



Galway, Ireland

7<sup>th</sup> – 10<sup>th</sup> April 2015

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# NoWPaS workshop 2015 Schedule



## Monday 6<sup>th</sup> April Arrivals

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Time	Activity
19:30	Meet and greet at O'Connell's bar

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## Tuesday 7<sup>th</sup> April NoWPaS day 1; Excursion

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Time	Activity
09:00	Coach departs from Merchants Road

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We will stop for a short visit at Cong village. Here we shall see an old salmon pass which was once used by the Monks of Cong Abbey. We then move on to Westport town, where we will stop for a short visit. The route is extremely scenic and we will pass Doolough Valley and Clew Bay.

**12.30 Arrive at Delphi Lodge**

Arrive at Delphi Lodge for a tour of the salmon hatchery, followed by lunch.

**14:00 Depart Delphi Lodge**

After lunch we will travel through Leenane Village, where we may be able to stop at Aasleagh Falls - a popular salmon fishing spot. There is one last stop at Celtic Crystal in Moycullen, where we shall experience a glass blowing demonstration.

**18:00 Arrival at The Ardilaun Hotel**

**19:30 Dinner**

**Wednesday 8<sup>th</sup> April**  
**NoWPaS day 2**

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**Time Activity**

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08:00 **Breakfast**

09:20 **Opening** - NoWPaS Committee

09:30 **Invited speaker** – *Philip McGinnity*, University College Cork

10:20 **Break**

10:50 **Session 1 –Habitat & Environment** – Chair: *Darryl McLennan*

*Carole-anne Gillis*

*Stina Gustafsson*

*Alex Seeney*

12.00 **Lunch**

13:15 **Invited speaker** – *Paul Kemp*, University of Southampton

14.05 **Break**

14:30 **Session 2 – Migration & Movement I** – Chair: *Anne Bateman*

*Casper van Leeuwen*

*Emily Winter*

*Daniel Nyqvist*

15.30 **Break**

15.50 **Session 3 – Behaviour & Physiology I** – Chair: *Mike Forty*

*Heather Dixon*

*Guillaume Bal*

*Monica Favnebøe Solberg*

19:00 **Dinner**

**Thursday 9<sup>th</sup> April**  
**NoWPaS day 3**

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**Time Activity**

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08:00 **Breakfast**

09:30 **Invited speaker – *Dorte Bekkevold***, Technical University of Denmark

10:20 **Break**

10:50 **Session 4 –Genetics & Molecular Biology – Chair: *Anne Bateman***

*Rafał Bernaś*

*Alison Harvey*

*Darryl McLennan*

12.00 **Lunch**

13:15 **Invited speaker – *Ian Fleming***, Memorial University of Newfoundland

14.05 **Break**

14:30 **Session 5 – Behaviour & Physiology II – Chair: *Mike Forty***

*Nicolas Larranaga*

*Brittany Palm*

*Elsa Goerig*

15.30 **Break**

15.50 **Session 6 – Migration & Movement II – Chair: *Darryl McLennan***

*Anne Bateman*

*Danielle Frechette*

*Mike Forty*

17.00 **Group discussion – NoWPaS 2016**

19:00 **Dinner**

**Friday April 10<sup>th</sup>**  
**NoWPaS day 4**

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**Time Activity**

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08:00 **Breakfast**

10.00 **Departure from The Ardilaun Hotel**

# Preface

## **NoWPaS – International (formerly Nordic) Workshop for PhD and post-doctoral fellows on anadromous *Salmo salar* and *Salmo trutta* research**

NoWPaS stands for International - formerly known as Nordic - workshop of PhD and post-doctoral fellows working on anadromous salmonids. The annual workshops aim to build and maintain an international network of young scientists working on migratory salmonids, such as Atlantic salmon (*Salmo salar*) and brown trout (*Salmo trutta*). The workshops have helped facilitate the sharing and dissemination of salmonid science. They have also been instrumental in initiating new international collaborations, as well as in identifying novel and timely research topics for the coming years.

The first NoWPaS workshop was held in 2005 in Norway, and was followed by others in Sweden, Finland, Denmark, England, Scotland, France and Wales. Although it started out as European initiative, due to the migratory nature of the species, it has grown into a global meeting with Canadian and US early stage researchers regularly attending. For the first time since its creation, we are excited to bring the 11th NoWPaS workshop to Ireland.

