



Värmland, Sweden
8th – 11th April 2014



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Sessions and detailed schedule

Monday 7th

Arrivals

<i>Time</i>	<i>Activity</i>
19:30	Ice breaker at Pitcher's, Karlstad town square

Tuesday 8th April

NoWPaS day 1 – field trip and transport

<i>Time</i>	<i>Activity</i>
09:15	Bus departs from the train station in Karlstad
10:00	Forshaga hydroelectric plant <i>Johnny Norrgård</i> – presentation of the fish trap
10:30	Forshaga sport fishing centre <i>Johnny Norrgård</i> - the River Klarälven fisheries <i>John Piccolo</i> – a holistic approach of the management of Lake Vänern
11:30	Lunch
12:30	Departure from Forshaga Bus stops in Munkfors (last opportunity to buy snacks, alcoholic beverages etc.)
14:00	Departure from Munkfors
15:00	Fänstjärnsskogen old forest Guide: <i>Sebastian Kirppu</i>
17:00	Departure from Fänstjärnsskogen
19:00	Arrival at Långberget
19:30	Dinner

Wednesday 9th April**NoWPas day 2**

<i>Time</i>	<i>Activity</i>
07:30	Breakfast
09:00	Opening – NoWPas Committee
09:10	Invited speaker – Eva Bergman , Karlstad University, Sweden
10:00	Break
10:30	Session 1 – Habitat – Chair: <i>Johnny Norrgård</i> <i>Sasha Nickel</i> <i>Stina Gustafsson</i> <i>Johan Leander</i> <i>Carole-Anne Gillis</i>
12:00	Lunch
13:00	Invited speaker – Olle Calles , Karlstad University, Sweden
13:50	Short break
14:00	Session 2 – Upstream migration – Chair: <i>Daniel Nyqvist</i> <i>Anne Bateman</i> <i>Michael Forty</i> <i>Anna Hagelin</i>
15:00	Break
15:30	Session 3 – Downstream migration – Chair: <i>Anna Hagelin</i> <i>Daniel Nyqvist</i> <i>David Aldvén</i> <i>Johnny Norrgård</i>
16:30	Short break
16:40	Session 4 – Genetics, diversification and populations I – Chair: <i>Stina Gustafsson</i> <i>Libor Závorka</i> <i>Stefania Giammanco</i>
19:00	Dinner

Thursday 10th April

NoWPas day 3

<i>Time</i>	<i>Activity</i>
07:30	Breakfast
09:00	Session 5 – Behaviour, foraging and physiology I – Chair: <i>Johnny Norrgård</i> <i>Johan Watz</i> <i>Stephen Dugdale</i> <i>Fia Finn</i>
10:00	Break
10:30	Session 6 – Behaviour, foraging and physiology II – Chair: <i>Johan Watz</i> <i>Heather Dixon</i> <i>Michael Puffer</i> <i>Joacim Näslund</i> <i>Dana Weldon</i>
12:00	Lunch
13:00	Invited speaker – Bror Jonsson , NINA, Norway
13:50	Short break
14:00	Invited speaker – Kjetil Hindar , NINA, Norway
14:50	Break
15:00	Session 7 – Genetics, diversification and populations II – Chair: <i>Daniel Nyqvist</i> <i>Darryl McLennan</i> <i>Jean Baptiste Torterotot</i> <i>Beatrix Bicskei</i> <i>Guillaume Bal</i>
16:30	Group discussion – NoWPas 2015
19:00	Dinner

Friday 11th April

Departure

<i>Time</i>	<i>Activity</i>
07:30	Breakfast
09:00	Departure with bus from Långberget
12:00	Arrival at the train station in Karlstad

Preface

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

NoWPaS is an international network for early stage researchers working on wild salmonids. It was started in Norway in 2005 with the support of the Norwegian Research Council in order to enhance dissemination of knowledge regarding the ecologically and socially important fish species *Salmo salar* L. and *Salmo trutta* L.

The main objective of NoWPaS is the staging of an annual international workshop where both PhD and post-doctoral delegates and keynote senior researchers can gather, exchange knowledge and ideas, and hold discussions in an interdisciplinary environment. During recent years, the body of knowledge concerning salmonids has continued to grow at a fast rate, and in tandem with this, the annual NoWPaS workshop has gone from strength to strength. Between 2005 and 2014, the annual workshop has been held ten times in eight different countries, comprising oral presentations from almost 250 early stage researchers and 40 invited speakers.

For the second time, 2014 sees the arrival of NoWPaS in the beautiful county of Värmland, Sweden. The River Klarälven winds its way through the county, and the city of Karlstad is built on the river delta where the river empties its water into one of Europe's largest lakes, Lake Vänern. In Lake Vänern, small wild populations of salmon and trout remains only in the heavily regulated Rivers Klarälven and Gullspångsälven, and these populations represent some of the last remaining large bodied (up to 20 kg) landlocked salmon stocks worldwide. Commercial and sport fisheries are maintained by hatchery stocking. Annual fisheries catch is roughly 75 metric tons, with an estimated 7.5% of hatchery smolts being recruited to the fishery. However, the current status and future prospects of the salmon and lake migrating trout in the River Klarälven and Lake Vänern are unclear, and researchers from Karlstad University are currently working to present a framework for a life history-based approach to research and monitor of the salmonid populations of Lake Vänern.

