Kotten" and its different fish ways and protection facilities, like a vertical slot fish pass and a natural like rock-pool channel, three different bypass types and a 12 mm-horizontal screen. Sixteen HDX-antennas were installed by Institute of Applied Ecology to identify the preferred migration routes of transponder tagged fish several species. An HDX-Antenna works like an electrified coil, which creates an electro magnetic field trough to the antenna. So tagged fish enter the antenna the transponder is activated and emits an individual code, which is registered by the antenna and archived by data logger time-, location- and individual-precise.

In autumn 2013 nearly three-hundred silver eels were tagged intraabdominal with transponders and released upstream the hydropower plant in the Wupper. Additionally 999 smolts of Atlantic salmon were released in spring 2014. The preferred migration corridors as well as the time for passing the different facilities could be identified by a redetection of 77 % of the silver eel and 68 % of the salmon smolts. As one of the results it was shown that neither the two surface bypasses, nor the bottom bypass were used properly by the downstream migrating fish. In opposite the vertical slot fish pass and a episodically

working gate next to the trash rack screen, to send debris into the trailwater were often passed, sometimes maybe forced.

Moreover wild fish of different species were caught ca. 20 km downstream the "Auer Kotten" by electro-fishing, tagged and released to get information about the preferred upstream migration routes. Most of the so far redetected fish arrived in the trailwater of the turbine outlet, while just lamprey preferred to swim into the original river bed.

The results of the survey points out that the HDX-technology is perfect for field studies on the migratory behaviour of fish, even an intensive maintenance is needed f. e. to protect the installations for damages caused by high floods.

Monitoring the downstream passage of small fish at the TUM-Hydro Shaft Power Plant Prototype

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Abstract Body:

For the innovative TUM-Hydro Shaft Power Plant concept, we investigated the downstream passage of fish that can physically pass through the screen.

Experimental investigations with live fish have already confirmed fish protection and fish downstream migration for a number of fish species and sizes bigger than the bar clearance at the TUM-Hydro Shaft Power Plant prototype. This investigation continues to evaluate the concept's qualification for fish protection and its downstream migration efficiency.

The 35 kW prototype allowed nature-like but controlled open-air laboratory conditions for behavior studies with brown trout, grayling,

barbell, minnow, and bullhead with body lengths from 5 – 20 cm. The passage distribution between the turbine and the fish downstream migration corridor as well as the injury and mortality rates during turbine passage were recorded for different flow velocities towards the screen and for different arrangements of the bypass.

The results reveal that portions of the downstream migrating or drifting fish did not pass through the turbine. Instead, they traversed the provided migration corridor. With regard to facility passage, the injury and mortality rates of the fish were smaller than the turbine specific injury and mortality rates. This was due to the passage distribution between turbine and bypass; however, detailed statements on migration distributions and damage rates depend on the respective fish species, fish sizes and facility configurations. Additionally, general influences of the parameters were assessed and the results were compared with literature references.

With regard to ecological requirements of specific river sites, the findings can be useful for the future design of hydro power plants; the methodology offers prospect for a more targeted adaption of these criteria for fish protection.

Following downstream migration of Atlantic salmon smolt at a German hydropower station with novel fish protection technology: a radiotelemetry study

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Abstract Body:

To mitigate negative effects of hydropower production on riverine fish populations, new technological solutions need to be found to increase downstream fish passage. In this study, downstream passage of Atlantic salmon smolt was documented at the power plant Unkelmühle (River Sieg, Germany). Here, a novel approach is used, combining a 10 mm vertical trashrack with surface bypasses and a vertical slot pass for fish protection. Fish migrating through surface bypasses can be diverted into a concrete basin for monitoring purposes.

A complex radio telemetry system was used to cover all potential migration corridors. In spring 2014, 78 salmon smolt were tagged with radio transmitters and released about 9 km upstream the power station. Additionally, another 800 smolt were dye marked and released at the same site. An intense monitoring program during the following weeks provided, amongst others, migration time, routes and speed. Catches in the monitoring basin showed that salmon was the dominant species migrating through the surface bypass (more than 60%), followed by nase, barbel and brown trout.