The 2015 NoWPaS workshop will be hosted by the National University of Ireland, Galway along with the University of Glasgow, Scotland. The workshop will be based in Galway, located on the west coast of Ireland by the shores of Lough Corrib, known for its brown trout and salmon angling fishery. Ireland is home to the only European populations of the endangered salmonid species of pollan and char which became landlocked after postglacial colonisation. There is a long tradition of salmon fishing in Ireland and salmon have a significant role in Irish culture and mythology. The decline of salmonid species in Ireland and across their range has resulted in a significant amount of scientific research on these species in order to develop effective conservation strategies. Ireland is committed to continuing this research and developing relationships within the scientific community.

## Acknowledgements

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NoWPaS 2015 has been made a possibility largely in thanks to the voluntary dedication of the organising committee who have contributed their time and efforts in to ensuring the continuation and success of the workshop. However, the workshop would not be a possibility without the contributions of the delegates whose presence and support is the lifeblood of the network. A huge thanks also goes the NoWPaS 2015 keynote speakers, who have generously donated their time and energy in presenting and participating at the workshop.

One of the founding and foremost principles of the NoWPaS network is that it be free to attend to all participants. Because of this we are especially grateful to the generous support and contributions from the following sponsors:



## The 2015 NoWPaS organising committee

Darryl McLennan, University of Glasgow, Scotland, UK

Anne Bateman, National University of Ireland, Galway, Ireland

Mike Forty, Durham University, England, UK

Beatrix Bicskei, University of Stirling, Scotland, UK

## Keynote abstracts

Releasing captive bred salmonids into the wild: Experiments that have provided some insight into the genetic and ecological impact.

McGinnity, P.<sup>(1)</sup>

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**Key words:** stocking; escapes; local adaptation, common-garden-experiments, genetic-markers

### **Abstract:**

Establishing the existence and the magnitude of local adaptation is central to determining whether the deliberate (stocking) or accidental (escapes) introduction of captive bred salmonids into wild populations is cause for concern. Fish, which have been bred in hatcheries, should theoretically, following hybridisation, result in a reduction of the fitness of recipient wild populations due to the disruption of locally derived adaptations. Hatchery maintained strains are also subject to intentional and unintentional domestication selection; consequent mal-adaptations making the captive bred fish less suited for life in the wild. Reciprocal transplant and common garden experiments are the most effective way to empirically detect fitness variation among populations of different provenance and to assess levels of adaptation to a given environment. Such experiments, where environmental effects are eliminated or reduced, are possible because of availability and deployment of molecular markers, allowing individuals released as eggs and recaptured in the wild at later stages of the life cycle to be assigned to families and groups. Some 20 years of studies using genetic markers conducted under wild conditions, both in freshwater and the sea, primarily on Atlantic salmon and brown trout, have provided novel insights into the potential ecological and genetic impacts of captive bred fish in the wild. In this presentation the outcomes of these experiments and other associated pedigree based studies are reviewed. The significance of these data for management of diversity and its importance for resilience and productivity of wild fish is considered.

# SALMONID ECOLOGY AND MANAGEMENT: RESEARCH INEQUITY AND WIDER LESSONS LEARNT

Kemp, P.<sup>(1)</sup>

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**Key words:** research bias, fishways, non-salmonids, migration, fisheries

## **Abstract:**

In his book *King of Fish*, David Montgomery suggests that due to a long history of research focusing on salmon ecology and management the causal factors for the repeated declines in populations (e.g. overharvest and construction of dams) is well understood. He questions the need for further similar research and argues that in the face of possible bleak outcomes for many stocks attention now should be diverted to developing more effective environmental decision making processes. Others argue that a historic research bias towards commercially important families, such as the salmonids, reinforced by legislation has negatively impacted the management and conservation of other species, and diversity and ecological processes more widely. Considering fish passage research as an example, much effort has been directed at developing alternative routes of migration (fish passes) at river infrastructure (e.g. dams and weirs) for salmon and migratory trout, and as a consequence is biased towards northern temperate regions of the world. Fish passes often perform poorly for non-salmonid fish, and current designs are often inappropriate for tropical and sub-tropical regions (e.g. South America and Asia) where the majority of infrastructure development is currently taking place, and where fish communities are highly diverse. However, many decades of salmonid research may provide valuable lessons to enhance management and conservation efforts for other species, communities, and systems. In this presentation research inequity favouring salmonids and the consequences, both favourable and adverse, for wider natural capital will be discussed.