Acknowledgements

NoWPaS 2014 is possible thanks largely to voluntary efforts by the organising committee, who have dedicated their time and hard work to ensuring the success of the workshop. Their contribution to running the workshop from inception to completion cannot be overstated. However, NoWPaS 2014 would not be possible without the contributions of the workshop delegates, whose presence is the very lifeblood of the network. We are also very grateful to the NoWPaS 2014 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:



Forskningsrådet Formas



The organising committee of NoWPaS 2014:

- Anna Hagelin
- Anders Andersson
- Daniel Nyqvist
- Johan Watz
- Johnny Norrgård
- Lo Persson
- Stina Gustafsson

Field trip

Fish trap at Forshaga HEP

The fish trap at the hydroelectric plant in Forshaga has been vital for the survival of the populations of large bodied salmon and trout in Lake Vänern. Spawners are collected both for transport past several hydroelectric plants and released to the spawning grounds, as well as for the hatchery stocking program.



Fänstjärnsskogen

Fänstjärnsskogen is one of the most valuable nature reserves in the middle of Sweden. In the old forest there are bogs and pine moors, and the oldest trees are more than 300 years old. Many threatened species inhabits the forest, such as rare fungi, mosses, lichens and birds. This area is also situated in one of the most wolf-dense regions in Sweden.



Keynote abstracts

Forest-stream linkages: the response of brown trout to woody debris and terrestrial invertebrate inputs

Eva Bergman

River Ecology and Management, Department of Environmental and Life Sciences, Karlstad University, Sweden

In small forested streams, the diet and growth of brown trout is expected to be affected by the surrounding forest, both through the forest's effect on in-stream habitat structure and on prey availability. In this presentation I focus on trout responses to woody debris and terrestrial invertebrate input, two factors influenced by riparian zone structure, potentially affecting brown trout (*Salmo trutta*), both directly and indirectly. Using a combination of laboratory and field experiments, we examined various qualities of woody debris and terrestrial invertebrate input on prey availability and on the growth rates, diets and behavior of different size-classes of trout. The field experiments showed that addition of high densities of large wood affected trout growth in a positive way. This positive effect of large wood on trout growth may be related to prey abundance, as indicated by the high standing crop of aquatic macroinvertebrates on the wood. The positive effects may also be related to decreased energy expenditures by the trout, as trout increased their feeding efficiency and decreased their swimming activity and level of aggression as wood densities were increased in a laboratory experiment. Similar results were shown using fine woody debris, where a field experiment showed an increased drift density in field sites enhanced with fine woody debris, and trout showed the same general pattern with decreasing activity with increasing wood density. However, trout had a much lower activity in fine woody debris than in large woody debris. Terrestrial invertebrates are generally assumed to be a high quality prey resource for fish, and our field experiments showed that reduction of terrestrial invertebrate inputs affected trout diet. Many of our results were also dependent on fish-size, and the effects on growth were generally stronger and more consistent for large trout.

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

Olle Calles

River Ecology and Management, Department of Environmental and Life Sciences, Karlstad University, Sweden

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

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

Genetics of anadromous salmonids in Europe

Kjetil Hindar

Norwegian Institute for Nature Research, Norway

Major breakthroughs in the understanding of the genetic structure of salmonid fishes, and of the application of this knowledge to management, have come from research in Europe. I will go through some of the major findings from the first applications of genetic methods to studies of Atlantic salmon and brown trout, and look into how the change of genetic methods have modified (or not modified) the lessons learnt. The recent build-up of enormous capacity for sequencing of whole genomes, combined with stronger computers and new statistical techniques, open up new research questions for the future. The most exciting ones are perhaps those that we could not dream of addressing a couple of decades ago. But the most interesting ones remain the same: What is the role of heredity and environment in salmonid biology? How do human activities influence salmonid populations? And how can science contribute to the (day-to-day) management and (long-term) conservation of anadromous salmonids?

Migratory timing, marine survival and growth of anadromous brown trout in the River Imsa, Norway

Bror Jonsson

Norwegian Institute for Nature Research, Norway

Migration, growth and sea survival of anadromous brown trout *Salmo trutta* were investigated in River Imsa 1976-2005. Mean annual duration of the sea-sojourn for first-time migrants moving to sea between January-June was 6-9 months. It was 8-18 months for those migrating to sea between July-December. For veteran migrants, the mean duration of their sea-sojourn was 12 months if descending to sea in August, and it decreased gradually with time thereafter to 2 months for those descending in June-July. Most trout returned from the sea between June-October. Early ascending fish stayed the longest in fresh water, as all returned to sea at about the same time in spring. The February North Atlantic Oscillation Index (NAOI) correlated positively with temperature and flow in the Imsa between February-April, and with day number of 50 % cumulative smolt descent between February and June. Mean annual sea growth during the first two years after smolting was higher for trout spending the winter at sea than those wintering in the Imsa. First year's sea growth was lower for trout descending in spring than autumn, higher for immature than mature trout, and for immatures it correlated negatively with the February NAOI of the smolt year. Sea survival was higher for spring than autumn descending trout with maximum in May. Sea survival increased linearly with the annual number of trout smolts with no sign of density-dependent sea mortality. Sea survival of brown trout smolts moving to sea between January-June correlated positively both with the annual number of Atlantic salmon smolts and the seasonal growth at sea, and negatively with the NAOI for February in the year they moved to sea. Thus, both abiotic conditions and the abundance of a concurrently migrating species appeared to influence the sea survival of brown trout.

