Nordic Workshop for PhD students on *Salmo salar* and *Salmo trutta* Research

Karlstad, Sweden
March 30th – April 2nd 2006

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Editor

Morten Stickler

Department of Hydraulic and Environmental Engineering

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Programme

Location: Karlstad, Sweden.

- **Wednesday 29 March:** Committee meeting and "ice breaker" on a local pub for early arrivers
- **Thursday 30 March:** Technical workshop at Karlstad University
- **Friday 31 March:** First day of meeting - invited speakers and presentations
- **Saturday 1 April:** Second day of meeting - invited speakers and presentations
- **Sunday 2 April:** Third day of meeting – closure, summing up and departure

Presentations by participants:

- 15 March: Deadline for submission of abstract (maximum 350 words) and committed registration to morten.stickler@ntnu.no
- Oral presentation or poster
- Time of talks would be approximately 10 min with 5 minutes for discussion

Invited speakers:

Invited talks given by: Neil Metcalfe (Glasgow University, Scotland), Torgny Bohlin (Göteborg University, Sweden), Lasse Kyläkorpi (Vattenfall, Sweden) and Tormod Schei (Statkraft, Norway).

Organizing committee:

Morten Stickler, coordinator (Norway), Line Sundt Hansen (Norway), Lasse Fast Jensen (Denmark), Olle Calles (Sweden), Pär Gustafsson (Sweden) and Mikko Kiljunen (Finland).

Costs and reimbursement:

Accommodation (included 3 meals per day) and conference fees are covered by NoWPaS. You have to bring your own sleeping bag or sheets. You have to share room with 1-3 other participants. Travel costs will be partly covered. Participants can apply for reimbursement. Maximum 350 Euros. Reimbursement form will be send out by e-mail in front of the workshop. Receipts and forms are to be collected during the meeting, so please bring necessary receipts.

Travel information:

You will be transported from Karlstad to Humletorp and back. The transportation will leave Karlstad University at 1700 hrs Thursday 30 March and return to Karlstad Centre at 1300 hrs Sunday 2 April. If you need help to arrange transportation on any other time you should contact Olle Calles (organizer at Karlstad University, olle.calles@kau.se) or Morten Stickler (NoWPaS coordinator, morten.stickler@ntnu.no).

Our sponsors:

VATTENFALL NTNU Det skapende universitet Norges forskningsråd KARLSTAD UNIVERSITY DN

Sessions and detailed schedule

Wednesday 29 March

CM and arrivals

Time	Activity
18:00	Committee meeting (Morten, Olle, Pär, Line, Mikko, Lasse)
20:00	Ice breaker at Arena Lounge (Everybody welcome! See map 2)

Thursday 30 March

Technical workshop at Karlstad University

Time	Activity
12:00	Lunch at Restaurant Etikett
13:00	**Technical workshop - Tagging techniques and associated tracking devices** (Department of Biology - House 5F - basement and Room 5F423) - Chair Olle Calles **1) Telemetry** ➢ External tagging ➢ Surgical implant ➢ Gastric implant ➢ Receiver and logger **2) RFID/PIT-technology** ➢ Injection ➢ Surgical implant ➢ Subcutanous implant ➢ Receiver and antenna from Texas instruments **3) Other kinds of tags** ➢ Visible implants ➢ Floytags ➢ Panjet
17:00	Transport to Humletorp by cars and mini-busses picking up people on the way (if required).
18:30	Arrival at Humletorp conference centre.
19:00	Dinner at Humletorp - Trollebo

Friday 31 March

NoWPaS meeting day 1

All activities will take place in Storstugan (The Master Cottage) unless something else is specified