# Sea trout there and back: where and why assessed with molecular tools

Bekkevold D.<sup>(1)</sup>

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**Key words:** [*Salmo trutta*, marine migration, Single Nucleotide Polymorphism, local adaptation, management]

## **Abstract:**

Anadromous brown trout, *Salmo trutta*, 'sea trout', is a species of major conservation and management concern. Delineation of spawning and feeding habitat for individual populations is needed for effective conservation actions. Information for Single Nucleotide Polymorphism, SNP, markers mapped to genomic position presents a tool both to examine evolutionary differences among local populations, and a means to trace migratory behaviour in the marine environment. I will present results from a study using information about SNP variation in more than 3000 sea trout, spanning populations from the English Channel to the eastern Baltic Sea. Collections represent local spawning sites as well as marine migrants in both the North Sea and the western Baltic. The area displays strong environmental heterogeneity and I will use the molecular data to illustrate methods to assess how local adaptation and other evolutionary processes affect the distribution of sea trout in time and space. Results are implemented in management of trout in Denmark, and I will describe opportunities and challenges in applying molecular methods in conservation and management.

# Influence of environmental enrichment and transgenerational effects on salmon recovery

Ian A. Fleming

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**Key words:** captive breeding, phenotypic divergence, wild fitness, carryover effects

**Abstract:** As natural populations decline, captive breeding and rearing programs have become essential components of conservation efforts. However, captive rearing can cause unintended phenotypic and/or genetic changes that adversely impact on population restoration efforts. Here, I explore (1) how environmental enrichment amongst the earliest life stage shapes phenotypic development, and more importantly, how it may translate into fitness upon release; and (2) how effects of rearing may carry over across generations to influence the survival of descendents in the wild. In the first study, divergence in morphology, brain volume, behaviour (foraging and predator response) and gene expression of emergent Atlantic salmon incubated as eleuthero-embryos in simple (absence of gravel) and enriched (gravel) environments was quantified. Differences in these phenotypic traits may explain why enriched fish outperformed (growth and survival) non-gravel incubated fish over 42 d following emergence into near wild conditions. The second study tested whether the exposure of captive-reared Atlantic salmon to natural river environments (i.e., “wild exposure”) during early life can serve as a mitigation technique to improve the survivorship of descendents in the wild. Using genetic pedigree reconstruction, a two-fold increase in the survivorship of offspring of wild-exposed parents compared to the offspring of captive parents was observed. The results suggest that harnessing the influence of environmental enrichment and transgenerational effects in captive-rearing programs can improve the outcomes of endangered species restoration efforts.

# Abstracts

## Exploring the impact of *Didymosphenia geminata* nuisance growths on juvenile Atlantic salmon

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**Key words:** *Salmo salar*, *Didymosphenia geminata*, habitat selection, foraging behaviour, isotopes

### **Abstract:**

Since 2006, nuisance growths of the diatom *Didymosphenia geminata* (didymo) have occurred in the Restigouche River system in eastern Canada. These dense mats have shifted macroinvertebrate community structure and prey abundance for juvenile Atlantic salmon (JAS). To understand the impacts of didymo on JAS, we assessed its effect on prey production, location, and availability. In parallel, we outlined the impact of mats on prey-predator interactions, habitat selection, and growth rates of JAS. Increasing didymo coverage lead to a significant positive relationship between proportions of benthic forays vs. drift forays ( $R^2 = 0.54$ ,  $p < 0.001$ ). This shift in foraging behavior was not triggered by limited drifting prey availability. Isotopic signatures of JAS in didymo-affected sites suggest that these consumers have a more depleted diet than those in didymo-free sites. As for habitat selection, JAS site fidelity is sustained with increasing didymo cover. JAS daily weight gain is significantly lower in didymo-affected sites than didymo-free sites ( $p < 0.001$ ). Underlying mechanisms by which *D. geminata* alters Atlantic salmon habitat will be discussed and the importance of thresholds dynamics will be highlighted.

# Compensatory stocking of brown trout (*Salmo trutta*) in a freshwater pearl mussel stream (*Margaritifera margaritifera*) - A search for suitable fish hosts.

Gustafsson S.<sup>(1)</sup>, Calles O.<sup>(1)</sup>, Skurdal J.<sup>(2)</sup> and Österling M.<sup>(1)</sup>

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<sup>(2)</sup> Stiftelsen Lillehammer museum