Examples of early environmental influences on later performances in fishes

Conditions encountered by fish during the embryogenesis and early life history can leave lasting effects not only on morphology, but also growth-rate, life history and behavioural traits. I will here give examples of how early impacts can affect the ecology of fishes. Mechanisms behind such phenotypically plastic impacts are not well known, but epigenetic change may be one central mechanism. Thermal regime during development and incubation is particularly important, but also early food consumption and intraspecific density can all be responsible for later life history variation. Several issues for future studies will be presented.

Abstracts

Migration of sea trout (*Salmo trutta*) smolts and kelts through a complex coastal habitat

Aldvén D.⁽¹⁾, Hedger R.⁽²⁾, Økland F.⁽²⁾, Rivinoja P.⁽³⁾ and Höjesjö J.⁽¹⁾

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⁽²⁾ Norwegian Institute for Nature Research, Norway

⁽³⁾ Department of Wildlife, Fish, and Environmental Studies, Swedish University of Agricultural Sciences, Sweden

Key words: sea trout, mortality, migration, telemetry

Abstract: Migratory routes and habitat use of sea trout at sea (*Salmo trutta*) have been studied in fjord systems but little information exists from populations in rivers emptying into open coastal areas. Therefore a two year study on sea trout was conducted (2011-2012) using acoustic telemetry in a coastal system consisting of a river, a shallow inner estuary, a deeper outer estuary, and a coastal sea environment. The objectives were to test the predictions that kelts migrate faster than smolts and that mortality rates would be higher for smolts than kelts. Sea trout were captured and tagged with hydro acoustic transmitters, after which they were released and monitored during their initial migration. Migration was foremost nocturnal in the river and estuary whereas a tendency to daytime migration was observed along the coast. Migration speed tended to decrease as individuals progressed from the river through the estuary and along the coast, diverging from previous studies for Atlantic salmon. Mortality during the initial part of migration differed significantly between years for both smolts and kelts. A higher mortality occurred in 2011, which may have been related to increased predation resulting from lower turbidity during migration in this year. However no difference in mortality was observed between kelts and smolts.

Managing Irish salmon populations: from moving averaging towards a hierarchical Bayesian life cycle model

Bal G.⁽¹⁾ and White J.⁽¹⁾

⁽¹⁾ Irish Marine Institute, Rinville, Oranmore, Co. Galway, Ireland

Key words: Atlantic salmon, population management, Bayesian modelling, statistical model, life cycle model

Abstract: Currently, salmon surplus forecast used to set allowable catches on 176 Irish rivers are derived from Monte Carlo analyses based on angling catch and exploitation rates from the previous five years to determine next year pre-fisheries abundances. Estimated returns are compared against conservation limits, set at the necessary number of spawners to achieve maximum sustainable yield, defined from stock-recruitment analyses of index-rivers, to determine if a surplus is available in a river. We now aim at developing a new approach through ECOKNOWS (FP7) that will incorporate more biological relevant information from the life cycle of salmon, using various data source such as monitoring parr relative abundance and the recovery of adults tagged as smolts (coded wire tags) during multiple fisheries. This work investigating the application of Bayesian hierarchical life cycle models will provide the basis for further development of Irish salmon stock assessment.

Upstream migration of Atlantic salmon at an Irish hydropower dam

Bateman A.⁽¹⁾

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Key words: migration, Atlantic salmon, hydropower

Abstract: The Shannon is the largest river in Ireland with a catchment area of ~14,000 km² and a mean annual discharge of 186 m³/s. The catchment drains the lowland central plains of the country and is predominately underlain by limestone. Remarkably, from source to estuary, the Shannon only descends 47 m along its main channel (359 km). The aim of this study is to investigate the behaviour of migrating fish at the Ardnacrusha hydropower station by means of modern technologies (*i.e.* telemetry, PIT tagging, DIDSON acoustic sonar). The River Shannon and its salmon stocks have been exploited by man since prehistoric times. During the 1920s, the lower reaches of the river were harnessed for hydropower generation at Ardnacrusha. The completion of the hydropower station had a major effect on the salmon populations which resulted in a dramatic decline in stocks. Historical records have been compiled; they clearly show the impact of the hydropower scheme and other environmental factors (*e.g.* UDN, mortality at sea) causing the general decline in stocks evident across north-western Europe. Some measures taken in order to mitigate the effects of the scheme were: experimentation with a temporary electrified fish screen across the tail race; development of a salmon hatchery in order to restock salmon populations; construction of a Borland lift type fish pass at the hydropower station. Telemetry studies were carried out in order to assess the behaviour of ascending adults. The results were inconclusive however; lessons can be learned for future experiments. Studies were also conducted on other areas of fisheries management such as: survival rates of downstream migrating smolts; a national coded wire tagging programme; and an ongoing study investigating the genetic pedigree of River Shannon salmon. As part of the current study, a review of previous research conducted on the salmon of the River Shannon will be completed. Historical records on the numbers of fish passing through the Borland lift will be compiled and analysed. A new fish counter and video camera system are being installed at Ardnacrusha in order to facilitate this research. Observation of salmon behaviour at the dam will be evaluated by means of telemetry, PIT tagging and DIDSON acoustic sonar techniques. It is hoped that development of behavioural deflection technologies in the vicinity of the dam will be carried out as part of the project. This study will build on previous research conducted at the Ardnacrusha hydropower station and incorporate current advances in knowledge and technology. A comparison of gene transcription profiles of domesticated and wild Atlantic salmon embryos reared under controlled conditions