Time	Activity
07:00	Breakfast
08:30	Opening. (The committee)
09:00	**Invited speaker - Dr Torgny Bohlin** - Göteborg University *Compensatory growth and its costs - experiments in a wild trout population?*
10:00	Break
10:30	**Session I - Population dynamics** - Chair Morten Stickler ➢ Mikko Kiljunen - Development of brown trout (*Salmo trutta* L.) embryos and their date of hatching and emergence in boreal lake outlet streams ➢ Panu Orell - Reliability of snorkeling counts in assessing spawning stock of Atlantic salmon in small and medium sized rivers ➢ Rasmus Kaspersson - Competition in size- and age-structured populations: unfolding mechanisms and effects using juvenile brown trout (*Salmo trutta* L.) ➢ Kai Korsu - Invasion of brook trout to northern streams: a threat to the native brown trout? **Session II - Behaviour and migration -** Chair Line Sundt-Hansen ➢ Monika Haugland - Energy content, body composition and growth of Atlantic salmon smolt and postsmolt during migration from freshwater to the high seas. ➢ Ignacio Serrano - Characterization of the coastal habitat of anadromous brown trout (*Salmo trutta*) in the Bothnian Bay.
12:00	Lunch
13:15	**Invited speaker - Lasse Kyläkorpi -** Vattenfall AB *"Environmental adaptation of hydropower"*
14:15	Coffee break
14:30	**Session II cont. - Behaviour and migration -** Chair Line Sundt-Hansen ➢ Ivan Olsson - Landlocked Salmon in Lake Vänern: Part One ➢ Jens Hultman - Landlocked Salmon in Lake Vänern: Part Two ➢ Olle Calles - Downstream passage problems in regulated rivers. ➢ Johan Östergren - Overwintering and downstream migration of sea trout (*Salmo trutta* L.) kelts in two regulated rivers in northern Sweden. ➢ Peter Rivinoja - Migration Problems of Atlantic Salmon (*Salmo salar* L.) in Flow Regulated Rivers.

- Elianne Wassvik - Attraction channel as an entrance to fish ladders at hydropower plants.
- Petri Karppinen - Use of motion-sensitive radio tags to record the behavioural patterns and activity of spawning Atlantic salmon

16:00 Break

16:15 **Session III - Genetics** - Chair Pär Gustafsson

- Lasse Fast Jensen - Does selection occur at microgeographical scales? A comparison of genetic differentiation at neutral and MHC-linked microsatellite loci in Danish brown trout (*Salmo trutta*, L.) populations.
- Lars Forsberg - MHC and Mate Choice in brown trout.
- Anna Palmé - Genetics of stream resident trout: one or several populations?
- Juha-Pekka Vähä - Genetic population structuring of Atlantic salmon within the subarctic Teno river system.

18:30 Dinner at Trollebo

21:00 Ruotsin-Suomalainen, ice bathing and hot tub

Saturday 1 April

NoWPaS meeting day 2

(N.B. Trick day)

Time	Activity
07:00	Breakfast
08:30	**Invited speaker - Dr Neil Metcalfe** - Glasgow University *Why are salmon so badly designed for feeding at night?*
09:30	Break
09:45	**Session IV - Habitat - Chair Lasse Fast Jensen** - Pauliina Louhi - Spawning and intragravel habitat requirements of Atlantic salmon (*Salmo salar*) and brown trout (*Salmo trutta*) - Anders Finstad - Shelters affecting juvenile Atlantic salmon performance during wintertime. - Morten Stickler – Influence of the physical habitat on Atlantic salmon parr in a small, natural river - Karen Millidine - Presence of shelter reduces maintenance metabolism of juvenile salmon.
10:45	Break
11:00	**Session IV cont. - Habitat - Chair Lasse Fast Jensen** - Bart Adriaenssens - Coping with divided attention: effects of the social and physical

environment on salmonid performance.

- John Conallin - Development, application, and validation of habitat suitability criteria (using brown trout) for use in habitat modelling under Danish conditions.
- Pär Gustafsson - The effect of light and input of terrestrial invertebrates on a boreal stream food web, with special regards in brown trout (*Salmo trutta*).

11:45 Lunch

13:00 **Session V - Advances in salmonid ecology - Chair Mikko Kiljunen**

- Conor Graham - The impact of nutrient enrichment on salmonid ecology in Irish streams.
- Martin Österling - Spawning and glochidiosis in the freshwater pearl mussel
- Line Sundt-Hansen - Hypoxia tolerance - Comparing performance of transgenic and wild Coho salmon eggs.
- Magnus Lindberg - Competitive and behavioral differences between native brown trout (*Salmo trutta*) and non-native brook charr (*Salvelinus fontinalis*) – implications on the invasiveness of brook charr?
- Anja C. Winger - Effects of gyrodactylosis in the two rivers Skibotnelva and Signaldalselva in northern Norway.

14:15 Break

14:30 **Invited speaker - Tormod Schei** - Statkraft

15:30 **Group discussions**

- The meeting in Trondheim in fall
- Next year's meeting in Finland
- Next year-s technical workshop
- Future NoWPaS
- The homepage - what do we want from it?