**Key words:** nature-like fishway, host fish, conservation

## Abstract:

Freshwater pearl mussels (FPM) (*Margaritifera margaritifera* L.) are long-lived organisms with a complex reproductive strategy. The FPM spend their first 9 months as obligate gill parasites on brown trout (*Salmo trutta*) or salmon (*Salmo salar*), whereupon they metamorphose to juvenile mussels. The post-parasitic juvenile life stage has been identified to be particularly sensitive to anthropogenic land use changes as juvenile mussels transform to adults while being buried in the stream sediment. In recent decades, the recruitment of FPM has decreased in Sweden, which can be directly linked to factors negatively affecting juvenile survival. However, the close relationship to their host fish may imply that factors affecting the parasitic stage also contribute to the impaired mussel recruitment. Dam constructions, for example, do not only change flow regimes and cause clogging of stream sediments, but also disrupts connectivity in running waters. This may prevent host fish from reaching areas with FPM, impeding mussel life cycle completion, and obstructing mussel dispersal by larvae attached to fish. In south-central Sweden a hydroelectric power plant was constructed in the River Västerdalälven in 2009. To mitigate the effects of the dam construction a 500-m long nature-like fishway was built. The fishway was fit with a range of different habitats, some specifically designed to host a population of FPM and brown trout. To compensate for lost catches due to the power plant construction the power plant company are obliged to release 50 000 stocked brown trout (0+) individuals of the Siljan strain in the area. It has been shown that host fish origin may affect the survival, growth and metamorphosis rate of juvenile mussels. Before compensatory stocking can commence it is therefore important to identify the brown trout strain most compatible to the mussel. An infestation experiment containing FPM from the river Tansån (a nearby river with natural recruitment of FPM), its sympatric trout strain and three allopatric trout strains, one wild from the area, the Trettonjällbäcken strain, in the vicinity of the power plant and two hatchery reared, Siljan and Gullspång strains, were used. Preliminary results indicate that there were no differences in weight normalized encystment rate between any of the trout strains. However, larvae seemed to grow faster on the Siljan strain, which may imply a higher survival for the remaining parasitic period and for the relatively large juveniles starting their benthic life. The higher growth may be a result of the higher condition factor of the Siljan strain, where the glochidia larvae may benefit from a high nutritional supply. In conclusion, it seems important to investigate the compatibility between FPM and its potential host fish strains before re-location or stocking of either fish or mussel. In the present case, the stocked trout strain seems to be functioning with the mussel strain that is planned to be introduced, at least for the parasitic stage of the mussel.

# Linkages between riparian invasive plants, hydromorphology and salmonid fish in Scottish rivers

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## Key words:

## Abstract:

The riparian interface between terrestrial and aquatic communities is of critical importance to aquatic ecosystems. Riparian invasive plants ('RIP' hereafter) can influence the aquatic environment through processes such as shading and thermal buffering, or via the contribution of primary and secondary terrestrial energy sources<sup>1</sup>. These allochthonous energy sources can vary depending on the density and diversity of the riparian plant community<sup>2</sup>, consequently affecting stream biota. The RIPs studied in this project (Japanese knotweed (*Fallopia japonica*), Himalayan balsam (*Impatiens glandulifera*) and giant hogweed (*Heracleum mantegazzianum*)) can directly affect many hydrological processes<sup>3</sup>, and the hydrology and geomorphology of riparian zones have been highlighted as crucial factors in the distribution of vegetation<sup>4</sup>. The importance of the riparian zone is well documented, but clear links between RIPs and the abundance, structure and persistence of economically significant salmonid species (brown trout (*Salmo trutta*) and Atlantic salmon, (*Salmo salar*))<sup>5</sup> have not been established. Furthermore, given the lack of quantitative evidence, the impacts of RIPs on stream biota can at present only be inferred<sup>6</sup>.

This research aims to highlight target areas for RIP removal, as well as demonstrating links between RIP presence and suitable habitat availability for salmonids. A clear understanding of links between RIPs and salmonid population density is essential, as well as the ability to tease apart the impacts of RIPs from other pressures. This research will inform future RIP treatment programmes, with an emphasis on improving in-stream habitat availability and maintaining stream biodiversity. This project also aims to build relationships with organisations such as the Rivers and Fisheries Trusts of Scotland (RAFTS), who are already contributing time and funding towards RIP removal. Of particular interest is the potential to influence future management policy, as the project will be carried out in close communication with Scottish Natural Heritage (SNH).

# MIGRATION DEPENDENT FITNESS IN A FRESHWATER SALMONID

Van Leeuwen, C.H.A.<sup>(1)</sup>, Museth, J.<sup>(2)</sup>, Qvenild, T.<sup>(3)</sup>, Vøllestad, L.A.<sup>(4)</sup>

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**Key words:** environmental conditions, fitness, growth, migration, salmonid.

## Abstract:

Many salmonids migrate between marine and freshwater habitats for feeding, spawning and overwintering. A selection also migrates within freshwater (potamodromous migrations), which is typically associated with moving between overwintering and spawning habitats. However, still too little is known about other potential causes of migrations and movements of salmonids within freshwater systems.