Bicskei B.⁽¹⁾, Bron J. E.⁽¹⁾, Glover K. A.⁽²⁾ and Taggart J. B.⁽¹⁾

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⁽²⁾ Institute of Marine Research, Population genetics, Bergen, Norway

Key words: Atlantic salmon, escapees, microarray, transcriptome, embryo

Abstract: Atlantic salmon (*Salmo salar*) have been domesticated for approximately ten generations leading to the genetic differentiation of farmed strains from their wild counterparts. As a result of large scale escapes from fish farms, interactions between wild and domesticated fish and their genetic consequences are concerns for both the fish farming industry and fisheries managers.

Following on from a previous gene expression experiment conducted on wild and domesticated strains of Atlantic salmon juveniles, this study focused on embryos of the same stocks. We used microarray technology to identify transcriptional differences among Mowi (domesticated), Figgjo (wild) strains and their reciprocal hybrids to examine patterns of differential gene expression. Functional analyses revealed both common and life- stage specific transcriptional differences between the wild and domesticated stocks, with hybrids generally displaying intermediate expression patterns. Approximately 33-42% of the differentially expressed genes displayed an additive gene expression pattern and a further 24-28% showed maternal dominance, indicative of a strong maternal effect at the embryo stage. The findings of this study can assist efforts to define the genetic impacts of the exposure of wild stocks to domesticated fish. This work needs to be expanded to include further stocks in order to better discriminate strain-specific from more general wild-domestication effects.

Spatial and temporal differences in Atlantic salmon marine feeding in the Northwest Atlantic

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Key words: Atlantic salmon, West Greenland, marine feeding, gut contents, stable isotopes

Abstract: Atlantic salmon, *Salmo salar* L., suffer from low growth and high mortality in the marine environment, despite steps being taken to protect the species such as the cessation of commercial fishing. Many non-maturing adult salmon of North American origin migrate up the west coast of Greenland in late summer, during which they feed extensively. Salmon diet during this migration was last studied during the 1970s. Since that time changes have occurred in both the oceanic environment (e.g. temperature) in which they feed and the food webs within which they feed (e.g. species composition). Here questions relating to potential changes in salmon diet during the intervening 40 years and how salmon diet may be affecting marine survival are addressed. Salmon migrating along the West Greenland coast were sampled at three communities between 2009 and 2011. Stable isotope methods were used to examine the trophic status of the salmon, and the feeding relationships between salmon and their prey. Gut content analysis methods were also employed to assess whether the migrating salmon are generalists, or whether salmon within that population specialise. Traditional diet studies can provide insight into prey resources consumed, but stable isotope analyses yield a longer-term view of feeding relationships by accounting for all sources of energy assimilated during a feeding season and the combination of approaches provides a useful temporal prospective on marine feeding. Examining the diet of these salmon could provide answers to the problem of poor marine survival in this commercially important species, potentially allowing for the development of further management techniques to help revive salmon populations.

Reach-scale movement of Atlantic salmon in response to summer high temperature events in a thermally-stressed river

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Key words: Atlantic salmon, movement, thermal refuge, temperature, PIT-tag

Abstract: River ecosystems comprise a diverse mosaic of habitats created by the interaction between channel processes and the physical environment. Movement in response to changing habitat patterns and resource gradients is therefore a characteristic of many fish species. The movement of Atlantic salmon in response to migratory and seasonal cues is fairly well understood, with previous research detailing displacements due to predation, resource seeking or spawning behaviour. However, less is known about the movement behaviour of salmonids in response to elevated water temperatures. Although Atlantic salmon are the most temperature tolerant of the salmonids, they are adversely affected by thermal extremes, experiencing heat stress in water temperatures exceeding ~23° C. Because continued heat stress eventually leads to mortality, salmonids thermoregulate by moving to occupy discrete patches of cold water, sometimes traversing considerable distances. Termed thermal refuges, the use of these cold water patches by salmonid aggregations during summer heat waves is well documented. However, in spite of knowledge concerning fish behaviour *within* thermal refuges, questions still remain about how salmonids actually move in search of thermal refuges, and little is known about the timescales and temperatures over which these movements occur. Given the widespread consensus that water temperatures in northern latitude catchments are rising and will continue to do so under future climatic change, a better understanding of salmonid thermoregulatory movement behaviour is of critical importance. This paper therefore details the results of a passive integrated transponder (PIT) tag experiment conducted in a thermally stressed Atlantic salmon river in Québec, Canada, with a view to understanding salmonid movement behaviour prior to thermoregulation in cold water patches during heat wave events.

Personality and migratory behavior; are there correlations? A case study in compensatory reared salmon

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Key words: behaviour, migration, boldness, *Salmo salar*.