17:00 **NoWPaS 60 minutes - Pimpling competition on Lake Visten**

19:00 Conference dinner at Trollebo

21:00 Ruotsalais-Suomalainen sauna, icebathing and hot tub

Sunday 2 April

NoWPaS meeting day 3

Time	Activity
08:00	Breakfast
09:30	Closing - The committee of 2006/2007
11:00	Leaving for Karlstad... Airport, Bus station, Train station, Hotels

Preface

NoWPaS ~ Nordic Workshop for PhD students on *Salmo salar* and *Salmo trutta* research

Background

During the last decade's research on *Salmo salar* and *Salmo trutta* has increased and will most likely augment in the future. In this connection, PhD and post-doctoral students with related focus will play an important and central role in gaining new knowledge and by developing new methods in order to cope with today's and the future challenges. In order to increase and further improve the profit obtained from the PhD study's a new network has been established. As an element of building an international network a Nordic workshop with title NoWPaS (*Nordic Workshop for PhD students on Salmo salar and Salmo trutta research*) was established in 2005. The first workshop was held at Agdenes, Mid-Norway, April 2005. 27 participants gave oral presentations whereas four key note speakers held extended lectures. The workshop was a great success and this year we continue with a new workshop which will be held in Sweden. Also this year NoWPaS invited external guest lectures where among others Professor Neil Metcalfe (Scotland) and Professor Torgny Bohlin (Sweden) held a presentation. Today, NoWPaS has approximately 50 members and are increasing.

Today's and future PhD students are representing the recruitment of researchers within the science. Therefore it will be important that younger scientists establish connections with thoughts of future collaboration in an international environment. The chief objectives with the presented network is two fold: 1) we wish to arrange an annual independent workshop where the participants can gather, exchange knowledge and ideas and to have discussions in an interdisciplinary forum; 2) we wish to establish connections with the "outer world" by inviting key researchers to give lectures and short courses within the sphere. Further, it will also emphasize the opportunity for collaboration through existing and future projects. On the basis of this we mean that the utility value is potentially larger for both the participants and the community. As an overview the network will have following main objectives:

i. Participating PhD and Post-doctoral students shall present their work and obtained results. In this way they will have the opportunity to get feedback on their own work and to be oriented of other people's work and findings within the sphere.
ii. The network will aim at invitation of external scientists within the sphere to present actual problem issues in addition to take part in discussions.
iii. Presented materiel and the discussions will make basis for a report which will be published and send to all participants and members of the network. This will also always keep them updated within the research sphere.
iv. A homepage (**www.nowpas.org**) will be accessible where publications of the members work, information on international conferences, workshops etc. will be

presented. This web page will therefore act as an information centre to both members and other interests.

Acknowledgements

NoWPaS-2006 has preliminary been based on voluntary work by the steering committee. There is not possible to put words on the effort they have put into this network. Their contribution and quality of work have been tremendous and of vital importance. On behalf of the committee great thanks goes to first of all the participants and their contribution which make the basis for this network; without them this would of course not be possible. Further, thanks go to external participants for their oral presentations; Neil Metcalfe (Glasgow University, Scotland), Torgny Bohlin (Göteborg University, Sweden), Lasse Kyläkorpi (Vattenfall, Sweden) and Tormod Schei (Statkraft, Norway). And finally our investors that have contributed greatly and that believe in the work we are doing; The Norwegian Research Council (Norway), Statkraft (Norway), Vattenfall (Sweden), The University of Science and Technology (Norway), Karlstad University (Sweden), The Directorate for Nature Management (Norway) and Sintef Energy Research (Norway).

Thank you!

The organizing committee of NoWPaS-2006 has consisted of following people:

- Morten Stickler, Norway, coordinator
- Olle Calles, Sweden, organiser Karlstad University
- Pär Gustafsson, Sweden
- Line Sundt Hansen, Norway
- Mikko Kiljunen, Finland
- Lasse Fast Jensen, Denmark

Morten Stickler, Coordinator.

Trondheim 24th of March 2006.

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Key Note Speakers

Member list of NoWPaS-2006

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Development of brown trout (Salmo trutta L.) embryos and their date of hatching and emergence in boreal lake outlet streams

Jukka Syrjänen[1], Mikko Kiljunen[1], Juha Karjalainen[1] and Timo Muotka[2]