We analysed 28 years of European grayling (*Thymallus thymallus*) movement patterns in relation to environmental heterogeneity in Glomma River, Norway's largest river system. Grayling in this system migrate upstream after the winter to spawn in early spring. However, many fish continue to migrate upstream during the subsequent summer months. Tagged grayling that were recaptured farther upstream turned out to have higher growth rates than grayling recaptured locally in the fishways where they were tagged. Upstream migration after spawning significantly increased growth rates both within and between seasons. Annual survival did not differ between these local migrants and long-distance migrants. This together suggests that upstream movement during summer after the spawning period is a life history strategy that promotes growth without survival costs, i.e. increases individual fitness.

We discuss the observed difference in growth rates in relation to the environmental heterogeneity present in this system. Even in seemingly homogeneous freshwater systems long-distance migration can increase individual fitness, and therewith preserve migratory life history strategies. Our results imply that connectivity in freshwater systems also needs to be maintained outside of spawning migration periods.

# Characterising autumn and winter seaward movements of trout parr, *Salmo trutta*, in an English stream

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**Key words:** Brown trout, migration, PIT telemetry

## **Abstract:**

The phenological plasticity of juvenile trout, *Salmo trutta*, emigration from an English stream is defined throughout autumn and winter using passive integrated transponder (PIT) telemetry, and makes preliminary comparison to patterns in Danish streams. Three fixed PIT tag readers detected an early downstream movement of individuals in autumn, ahead of the typical smolt run in spring, and low-levels of continued movement through winter. Probability of downstream movement is shown to be strongly influenced by stream discharge, temperature and size class. This study exemplifies the remarkable life history flexibility of a key anadromous species.

# 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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**Key words:** kelt, repeat spawning, post-spawning survival, downstream migration, passage

**Abstract:** 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. 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.

# Using stable isotope metrics to assess differences in Atlantic salmon marine feeding off the West Greenland coast

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**Key words:** Atlantic salmon, West Greenland, marine feeding, stable isotopes, niche metrics

## Abstract:

Atlantic salmon, *Salmo salar* L., are widely studied in the freshwater environment, but due to the difficulties of sampling in the ocean, the ecology of the marine life-history stage is poorly understood. Many non-maturing adult salmon of North American origin undertake a feeding migration up the west coast of Greenland in late summer, which has not been studied since the late 1960's. In the face of the widely documented Northwest Atlantic oceanic regime changes, a contemporary feeding study using modern stable isotope analysis (SIA) methods was undertaken. Atlantic salmon were caught at three locations at differing latitudes off the West Greenland coast between 2009-2011. The hypotheses tested were that there were significant differences in the SI values of Atlantic salmon among communities and years. Significant differences were found among the years and communities when a two-way ANOVA was run for both  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$ , with a significant interaction between the two variables ( $p < 0.001$  for both  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$ ). The significant interaction indicates that differences among years depend on the community being analysed, and varying differences between year and community were also evident in the results of SI centroid testing and ellipse overlap. Although there was no consistent pattern across years as to the niche metrics, Atlantic salmon at Nuuk consistently had the lowest  $\delta^{13}\text{C}$  values. When Atlantic salmon stable isotope data were represented in a bi-plot space, they varied less on the  $\delta^{15}\text{N}$  axis ( $\approx 1$  trophic level) than on the  $\delta^{13}\text{C}$  axis ( $> 4$  trophic levels). A lack of consistent patterns among years and communities shown in the SIA data is understandable, given the complex interplay between ocean temperature, changes in ocean currents and water bodies and associated variation in the distribution, abundance and use of prey species.

# BROAD SCALE VARIATIONS IN SIZE, WEIGHT, CONDITION AND MIGRATION TIMING IN ATLANTIC SALMON

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**Key words:** Global change, long term, large scale data, run timing, life history traits

## **Abstract:**

Atlantic salmon (*Salmo salar*), reproduce in freshwater and juveniles migrate to sea for growing, hence these organisms are highly sensitive to changes in freshwater and marine environments. In southern populations, juveniles spend one or two years in freshwater before migrating to sea and then return to their natal river for spawning after one to three years sea time residence. In this species, individual morphometric and phenology characteristics are prone to plastic and adaptive responses to environmental variations and may thus be good indicators of responses to global changes. We investigated spatio-temporal trends in size, weight, condition and timing of migration in adult stage using a unique long term (1987-2013) and large scale (34 rivers from North to south) dataset from recreational fishery on Atlantic salmon in France. Our results echo a global decreasing trend in size and weight together with a delay in return migration timing; these differences are stronger in grisle than in multi sea-winter fish. Date of river entry also appeared negatively correlated with both size and weight of fish. Moreover, biometric and phenological changes differ between the northern and southern rivers. Our results, when considered together with a change toward a younger age at maturity and common patterns in migratory characteristics of European stocks, may suggest an adaptive response to the degradation of marine environmental conditions.