Abstract: Individual variation and limited plasticity in behavior are factors that have been shown to shape populations and determine how well they are doing in different stages of life. When salmon stocks are declining all around the world it is important to understand what defines a successful individual when it comes to all stages of the salmon life cycle. One step in the life cycle of the salmon is the smoltification and the migration out to sea. The hypothesis of this study was that individuals

that smoltify at different age differ in behavior and that this is correlated to their inclination to migrate. Specifically, difference in the shy/bold continuum was tested. To determine if the individuals differed in boldness, and/or displayed a bold behavioral syndrome, two essays were performed in different contexts. Migratory intensity was quantified in an artificial stream. The one year old smolts were bolder in one of the two contexts and they had a lower tendency to migrate in the artificial stream. Condition had a negative effect on the migratory intensity of the two year olds and outer smolt-status had no effect on migratory intensity. Being bolder can have an effect on several aspects connected to fitness in the salmon life cycle and, even though no correlations to migration were found in this study, it could be important to consider individual difference in behavior when rearing salmon smolt for compensatory reasons. The fact that two year olds with a high condition factor had lower migration intensity and that smolt status had no effect on migration intensity are also results that could be interesting to consider when rearing smolt for compensatory release.

Evaluating the impact of individual and cumulative barriers to the upstream migration of *Salmo trutta* using PIT telemetry

Forty M.⁽¹⁾ and Lucas M. C.⁽¹⁾

⁽¹⁾ Durham University, School of Biological and Biomedical Sciences, Durham, UK

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

Abstract: Upstream migration of brown trout (*Salmo trutta*) and its anadromous form sea trout was monitored past a selection of individual and cumulative barriers on two tributaries of the River Ribble (Lancashire, UK) using PIT telemetry during the autumnal migration season in 2013. The efficiency of a low-cost baffle fish pass and two pool-weir passes was evaluated in addition to an assessment of the impact of three other structures (two culverts and one weir) on upstream migration. This study uses a combination of monitoring naturally migrating *S. trutta* and displacement experiments where resident *S. trutta* were displaced below the structures and their homing instinct utilised to instigate ascent of the structure. Results showed passage efficiencies of 74% for a low-cost baffle fish pass, and up to 84% for the pool-weir pass design, with up to 90% of displaced fish observed attempting to ascend the structures. Of the two culverts studied, one was found to be a substantial barrier to upstream migration in terms of passage efficiency (42%) while the other was inconsequential (98%). Delay before successful passage as well as the time taken for successful ascents was also evaluated for each of the structures. This study provides empirical information on the efficiency of passage of *S. trutta* past multiple obstructions and for individual passage designs in relation to environmental factors and biological attributes, contributing towards future conservation and management efforts for both ecotypes.

Using fisheries recoveries of code wire tags to estimate salmon smolts and spawner population sizes: a Bayesian hierarchical approach

Giammanco S.⁽¹⁾, Bal G.⁽¹⁾ and White J.⁽¹⁾

⁽¹⁾ Irish Marine Institute, Rinville, Oranmore, Ireland

Key words: Salmon smolts, population estimates, Bayesian Hierarchical framework

Abstract: The data obtained through the Salmon Tagging Program in Ireland have traditionally been used to estimate return rates, mortality, sea age stock composition and migration patterns using expert opinion on fisheries efficiency. We extend the use of coded wire recovery data to estimate migrating smolt population sizes in the context of a simple mark and recapture experiment. The analysis is conducted in a Bayesian framework with the associated population sizes and parameter estimates providing a basis for further investigations of smolt-to-smolt relationship and smolt to adult dynamics, making assumptions to avoid the use of potentially biased expert opinion on catch probability.

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

Gillis C-A.⁽¹⁾ and Bergeron N.⁽¹⁾

⁽¹⁾ Institut national de la recherche scientifique, Centre Eau Terre Environnement, Québec, Canada

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

Abstract: Since 2006, nuisance growths of *Didymosphenia geminata* (didymo) have been occurring in eastern North America. This alga forms thick and extensive benthic layers in stable flow oligotrophic rivers. In a previous study, Gillis and Chalifour (2010) showed that the presence of didymo caused significant shifts in macroinvertebrate community structure and prey abundance. Despite an increase in overall prey production, prey location and availability may be altered by dense didymo mats. Therefore, the presence of didymo is suspected of altering juvenile Atlantic salmon foraging behavior and habitat selection through food web interactions. Research objectives aimed at evaluating the effects of didymo on juvenile salmon by assessing their foraging behaviour as well as prey availability in didymo-affected and didymo-free sites. Feeding behaviour data was collected in the Patapedia River by focal-animal sampling of young-of-the-year salmon conducted by one person while snorkelling. Each YOY was observed for a period of 15 minutes and all observed behaviours were recorded. Drift nets were set for a period of 24 hours in order to assess prey availability at each observation site. Results show a significant positive relationship between proportion of benthic forays vs. drift forays and increasing didymo cover ($R^2 = 0.54$, $p < 0.001$). Laboratory analysis is underway to examine whether the shift in foraging behaviour is triggered by limited prey availability induced by the didymo mats or if didymo presence enhances profitability. Further results, currently under analysis, will be presented and mechanisms by which *D. geminata* alters Atlantic salmon habitat will be discussed.