[1] University of Jyväskylä, [2] University of Oulu,

Abstract

Salmonid yearlings in the lake outlet streams have been observed to be larger than those in other parts of the river. This has been hypothesized to be a consequence of more favourable temperature regimes and better feeding conditions. It has also been hypothesized that salmonid larvae in the lake outlets hatch and emerge from the gravel earlier and thus start feeding earlier, gaining a growth advantage over those in the other parts of the river. We investigated how lake outlets affect embryonic development and energy use of brown trout (*Salmo trutta* L.) in two Finnish Lake District streams. Brown trout embryos from a hatchery were incubated in the field at four rapids. Energy content of embryos and several variables characterizing embryonic development were measured in the laboratory. Water temperatures measured from the rapids and energy content of the embryos were used in two models to predict fry hatching and emergence. Large lakes clearly had a greater influence on winter development of trout embryos than small ones. Larger lakes sustained higher winter temperatures in the lake outlets which accelerated embryonic growth and hatching. However, higher spring temperatures seem to compensate for later hatching in the rapids below smaller lakes, producing similar emergence intervals at all sites. The better growth of salmonid yearlings in lake outlets found in previous studies seems to be due to more favourable temperature regimes and food conditions during summer rather than to any advantages in larval development

Reliability of snorkeling counts in assessing spawning stock of Atlantic salmon in small and medium sized rivers

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Abstract

Reliability of underwater snorkel counts of adult Atlantic salmon Salmo salar was analysed in three tributaries of the large River Teno, northernmost Europe, close to the spawning period. In small rivers (width 5-20 m), where two divers were able to see the whole water column from bank to bank, the replicated total counts of salmon were reasonably precise (CV=5.4-8.5 %), while in the medium sized river (width 20-40 m) the precision of the counting method was considerably lower (CV=15.3 %). The low precision in a larger river was also observed in an experiment using marked live fish where the observing efficiency varied between 36.4-70.0 %. In a small river, the observing efficiency of test salmon was almost perfect in pools (98 %), but it decreased in rapids (84 %). However, a majority of live salmon (>70 %) were concentrated to pools just before spawning. Separate counts of males, females, grilse and large salmon were usually more variable than total counts, indicating that divers were more capable in locating a fish than properly identifying it. The behaviour of adult salmon was in favour of snorkel counts, as fish normally stayed still or after hesitating moved upstream (>95 % of the cases) when encountering a diver and only few individuals moved rapidly downstream. The high observing efficiency (>90 %) and favourable behaviour of salmon enables collecting reliable data on Atlantic salmon spawning stock provided that the environmental conditions are suitable and the divers are experienced.

Competition in size- and age-structured populations: unfolding mechanisms and effects using juvenile brown trout (Salmo trutta L.)

Rasmus Kaspersson, Johan Höjesjö, Torgny Bohlin and Jörgen I. Johnsson
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Abstract

The main objectives of my research project is to increase the knowledge of the mechanisms behind competition in size- and age-structured populations, and to quantify the effects of these interactions with main focus on population structure and density.
Size- and age classes (cohorts) of juvenile stream-dwelling salmonids often experiences habitat segregation, where large individuals have priority to favourable feeding territories or shelters. The effects of habitat segregation between different-sized individuals *within* cohorts has until this time received foremost interest, whereas the mechanisms and population-level outcome of *intercohort* competition remains unclear. As a consequence of strong selection for individual growth and intense competition for territories during the early life-stages, one would anticipate that older generations play a vital role in the population regulation, both by the assumed superiority in interference competition and by being prior colonizers in the stream habitat. Thus, this project aims to determine the importance of intercohort competition on age-0 growth and survival in field, and to investigate the effects on behavioural interactions in controlled semi-natural environments.
Individuals can compete by means of interference or exploitation. These *competition modes* are adopted according to environmental and individual characteristics, which influence the relative ability to defend a shared resource, such as a habitat or a mating opportunity. In the classical literature, individuals using interference competition (e.g. agonistic acts) were assumed to be superior in monopolizing resources. However, recent studies suggest that non-aggressive individuals may attain as high degree of monopolization as aggressive individuals during certain conditions. Thus, a revision of the classical theory is needed to fully appreciate how competition modes interact with individual characteristics (i.e. body size) and environment, which subsequently will have large impact on the knowledge of density-regulation of size-structured populations. This issue will be examined by manipulating size-composition and biomass of juvenile brown trout populations in field, and by behavioural studies in controlled semi-natural environments.

Invasion of Brook trout to Northern streams: Is it a threat to the native brown trout?