Smolt were mainly caught after dusk and migration could be related to water discharge and temperature with wild smolt migrating slightly later than the stocked ones. Telemetry data showed that most smolt migrated with the main current towards the turbines, but were prevented from going through the turbines by the trashrack and used the surface bypasses instead. Migration speed for smolt differed according to the river stretch fish swam through (natural river stretch, reservoir and power plant). Studies at Unkelmühle as well as at two other power plants with different technological approaches for fish protection will continue to compare solutions and concepts that enable downstream fish passage.

Priest Rapids Fish Bypass: A Case Study from Start to Finish

First Author Name:
Curtis Dotson

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Grant County Public Utility District

Abstract Body:

Priest Rapids Dam is a large (955 MW) hydroelectric dam on the Columbia River in Washington State, USA. As part of regulatory requirements associated with its FERC (Federal Energy Regulatory Commission) license and other agreements, the Public Utility District No. 2 of Grant County, WA was required to design and install non-turbine fish passage for downstream migrating juvenile salmonids at the dam, for the purpose to help meet its pre-establish survival standards for salmonid smolts passing through the Priest Rapids Hydroelectric Project during their downstream migration. This presentation is a case study highlighting the numerous steps that went into the design of that non-turbine fish passage facility which started with a surface-spill test at Priest Rapids Dam in 2002, followed by a number of years of physical and CFD modeling. Throughout those years of design work on a fish bypass system, results from actively tagged salmonid smolts studies were used to guide and validate each step of the design process. In 2011, a construction contract was awarded and the Priest Rapids Fish Bypass facility completed in the early spring of 2014. Final validation of this newly constructed facility came in the spring of 2014 with a survival and behavior study conducted using acoustic tagged yearling Chinook and juvenile steelhead smolts to evaluate the salmonid smolt survival rate through the bypass along with the fish passage efficiency (FPE) of the bypass facility.

Presenting Author Bio:

Curt Dotson is a fisheries biologist with 22 years of experience in fish passage issues at large hydroelectric dams. He has been involved with non-turbine fish passage design, turbine design and operations for safer fish passage and numerous fish

studies related to those different fish passage routes. His recent work has been involved with the issue of avian predation and its impact on smolt survival within the mid-Columbia River.

Post-spawning survival and downstream passage of landlocked Atlantic salmon (*Salmo salar*) in a regulated river: Is there potential for repeat spawning?

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Abstract Body:

Repeat salmonid spawners may make large contributions to total recruitment and long term population stability. Despite their potential importance, relatively little is known about this phase of the life history for anadromous populations and nothing has been reported for landlocked populations. Here, we studied post-spawning behavior and survival of landlocked Atlantic salmon in relation to downstream dam passage in the River Klarälven, Sweden. Eight hydropower stations separate the feeding grounds in Lake Vänern from the spawning grounds in the River Klarälven, and no measures to facilitate downstream migration are present in the river.

Forty-nine percent of the salmon survived spawning and initiated downstream migration. Females and small fish had higher post-spawning survival than males and large fish. The post-spawners migrated downstream in autumn and spring and remained relatively inactive in the river during winter.

Downstream migration speed in the free flowing part of the river was highly variable but averaged 9.30 km/day. Most fish passed

the first hydropower station via upward-opening spill gates after a median residence time in the forebay of 25 min. However, no tagged fish survived passage of all eight hydropower stations to reach Lake Vänern. This result underscores the need for remedial measures to increase the survival of downstream migrating kelts.

Cle Elum Dam Fish Passage; Novel, research driven dam retrofit to allow downstream passage for juvenile salmonids

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Abstract Body:
When Cle Elum Dam (Washington, USA) was constructed, a highly productive sockeye salmon fishery was lost. As part of

the proposed Yakima Basin Integrated Plan, fish passage will be restored at this site. For the migrating adults, a trap and haul fish collection facility will be constructed. For downstream juvenile salmon passage, a selective level outlet works, helical fish slide, and outfall will be constructed. The juvenile passage features groundbreaking research; primarily that of the helical fish slide. The presentation will cover aspects of the history of the project, the research driven designs, and the final designs (to be completed in 2015). The presentation can include computational fluid dynamics videos, descriptions of the physical modeling, renderings of the 3D facilities, and suitability of this design for other locations.