# Hatching time and alevin growth prior to the onset of exogenous feeding in farmed, wild and hybrid Norwegian Atlantic salmon\*

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**Key words:** farmed escapees, hybridization, introgression, embryonic development rate, endogenous resource utilization

## **Abstract:**

The onset of exogenous feeding, when juveniles emerge from the gravel, is a critical event for salmonids where early emergence and large size provide a competitive advantage in the wild. Studying 131 farmed, hybrid and wild Norwegian Atlantic salmon families, originating from four wild populations and two commercial strains, we investigated whether approximately 10 generations of selection for faster growth has also resulted in increased somatic growth prior to the onset of exogenous feeding. In addition, we tested whether relaxed selection in farms has allowed for alterations in hatching time between farmed and wild salmon. Across three cohorts, wild salmon families hatched earlier than farmed salmon families, while hybrid families displayed intermediate hatching times. While the observed differences were small, i.e., 1-15 degree-days (0-3 days, as water temperatures were c. 5-6 °C), these data suggest additive genetic variation for hatching time. Alevin length prior to exogenous feeding was positively related to egg size. After removal of egg size effects, no systematic differences in alevin length were observed between the wild and farmed salmon families. While these results indicate additive genetic variation for egg development timing, and wild salmon families consistently hatched earlier than farmed salmon families, these differences were so small they are unlikely to significantly influence early life history competition of farmed and wild salmon in the natural environment. This is especially the case given that the timing of spawning among females can vary by several weeks in some rivers. The general lack of difference in size between farmed and wild alevins, strongly suggest that the documented differences in somatic growth rate between wild and farmed Norwegian Atlantic salmon under hatchery conditions are first detectable after the onset of exogenous feeding. \*Solberg et al. 2014. PLoS ONE 9(12): e113697

# The phylogenetic position of the extirpated Atlantic salmon *Salmo salar* L. lines from the southern Baltic Sea

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**Key words:** Atlantic salmon, SNP genotyping, archived samples, dried scales, glacial refugia

## Abstract:

The phylogenetic position of the extirpated Atlantic salmon population from southern Baltic Sea has been unknown and is under discussion. In order to investigate this issue, dried scales from historical populations represented Oder and Vistula Rivers were collected and successfully genotyped with Atlantic salmon Illumina SNP chip. Obtained results were compared with salmon populations from neighbouring rivers and Polish restituted stock. Global  $F_{ST}$  obtained by AMOVA for all pairs of loci was 0.217; this can be interpreted as a high genetic differentiation among the studied groups. Pairwise  $F_{ST}$  values were significant for all comparisons with higher values for the contemporary Slupia River vs. extinct Vistula River. Bayesian analysis of genetic structure revealed existence of substructure in extirpated Polish populations and two main clads among the studied stocks. It is suggested that historical population from Oder River has been genetically closer to Neman River than to Vistula salmon. Vistula salmon is clearly distinct from all other analysed stocks. Salmon population from Morrum River had different origin than Polish native populations and was clustered with Polish-Latvian salmon.

# Investigating growth differences between farmed, hybrid and wild Atlantic salmon (*Salmo salar* L.)

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**Key words:** Atlantic salmon, farm escapees, introgression, growth,

## **Abstract:**

This project falls under the broader EU funded AQUATRACE, which aims to develop novel tools for tracing and evaluating the genetic impact of fish from aquaculture. Using a model species, Atlantic salmon, *Salmo salar* L., we aim to explore the links between genetic differences among wild and farmed fish, looking specifically at life-history traits which influence population fitness. The Atlantic salmon farming industry continues to grow each year, and hundreds of thousands of farmed salmon escape into the environment. Escapees can potentially impact on native salmon populations in two ways, ecologically via competitive displacement for resources, territory and mates or transfer of disease, and genetically, via introgression of maladapted domestic genes into locally adapted wild populations. This study aims to investigate trait variation in farmed, wild, and hybrid salmon by examining and comparing their phenotypic growth reaction norms, using a variety of farmed and wild strains. These experiments will take place in a common garden setting where temperature, density, rearing conditions, and feeding regime are varied. While data analysis is still on-going, in general, preliminary results indicate that the growth differences between farmed and wild salmon were not as pronounced as seen in previous studies; however on average, farmed salmon outgrew the wild salmon, with intermediate hybrid growth. Initial analysis of the temperature experiment indicates that growth differences between farmed and wild salmon are potentially temperature and strain dependent. This project has applications for both conservation and fish farming sectors through the increased knowledge of introgression impacts, as well as elucidating our understanding of the evolutionary consequences of within-species hybridization.