The habitat potential of nature-like fishways

Gustafsson S.⁽¹⁾, Calles O.⁽¹⁾, Österling M.⁽¹⁾ and Skurdal J.⁽²⁾

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Key words: nature-like fishway, habitat, mitigation, restoration

Abstract: 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. Such structures could both be constructed to maintain a high biodiversity and to compensate for the damage human activity has had on a given species. In Västerdalälven, Sweden a hydroelectric power plant was constructed in the vicinity of the village Eldforsen in 2009, replacing an old abandoned power plant. The impoundment flooded a large area of the river, consequently destroying and degrading habitats for many different species and also disrupting the longitudinal connectivity. To mitigate the effects of the hydropower construction a 500-m 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 thereby providing a range of habitats to potentially harbor a high biodiversity. Besides creating a diverse instream environment, some of these habitat were designed to host a population of freshwater pearl mussels (*Margaritifera margaritifera*) and their host fish, the brown trout (*Salmo trutta*). Investigations of the nature-like fishways habitat potential for these species will commence in spring 2014.

Fallback frequency and migration behaviour in landlocked Atlantic salmon (*Salmo salar*) and brown trout (*salmo trutta*): does timing matter?

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Key words: Atlantic salmon, brown trout, fallback, migration, restoration efforts

Abstract: Native and endangered landlocked salmon and trout populations inhabit Lake Vänern and River Klarälven. These populations are some of the last remaining large bodied landlocked stocks worldwide. At present the migration route is hindered by impassable hydroelectric power stations. Compensation and restoration efforts is being done through smolt releases and transportation of spawners, passed the power stations, to undisturbed areas. Between September 2011 and September 2013 a total of 152 (57 early and 96 late -migrating Atlantic salmon) and 28 brown trout (all early) were radio tagged with external transmitters to examine whether or not time of migration affects the (1) fallback frequency after release, (2) migration time, (3) time spent holding, or (4) spawning location. The average number of fallbacks was 47% in the early group, 10% in the late group and 14% in the trout group. The fallback rate did not relate to river discharge. There was a difference in time spent on migration where the fish in the early group completed their migration in 57 days, the late in 42 and brown trout in 59 days. The same pattern was also found in the time spent holding, where early salmon spent 56, late 22 and brown trout 57 days. When looking at the position held at spawning, early and late Atlantic salmon both used the same areas in the main stream, whereas brown trout mainly used tributaries.

Evaluating habitat selection of lake char (*Salvelinus namaycush*) using acoustic telemetry

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Key words: lake char, acoustic telemetry, habitat selection, temperature

Abstract: To learn more about the behavior and habitat selection by invasive lake char (*Salvelinus namaycush*) we are conducting a study using acoustic telemetry in Lake Gautsträsk. The lake covers an area of 5.5 km² and is located in the mountain area of Västerbotten county, Sweden. So far ten lake charrs caught by angling have been surgically implanted with transmitters giving information on xy-position, temperature and depth approximately every 260 seconds. A system of 36 receivers with overlapping coverage makes it possible to triangulate each individual with a high precision over the whole lake. The first result shows a good coverage of the lake, both temporal and spatial, providing a high resolution dataset. I will present a summary of our findings based on data during summer and autumn 2013, including the timing and location of lake char spawning, temperature preference, diurnal activity and more.

Life history variation and telomere heritability in Atlantic salmon

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Key words: telomere, heritability, life history, *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, which can lead to cellular senescence and eventually organism senescence. There are a number of negative consequences associated with having a relatively short telomere length, therefore an animal's initial telomere length and rate of loss are both of great importance. The inheritance of telomere length is still poorly understood, however the Atlantic salmon, *Salmo salar*, is an ideal species in which to examine this relationship. Adult salmon vary greatly in their age at first reproduction (e.g. spawning males in Scotland can range in age from 18 month old mature parr to anadromous multi sea winter fish, which are 100 times larger and at least 5 years old). This variation in age and growth may also result in differing telomere lengths. In addition, since Atlantic salmon are external fertilisers and produce relatively large numbers of offspring, data can be easily obtained from the gametes and the early developing embryo stages, as well as parental somatic tissues. This provides an ideal opportunity to explore the heritability of telomere length. In this project I am using a split-brood in vitro fertilisation experiment to determine the effect of both parental age and offspring age on telomere dynamics in wild salmon.

Environmental enrichment in salmon hatcheries: effects on behaviour and stress physiology

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Key words: environmental enrichment, cortisol, migration, shelter, stocking

Abstract: The usage of environmental enrichment in the rearing of fish destined to be released into the wild has been subject to much research during the last two decades. However, results have been mixed with respect to the effects on the fish. I present results from two enrichment-experiments on the effects of in-tank shelters on the behaviour and stress physiology in Atlantic salmon from the River Imsa stock in Norway. Shelters were used to a high extent by the fish in the tanks. Fish from enriched tanks were shown to be less stressed than fish reared in barren tanks. In addition, effects on shelter-seeking behaviour in a novel environment were detected, where fish from enriched tanks sought shelter to a higher extent than barren-reared fish. However, both stress and behaviour are potentially altered depending on density of fish in the tank. Seaward migration of the enriched fish was not improved by rearing with shelters.