Presenting Author Bio:
Jason Wagner, P.E. is the lead Civil and Hydraulic Designer for the Cle Elum Dam Fish Passage Facility Designs. In addition, he was the lead designer for the fish ladder system at Coleman National Fish Hatchery, the largest salmon hatchery on the west coast. He has designed numerous fish ladders, fish screens, fish barriers, as well as the juvenile fish passage facility at Cle Elum Dam. He works for the Bureau of Reclamation, in Denver, Colorado.

SESSION E9: Turbines and Pumps

Development of Low Head Fish Friendly pumps and Turbines

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Pentair Fairbaks Nijhuis

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Abstract Body:

Some fish have an instinctive urge to migrate from sea to river water and back again. Eel provide the most intriguing example. After birth in the Sargasso Sea, they swim more than 5000 km to dwell in European rivers, and when mature, they return all the way back to reproduce. During this journey, they are often confronted with barriers such as sluice gates, pumps and turbines. The urge to migrate is so dominant that fish and eel enter every opening, which includes the intakes of pumps and turbines. Different studies have shown that fish and eel are severely damaged when swimming through a conventional pump or turbine. Various injuries are observed during the passage, of which the most prominent injury mechanisms involves blade strike injury, which is the focus of this article. Large fish mortality rates in these (rotating) turbo machines are reported, with some measurements showing values in excess of 80 % of the passing fish.

A theoretical model was developed to predict the probability of a fish colliding with rotating components of a turbo machine as well as the probability of consequent mortality caused by the collision. This model is based on several design parameters, including size, shape and speed. With the aid of this theoretical model, fish friendly design principles have been defined and applied by Pentair Fairbanks Nijhuis to a developed prototype fish friendly pump as well as a fish friendly turbine. The performance of the pump and turbine was optimized using computational fluid dynamic (CFD) analysis. Extensive field tests were

performed by independent parties and showed excellent results on efficiency as well as fish mortality rates. Here the design model as well as the results of the performed tests are presented.

Presenting Author Bio:

Jacob Arnold is experienced in the analysis and design of turbo machines of various types. He is currently head of the R&D department of Pentair Fairbanks Nijhuis, located in Winterswijk - the Netherlands.

Migration of Atlantic salmon (*Salmo Salar*) at low-head Archimedean screw hydropower schemes

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Abstract Body:

There has been a rapid increase in development of small-scale hydropower schemes across Europe. Such schemes may impact upon migratory fish populations through modification of migration pathways. There is a clear need for scientific evidence to inform guidelines for the design, placement and management of small-scale hydropower schemes for the protection of migratory fish. The proliferation of the Archimedean screw turbine (AST) for low-head applications is concerning because although these turbines are purported to cause negligible damage to fish passing through them, the available data is limited.

The studies presented assess the impacts of low-head AST hydropower schemes on migrating populations of anadromous Atlantic salmon (*Salmo salar*) in Scotland.

Smolts were tracked through an AST hydropower scheme on the river Don using radio tags and passive integrated transponder (PIT) tags. Smolt movements through alternative passage routes were observed using an array of fixed loggers at the hydro scheme. The proportion of radio tagged fish which passed through the turbine was 27% (7/26). The majority of PIT tagged smolts passed through the turbine channel within 27 minutes. Passage behaviour is considered in the context of the scheme's operation and environmental conditions.

Adult fish were tracked using radio and PIT tags at three AST hydropower schemes with distinctive designs and operational regimes: on the middle reaches of the river Don, the upper reaches of the Don, and on the Ettrick water. A mixture of fine-scale radio detection zones and PIT antennas was used to investigate attraction to the competing flows at each of the turbine and fish pass or depleted stretch outflows, and the efficiency and efficacy of the fish pass. Behaviours at these regions are related to the turbine operation, scheme layout and the resulting hydrodynamics at the regions of interest.