# Temperature effects on telomere dynamics in Atlantic salmon

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**Key words:** telomere, temperature, *Salmo salar*

## **Abstract:**

Telomeres cap the ends of eukaryotic chromosomes and play an important role in chromosome protection. Telomere length decreases with each cell division until a critical length is reached, which can trigger cellular senescence and eventually organism senescence. In addition, telomere loss can also be accelerated by oxidative stress. A relatively short telomere length is indicative of poor biological state e.g. reduced longevity. Therefore, an animal's initial telomere length and rate of loss are both of great importance.

Temperature is one of the most important abiotic factors affecting metabolic processes and cell division in fish. However, very little research has considered how telomere dynamics might be influenced by environmental temperature. If there is a relationship between temperature and telomere, you may expect it to be stronger in early life, as early life stages are more susceptible to temperature effects.

I have undertaken 2 experiments which address the following hypotheses:

1. The temperature experienced by Atlantic salmon in early life will have an effect on telomere dynamics.
2. Cell proliferation rate and oxidative stress will partially explain the relationship between incubation temperature and telomere dynamics.

# Inter vs intra-population effects of temperature on the temporal and spatial behavior of juvenile Arctic charr

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**Key words:** diel activity, aggregation, *Salvelinus alpinus*, growth rates

**Abstract:** There is considerable variation in the way young salmonids distribute their activity in time. In summertime, juveniles are mostly diurnal, although post young-of-the-year (PYOY) become gradually nocturnal. Water temperature can act in several ways on diel activity patterns. As rivers get warmer, fish become more active to sustain increased metabolic demand. In addition, decreasing water temperature results in decreasing diurnal activity and increasing ratio of night/day activity. Salmonids diel activity has been monitored at temperatures ranging from 7-8 °C up to 27 °C, and proposed threshold temperatures to switching to nocturnal feeding range between 5 and 13 °C. However, so far, there has only been few attempts to systematically compare diel activity patterns in rivers with considerable differences in temperature profiles. In Iceland, Arctic charr *Salvelinus alpinus* inhabits streams within a wide range of temperatures, which offers the potential to perform such comparisons. We repeatedly monitored 60 PYOY Arctic charr from 3 streams (~4, 9, and 14 °C) in semi-natural enclosures during two weeks in summertime. As predicted, activity rates increased from cold to warm streams. Fish avoided crepuscular times in the coldest stream, and activity rates increased primarily at night in the intermediate river. In the warmest stream, 90% of the fish were active at night and daytime activity also increased. However, the effect of temperature on activity rates decreased from cold to warm streams, indicating that fish in warm rivers could not extend their activity further, or that the net benefits of increased activity are reduced at high temperature. Fish were also significantly dispersed and aggregated in the coldest and warmest stream, respectively, but the effect of temperature varied among populations. In the coldest and warmest streams, aggregation decreased and increased with increasing temperature, respectively. These results shed new insight on the behavior and local adaptation of young salmonids to different thermal regimes.

# Does marine growth rate influence age at maturity in Atlantic salmon?

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**Key words:** Marine growth, scales, Atlantic salmon, Burrishoole, maturation age

## **Abstract:**

Atlantic salmon, *Salmo salar* L., generally experience high growth rates during the marine life phase but the timing of sexual maturity can vary, producing variation in age at return within and between populations. In order to determine how growth during the marine phase is related to the timing of return to freshwater, scales from Atlantic salmon, which provide a permanent record of growth history, were analysed to observe variations in fish growth rates and estimate time spent at sea. In 2009, hatchery reared smolts, produced by a limited group of multi-seawinter (MSW) parents, were microtagged, adipose fin clipped, and released into the Burrishoole catchment of western Ireland. After time spent at sea, the returning adults were captured in upstream traps and removed from the river. Fish were measured for fork length and weight, and scales were collected for analysis. Examination of microtags confirmed that of 120 fish that were recaptured from the experimental group, 40 fish were 1SW (2010) and the remaining 80 were 2SW (2011). Variation in growth histories between the 1SW and 2SW returns will be discussed in relation to environmental and genetic determinants of maturation in Atlantic salmon. o'maoileidigh

# Sprinting performance and kinematics of adult Atlantic salmon and brown trout.

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**Key words:** salmonid, hydraulic, sprinting capacity, behaviour, kinematics.