Application of sea trout parr habitat index in Germany - challenges and first results

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Key words: *Salmo trutta*, river morphology, habitat quality, electro-fishing, management

Abstract: In the EU, migratory fish species are among the most endangered vertebrates. A notorious example is provided by anadromous trout populations (*Salmo trutta* L.) in German river systems, which became almost extinct in the middle of the 19th century due to water pollution, habitat loss and the obstruction of its migration routes. Intensive stocking and conservation efforts improved the situation and today sea trout yet again occur in most of the suitable water systems. In the northernmost federal state of Germany, Schleswig-Holstein, sea trout is important for both recreational and commercial fisheries. Nevertheless, information on distribution, spawning (and stocking) success as well as the proportion of natural reproduction within river systems is lacking. In the present study we followed the recommendations of ICES Working Group on Baltic Salmon and Trout (WGBAST) and applied the sea trout parr habitat scoring system. Specifically, in 2013, we monitored habitat suitability and abundance of young sea trout life stages (parr phase) by electro-fishing surveys at 123 stations within 30 watercourses draining into the Baltic Sea. The results present the first comprehensive (but not yet repeated) German inventory of parr stages in small rivers and creeks flow into the Baltic Sea.

Predation by northern pike *Esox lucius* on migrating hatchery reared salmonid smolts

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Key words: ecological window, habitat-specific predation, migration, opportunistic predator, salmonid management

Abstract: Supplementary stocking of hatchery reared smolts is the main method used to mitigate and compensate for lost production of Atlantic salmon (*Salmo salar*) and brown trout (*Salmo trutta*) populations in rivers. The survival of hatchery reared smolts in nature is generally low, and predation is often liable for a high mortality. In the River Klarälven, Sweden, 175 000 hatchery reared salmon and trout smolts are annually released 25 km upstream the river. The salmon and trout are non-anadromous and stay in Lake Vänern until maturity. During 2006-2010 half of the released hatchery reared smolts tagged with telemetry transmitters did not reach Lake Vänern. The loss rate of smolts was higher in river stretches with shallow vegetated areas, and in stretches with deep pool areas, than in the dominating habitat with intermediate depth and sandy, uniform bottom substrate. Similarly, average CPUE of northern pike (*Esox lucius*) was high in the same habitats as where smolts were lost. Gut content analyzes of pike showed that they fed chiefly on European smelt (*Osmerus eperlanus*) in April, hatchery reared salmonid smolts in May and European river lamprey (*Lampetra fluviatilis*) in June. We argue that when these energy and lipid rich alternative preys occur in high densities during their spawning periods they are probably easy caught and an energetically favourable prey for pike. Our results revealed that there may be ecological windows of opportunity for the hatchery reared smolts to attain an increased migration success in the River Klarälven.

Post-spawning behaviour and downstream migration of landlocked Atlantic salmon kelts in the River Klarälven, Sweden

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Key words: kelt, repeat spawning, downstream migration, landlocked salmon, dam passage

Abstract: Repeat salmonid spawners potentially make large contributions to total recruitment and long term population stability, and yet, relatively little is known about this phase of salmonid life history. Even less is known about the post-spawning dynamics of landlocked Atlantic salmon. Thus, we studied post-spawning behaviour and survival of Atlantic salmon in relation to downstream dam passage in the River Klarälven in south central Sweden. 49% of the fish survived spawning and initiated downstream migration. The kelt 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 21km/day. Most fish passed the first hydropower station via upward opening spill gates after a median delay of 25min. No tagged fish survived passage of all 8 hydropower stations in the system to reach the Lake Vänern. Remedial measures such as guidance and bypass systems, organized spill and trap and trucking are potential solutions that need to be tested.

Seasonal effects of hydropeaking on growth, energetics and movement of juvenile Atlantic salmon

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Key words: Body fat; dewatering; hydropower production; salmonids; artificial stream channels

Abstract: The performance and movements of juvenile Atlantic salmon *Salmo salar* exposed to variable water discharge (simulating hydropeaking) but with a stable water covered area were studied in six experimental stream channels, both during winter and summer. During winter, no effect of hydropeaking was documented on performance or movement. In summer, fish experiencing hydropeaking had a significantly lower body mass and higher movement rates than the control fish. The results for body fat were mixed, with small fish having less and large fish having more body fat than similar sized conspecifics in the control. In general, however, effect sizes were small and the rapid and frequent changes in water discharge and water level in the present study had small effects on the performance of juvenile Atlantic salmon. The cumulative long-term effect at the population level is unknown, but reduced growth might to some extent translate into increased smolt age.

Influence of forest road culverts and waterfalls on the fine scale distribution of brook charr (*Salvelinus fontinalis*) genetic diversity in a boreal watershed

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Key words: habitat fragmentation, landscape genetics, brook charr, culverts.