Cumulated mortalities of salmon and eel in the turbines of the Loire-Brittany basin

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Abstract Body:

The effect of dams on mortality during downstream migration was simulated using distribution and mortality models in the whole Loire-Brittany water district (155 000 Km²). A combination of models was used:

(1) juvenile habitats for smolts,

(2) productivity of juvenile salmon habitats,

(3) production of silver eels (EDA model),

The models (1)*(2) and (3) were used to predict the number of downstream migrants in the current conditions and with a transparent upstream migration.

(4) Turbine mortality was calculated from either the characteristics of the turbine (diameter, rotation speed, height ...) or by extrapolation from the average mortality when information was missing to run the model.

(5) Mortalities at the dam level were then derived from the nominal flow of each turbine and from the flow of the spill under 5 flow scenarios.

A similar overall production of about 100 000 smolts per year was found in the Loire and Brittany and the current production of eels was evaluated at 306 700, 314 900 and 124 400 silver eels for Brittany, the Loire and Vendée coastal streams respectively. The average mortality calculated at 387 dams and 578 turbines was estimated at 16.9% in Kaplan, 19.6% in Francis turbines, for smolts, and 45.8% and 88.5% for eels.

For salmon, the number of kills was evaluated as N=26 900 (ie 27% of the Loire's smolt production), and N=1 636 (ie 2%) in Brittany. For eel, the number of kills was evaluated as N=9 800 (ie 3.1%) of the silver eel production in the Loire, N=9 400 (ie 3.3%) in Brittany and N=2 700 (ie 2.2%) in Vendée.

The results will allow to prioritize actions and provide a first estimate of the level of mortality affecting eel and salmon in the Loire-Brittany basin.

Presenting Author Bio:

Cédric Briand has done his PhD on glass eel population dynamic, he has worked with Russell Poole (Marine Institute, Ireland) as co-chair to the EIFAC-ICES working group

on eel, and is currently works on migration monitoring and the development of eel stock assessment models. This work is the result of a long collaboration between authors from different structures, and the field work for turbine data collection was performed by ONEMA.

Fish friendly solutions in existing pumping stations; An economical solution enabling fish migration

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Abstract Body:

The low lying parts of Holland are vulnerable to flooding and are therefore heavily protected by dykes and several pumping stations. These however cause serious obstacles to migratory fish. Pumping stations can be lethal barriers for fish migration. Currently a lot of pump manufacturers are developing new fish friendly pumps. To fit these new pumps in existing pumping stations, usually civil adjustments are required at considerable costs. A more cost effective alternative would be to perform a fish friendly upgrade of the existing pumps.

During the last 3 years Flowserve conducted excessive research to increase their knowledge on fish friendly pump design. This research project led to a comprehensive calculation method to predict survivability rates of fish passing pumps. With this knowledge Flowserve has developed a very cost effective retrofit program to upgrade existing pumping stations equipped with fish unfriendly concrete volute pumps that have open axial flow screw impellers, also known as BVOP pumps. Currently Flowserve has executed several retrofit projects proving fish friendly upgrade possibilities at relatively low costs, lowering the investment threshold to solve fish migration barriers.

The presentation will take you along the developments made the last three years including the full scale in house fish survivability tests performed to validate our developed calculation method. The full scale

test involved a total of +/-1800 fish at 7 different operating conditions. Hereafter we will give you insights on two current projects:

- A BVOP retrofit project consisting of a new impeller/wear ring combination that fits the existing pumps without civil adjustment requirements.
- The upgrade of 2 fully metal, Stork heritage, open axial flow screw impeller, diffuser pumps. To fit the geometrical constraints of these pumps, a new patented fish friendly diffuser-bend combination was developed.