Kai Korsu[1], Ari Huusko[2] and Timo Muotka[1,3]

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Abstract

Salmonid fishes are introduced beyond their natural barriers worldwide. This has resulted in many harmful effects on native stream ecosystems. In the 1970s, brook trout of North American origin was introduced to two large northern Finnish drainage systems with native brown trout populations. The establishment and invasion of brook trout was monitored (altogether 142 sites) after the cessation of introduction. The invasion process averaged a speed of two kilometers per year in the upstream direction. The invaded sites, with allopatric brook trout populations, were abundant (20% of all sites studied) and they have distinct habitat characteristics: they were narrow and acid, with low water velocity. Such habitats were infrequent within the stream network and, thus the habitat niche of brook trout was marginal. By contrast, the habitat niche of brown trout was non-marginal and the sites were best characterized as wide and circumneutral, with high water velocity. The density of the allopatric brook trout was clearly higher than that of brown trout. Moreover, between 1994 and 2004, brook trout had increased its density compared to brown trout in sympatric sites. This finding, supplemented by the fact that brook trout had established numerous allopatric populations, gives support to the hypothesis that brown trout has displaced by brook trout in many parts of its distribution range. The introduced brook trout, naturally adapted to harsh headwater conditions, may pose a threat to native brown trout, at least in the species-specific habitats of the invader.

Energy content, body composition and growth of Atlantic salmon smolt and post smolt during migration from freshwater to the high seas

Monika Haugland

Abstract

The anadromous lifecycle of Atlantic salmon implies reproduction in fresh water and growth in the sea. The smolt leave their home river in spring/early summer and migrate relatively fast through fjords and coastal areas to the feeding areas in the high seas were the main growth occurs.

The present study deals with aspects of this life-history strategy of Atlantic salmon in the northeast Atlantic, specifically of the oceanic migration of postsmolts on the west coast of Norway and in the Norwegian Sea. We investigated energy content, body composition and growth of smolts and postsmolts of Norwegian and mixed European origin. RNA:DNA ratio was used as a measure of protein synthesis and growth. The results support the hypothesis that postsmolts prioritize rapid growth and protein deposition during the feeding migration in the ocean in summer. They also indicate that the energy intake in this period is so high that deposition of energy is possible in addition to growth. In the autumn somatic growth is reduced and energy deposition is prioritized to meet the challenge of the winter season.

Characterization of the coastal habitat of anadromous brown trout (Salmo trutta) in the Bothnian sea

Ignacio Serrano
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Abstract

During out-migration and while in the sea, anadromous fish species are thought to be faced with a trade off between high growth rates and increased mortality. Anadromous brown trout spawn in freshwater and, in order to grow large, at a certain fish size or time of season they descend to sea. However, the initial period at sea are suggested to be critical, both in terms of risk of predation and energy depletion. Preliminary telemetry studies have indicated that post-smolt brown trout congregate in specific coastal areas. In order to understand the high growth rate-high mortality trade off, these areas need to be described in terms of substrate types, food resources, temperature and predator abundance. We propose to identify and comprehensively quantify the habitats used by anadromous brown trout in coastal waters of the Gulf of Bothnia, thereby generating insights to the suggested trade off and obtaining pertinent information necessary for the management of trout populations in the Baltic area. This study will integrate telemetry, abiotic assessments, benthic sampling, and GIS to quantify fish habitat. Field studies will be combined with laboratory experiments.

Landlocked Salmon in Lake Vänern: Part One

Ivan C. Olsson
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Abstract

Historically, Lake Vänern had three populations of landlocked Atlantic salmon (Salmo salar L.), originating from three major tributaries; River Gullspångsälven, River Klarälven and River Norsälven. During the first half of the 19th century, hydropower constructions resulted in that the Norsälven population become extinct, whereas the remaining two populations become subject for farming and stocking activities as they no longer were able to reach their natal spawning habitats. Henceforth, approximately 200 000 hatchery reared salmon smolts have been stocked annually into the lower part of River Klarälven. By analysing recapture data of Carlin-tagged smolts from 1988 to 2004, the recapture rate of adults has dropped from around 10 to 2 % since 1995. Simultaneously, farmed smolts have increased in body mass (c. 30% increase) and condition factor. Previously, we have shown for landlocked brown trout (Salmo trutta L.) that migratory behaviour was developed when food levels and growth rates were low, whereas non-migratory behaviour was developed when food levels and growth rates were high. As the salmon stocked in River Klarälven have been subjected to high food levels and growth rates during farming conditions, we hypothesise that the low recapture rates of adults may be the result of few smolts ever initiating migration to Lake Vänern. Next presentation will address this topic further.