## **Abstract:**

Adult salmonids return to natal headwater streams to spawn and high quality spawning habitat is of primary importance for maintaining salmonid populations. Salmonids also often use different habitats during their freshwater residence and freedom of movement between habitat types is a fundamental metric of habitat quality. Natural and anthropogenic riverine features such as waterfalls, culverts or fishways may impede or delay fish movements, with associated consequences on fitness. Available data on sprinting performance of Atlantic salmon are scarce but interesting progress has been done in open flumes for brown trout, brook trout, and other species. The knowledge of maximum swimming capacity and endurance are of primary interest to fish passage issues. However, fish behavior also plays an important role in the fish's ability to overcome barriers. Here we describe a new project whose aim is to quantify the sprinting performance of Atlantic salmon and brown trout as well as their swimming behaviour. Brown trout were captured by electrofishing and tagged with 12 mm passive integrated transponders (PIT-tags). Fish were then released in a large staging area located at the downstream extremity of a 35 m tilted open flume instrumented with 20 PIT antennas. Adult wild salmon migrating upstream in the Connecticut River will be captured at a fish lift at Holyoke dam. Volitional attempts to ascend the flume under a range of flow velocities were recorded by the PIT system. These data will be used to estimate the relationship between swim speed and fatigue time in prolonged and sprint modes for both species. Two high-speed video cameras record side and ventral views of the fish, in order to perform kinematic analysis and describe the swimming behaviour of the fish. This project is part of a larger effort involving other migrating species and the results will be useful in prediction of fish passage at barriers and design of fishways, as well as addressing fundamental questions pertaining to the limits to swimming performance.

# Boys chase girls? Pre-spawning movement of Atlantic salmon at low density

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**Key words:** transport, telemetry, spawning

## **Abstract:**

In response to loss of Atlantic salmon habitat created by the construction of hydroelectric dams, a program to enhance habitat accessibility for salmon has been developed in the province of Québec, Canada. This project involves creation of new Atlantic salmon habitat on the Sainte-Marguerite River (SMR) via a transport program initiated in 2014. Returning adults are captured in a fish ladder in the northeast branch of the SMR, transported by truck, and released upstream of a pair of waterfalls that act as a natural barrier to fish passage. During the inaugural year of the transport program we evaluated acoustic telemetry as a means of tracking movements of adult salmon following translocation. Specifically, we conducted an acoustic range test and tested two different mooring devices for anchoring passive acoustic receivers (Vemco VR2W) in this shallow, high velocity, gravel-bed river. We captured and transported 12 returning adult salmon (2 females, 10 males) between June and September 2014. Before release, we surgically implanted each fish with an acoustic transmitter (Vemco V13). We tracked fish movements passively via a network of nine VR2Ws and actively via a mobile receiver (Vemco VR100). Following transport, one female and four males departed the study area. Spatial use of the river varied considerably among individuals that remained above the falls, however, movement by males increased dramatically in September and October, relative to July and August. It is unclear whether the increase in movement was due to female presence or the approach of the spawning season. Beginning 15 October, 5 of 6 remaining males converged on a single stretch of river, coincident with a directed movement by the single female to an area thought to contain ideal spawning habitat. High discharge prevented documentation of spawning, however, the putative spawning habitat will be assessed for presence of juvenile Atlantic Salmon in 2015.

# Evaluation of upstream passage of resident brown trout (*Salmo trutta*) at three newly constructed fish passage structures

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**Key words:** *Salmo trutta*, radio telemetry, fishway, efficiency

## **Abstract:**

The efficacy of three newly constructed fish passage structures for upstream passage of brown trout was evaluated on Colne Water, a tributary of the River Calder in the River Ribble catchment, Lancashire, UK in 2015. Radio telemetry was utilised in order to assess a pool-weir type pass, an embedded rock ramp and a structure which combined an embedded rock ramp with a 'nature like' two-tiered embedded s-bend pass. The study was conducted during the autumnal migration season using a combination of naturally migrating trout as well as displacement experiments designed to use their homing instinct to instigate fish to attempt to pass upstream of structures. Fish were followed using a combination of fixed logging stations and up to twice a day manual tracking by foot on the bank. Results demonstrated 100% of fish passed a control site where there was no in-stream structure present, compared with the highest passage efficiency observed, which was at the s-bend nature-like pass of 75%. Passage efficiencies were observed to be highest for displaced fish than those migrating naturally with few fish tagged at the downstream extent of the study area naturally migrating to attempt the most upstream structure. Displacement experiments were successful in instigating attempts with up to 91% of fish displaced downstream of structures observed attempting to pass upstream. This study contributes towards the conservation of brown trout populations by providing empirical evidence of the efficacy of three newly constructed cumulative fish passage structures for upstream passage.

## Participants NoWPaS 2015

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# Notes

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