Presenting Author Bio:

Born at Hengelo ov in the Netherlands, Studied Aerospace engineering at TU Delft. PhD at TU Delft on multidisciplinary fuselage design of passenger aircraft. Post doc on piezoelectric materials at NIMR-TU Delft. In 2006 started at Flowserve Hengelo as hydraulic engineer. Currently product specialist at Flowserve for water pumps. Last 3 years mainly spent on fish friendly pump design.

Influence of time period and hydropower operation on movements and abundance of two migratory fish within the tailrace of Três Marias Dam, São Francisco River, Southeastern Brazil and their implications for hydropower impacts

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Abstract Body:

Fish attempting to move upstream through hydroelectric dams can be trapped and

killed in turbines. Understanding fish movement patterns can provide useful insights for how to manage dam operation and maneuvers to minimize fish kill in turbines. We evaluated the movements and abundance of two migratory fish (*Prochilodus argenteus* and *Pimelodus maculatus*) most affected by turbine operation, using acoustic telemetry and cast nets in the tailrace of Três Marias Dam (São Francisco River, Brazil) from 31 October 2011 to 16 February 2012. The General Linear Models were applied in the data in order to assess the influence of time period (diurnal and nocturnal) and operational discharge (turbine and spillway) on the biotic data. The majority of tagged fish left the tailrace in less than one week, however some individuals returned, performing several visits to the tailrace. The number of visits was influenced by time period, turbine and spillway discharge.

Although the time period was the only important contributor to the visits performed by *P. argenteus*, the movements of *P. maculatus* were significantly influenced by the three factors. We found that whereas *P. argenteus* was predominantly diurnal, *P. maculatus* showed nocturnal habits. Additionally, visits of *P. maculatus* were significantly lower during minimum turbine and spillway discharge. This result agrees with temporal changes in fish abundance in the tailrace. The number of *P. maculatus* captured using cast nets was also significantly lower during minimum turbine discharge. These results provide hydropower managers with useful information about the likelihood of occurrence of a fish injuries/kills events since these impacts can occur in combination with fish attraction to the tailrace. With an increased understanding of the behavior and vulnerability of fish species to turbine operational maneuvers, future operational procedures of hydropower facilities may be modified and adapted in order to protect native species.

Presenting Author Bio:

Fábio Suzuki is a fisheries biologist and received his Master and PhD degree in Applied Ecology from Federal University of Lavras, Brazil. Currently, he is environmental consultant at "Pisces - Consultancy and Environmental services"

and also associate researcher at Federal University of Lavras where has been working on fish ecology, impacts of dam and fish behavior using acoustic telemetry.

Function control of fish migration facilities at the Hydro Power Plant Kostheim at river Main

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Abstract Body:

Applying various conventional and modern monitoring methods a function control of downstream migration facilities and turbine passage related mortality was conducted at the Kostheim Hydro Plant (4,9 MW; two Kaplan turbines; Δh max. 3,74 m, at MQ 2,36 m) at the river Main (km 3,2).

Furthermore, the perceptibility and passability of a nature-like bypass for upstream migration was examined. Results showed a size selectivity of the bypass caused by an unsuitable entrance position 40 m downstream of the outlet of the turbines. The effectiveness of the downstream migration facilities proved to be low, leading to high mortalities at the trashrack and during turbine passage. The vertical bar trashrack with a bar spacing of 20 mm showed little repellent effect and was passed by most fish up to a size of 20-25 cm total length, causing scale loss and haematoma in Atlantic salmon smolts and cyprinid species. Eels smaller than 65 cm were unable to pass the trashrack and the majority was killed by the trashrack cleaning device. Particularly, smaller eels experienced high mortalities at the turbine passage.

Presenting Author Bio:

Born 17/5/1961 in Frankfurt am Main, Germany. Advanced studies and postgraduate studies in biology at the

Johann Wolfgang Goethe – University in Frankfurt am Main. 1999 PhD (thesis in salmon ecology). 1993 -1997 research assistant at the Research Institute Senckenberg, Frankfurt am Main; since 1997 freelance biologist (specialized in freshwater fish ecology), founder of the Bureau for Fish-ecological Studies – BFS.