Abstract: Habitat fragmentation has become an increasing concern in conservation biology and is of prime importance with the expansion of forest-road networks toward boreal and arctic regions. The aim of this study was to evaluate the effect of artificial and natural barriers to fish movement on the fine scale distribution of genetic diversity in brook charr (*Salvelinus fontinalis*). We genotyped 995 individuals sampled from 25 locations in a boreal watershed fragmented by culverts and natural waterfalls. Using a landscape genetic approach, we tested whether the presence of both types of barriers resulted in decreased genetic diversity and increased divergence within isolated locations. Results showed that genetic divergence was enhanced between sites separated by barriers and genetic diversity was reduced within sites located above barriers. Moreover, the changes observed in the levels of divergence and diversity correlated with the number of barriers. Overall, results of this study suggested that the effects of culverts and natural waterfalls were similar but the effect of

culverts was globally more pronounced. To our knowledge, this is the first study illustrating the effects of forest-road culverts and natural waterfalls on the distribution of genetic diversity in brook charr within a boreal watershed. We discuss our results in the context of boreal forest-road network expansion and in light of the necessity for a better understanding of the potential impact of road infrastructure on long-term fish population persistence.

Winter behaviour of brown trout: surface ice provides overhead cover and increases foraging activity and growth

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Key words: behavior, energetics, ice cover, PIT, predation, *Salmo trutta*, ventilation rate

Abstract: Behavioural responses by fish to river ice may affect habitat selection, growth and survival during winter. Different forms stream ice have opposite effects. Frazil and anchor ice may exclude fish from winter refuges, whereas surface ice prevents instream ice formation and may function as overhead cover. Predation risk from mammals and birds is high for juvenile salmonids during winter. Consequently, juvenile salmonids reduce their daytime activity and become nocturnal, with low foraging efficiency. Because surface ice may offer protection from endothermic predators, we predicted that juvenile salmonids increase their daytime foraging activity, spend less energy on anti-predator behaviours and, as a result, grow better in the presence of ice cover than in its absence. These predictions were tested in laboratory and field experiments using brown trout as a test species. In a laboratory flume, trout under surface ice had lower ventilation rates and higher foraging activity than trout without surface ice. In a boreal forest stream, we simulated ice cover by suspending plastic sheeting over five 30-m-long stretches of the stream. Trout that had spent winter under the simulated ice cover had grown better than trout in control stretches. Surface ice may be an important factor for overwinter survival rates of stream fish at high latitudes or altitudes.

The effects of acute exhaustive exercise on immune function in brown trout

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Key words: exercise, immune function, aerobic scope, brown trout

Abstract: Studies examining human responses to bouts of acute exercise have shown that individuals undergo a period of immunosuppression following exercise resulting in an increased susceptibility to infections. This would suggest that a trade-off exists between immune function and energetic activities; such as predator evasion, intense mating displays, and foraging, which may influence the behaviour and life history strategies of individuals. This conflict may be reduced in individuals with larger aerobic scopes, however, due to their increased respiratory capacity that would allow them to carry out energetic activities while maintaining baseline levels of immunocompetence. The purpose of this study is to examine the relationship between aerobic scope and immune function in brown

trout to determine if immunosuppression occurs as a result of acute exhaustive exercise and if aerobic scope has an effect on baseline immunocompetence and intensity of immunosuppression following exercise. All brown trout in the study were exercised to exhaustion in a swim tunnel and placed in an intermittent-flow respirometer to measure their aerobic scope. Experimental fish (N=30) were then terminally blood sampled to create blood smears at 2 and 24 hours post exercise to examine levels of immunosuppression and if a recovery phase had begun. Control fish (N=30) were returned to their tanks for one week following exercise before being terminally blood sampled to determine baseline levels of immunocompetence. This study has implications for our understanding of the interaction between aerobic scope and fish immunology and its potential effects on how individuals may respond both behaviourally and physiologically to changes within their environment.

Demogenetic study of brown trout *Salmo trutta* population in a dendritic headwater system

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Key words: demographic synchrony, metapopulation, migration

Abstract: In species with a high ecological variability like brown trout *Salmo trutta* and other salmonid fish population structure is complex and flexible. The determination of population structure, dynamic and history can help to outline basic management units and thus enhance the quality of protection and management of the aimed species. In this study, combined data from analyses of genetic divergence (F_{ST}) and demographic synchrony (r) based on seven years long observation (2005-2011) were used to examine population structure of brown trout in pristine dendritic headwaters. The value of genetic divergence (F_{ST}) among sampling units ranged from -0.03 to 0.16. Demographic synchrony was moderate and average correlation coefficient for sampling unit (r) ranged from 0.28 to 0.66. No effect of isolation by distance was found in genetic divergence or demographic synchrony among sampling units. However, gradual pattern in genetic divergence was observed, with high elevated headwaters being the most distinct from the mainstream. This pattern seems to be reflexion of extinction risk, which was increasing with both distance from the mainstream and average distance from other sampling units and/or behavioural isolation among stationary fish in headwaters and the mainstream migrants. In conclusion, the moderate genetic divergence, lack of isolation by distance and influence of mainstream proximity on extinction risk implies that the source-sink (mainland-island) metapopulation model fitted the best to the observed pattern. We showed, in contradiction with usual model of stream dwelling salmonids, the upstream sections of headwaters can present ephemeral islands (sinks) while the mainstream can play a role of mainland (source) and nursery area in the metapopulation of stream dwelling salmonid fishes. This findings stress on the importance of mainstreams in conservation management of brown trout in dendritic mountainous headwaters.

Participants NoWPaS 2014

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Notes