Landlocked Salmon in Lake Vänern: Part Two

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Abstract

Environmental factors that affect growth rate of salmonids are believed to be of particular importance in explaining migratory variations. Interestingly, there are studies that have coupled both high growth rates and low growth rates to migratory behavior. This discrepancy between studies may reflect the fact that growth rate alone is inadequate for predicting whether or not a fish will migrate. Instead, one may need to couple metabolic costs with growth to be able to make reliable predictions about migratory behaviour. Two different studies will be performed to test how different factors affect the migratory behavior, both of them on one-year old hatchery reared Atlantic salmon from the River Klarälven: 1) effects of food supply on migratory behaviour 2) relationships between standard metabolic rate, growth, aggressiveness and migratory status. In the first study two groups of fish will be fed with different amount of food during the winter before they will be marked with radio-transmitters and released in the River Klarälven in late April. The second study will be conducted at the laboratories at Karlstad University, where standard metabolic rate will be measured by intermittent flow-through respirometry and migratory status by both ATPase levels and body and fin coloration. The studies will be performed during spring and summer 2006.

Downstream passage at hydropower plants

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Abstract

In most cases the construction of a fishway is the only measure taken to re-establish longitudinal connectivity in a river, thereby focusing on upstream movements and largely ignoring downstream movements. Brown trout and Atlantic salmon, as opposed to some North-American salmonids, are iteroparous which means that they spawn repeatedly, returning to sea to recondition themselves before the next spawning event. In addition, juvenile salmonids (smolts) migrate to sea in spring, after spending 1-4 years in the river. At the same time many species of cyprinids, percids and esocids spawn, which means that many of these species are highly mobile. There is hence a need for a maintained longitudinal connectivity during most of the year, with peaks at fall and in the spring, something that has rarely been addressed in Swedish rivers.

A study conducted in the River Emån 2001-2005 confirmed that there was a great need to rehabilitate downstream passage of two power plants for several species and life-stages of fish. Of the anadromous trout, only about 50% of the smolts and kelts managed to successfully pass two power plants located some 25 km from the Baltic Sea. A pilot-study showed that trash racks and gates at these plants may function to guide and pass downstream moving fish, but that they need to be modified to increase fish guidance efficiencies and to minimise injury to sensitive non-salmonid species. Some possible examples of fish guiding devices suitable for the power plants in the River Emån are described and discussed. Other examples of regulated rivers where this issue has recently been brought to attention are the River Ätran and the River Klarälven, where work will be initiated during 2006.

Overwintering and downstream migration of sea trout (Salmo trutta L.) kelts in two regulated rivers in northern Sweden.

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Abstract

The post spawning movement of sea trout (*Salmo trutta* L.) were studied in two northern Swedish river systems: Umeälven and Piteälven. Fifty-eight sea trout (L_T = 50 to 86 cm) radio-tagged at the beginning of their spawning migration, June-September 2003 and 2004, spawned in October the same year. Of these, 90% survived spawning and were defined as kelts. A majority of the kelts (90%) migrated downstream various distances (0-140 km) overwintering in deep slow flowing sections of the river under ice cover. Five individuals migrated seaward in fall immediately after spawning. The kelts showed no or limited movements during winter once the overwintering location were chosen. Three kelt individuals died in the river during winter (November to April). The time window for seaward migration was 12th of May to 7th of June, and was initiated by rising water temperatures above 6°C, and independent of forest and mountain flood (maximum discharge 1000 m^3/s). The highest downstream migration speed was c. 25 km/day and migration was registered independent of hour of day. During their seaward migration, the kelts faced hydropower facilities, dams and turbine intakes, in the lower parts of the rivers. In 2005 the migration behaviour at the power plants were studied. In Umeälven and Piteälven, 80% and 17%, respectively, of the kelts were lost due to the power stations. Surviving passing individuals were registered at automatic listening stations c. 1-2 km downstream the turbine outlets in the two rivers. The elevated mortality caused by these hydropower facilities, with no downstream guidance devices, is destructive for the relatively small populations of sea trout in the rivers and not in agreement with a sound management strategy. The high winter survivals of kelts in the river systems underline the importance of passage possibilities for kelts at dams and power stations.

Migration Problems of Atlantic Salmon (Salmo salar L.) in Flow Regulated Rivers.

Peter Rivinoja
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Abstract

Migration patterns of adult Atlantic salmon (Salmo salar) and smolts of salmon and brown trout (Salmo trutta) were studied in the flow controlled areas of two northern Swedish rivers. Fish behaviour and migration success at passages of various hydropower facilities were evaluated in different flow regimes. In addition, the impacts of the power-stations on the salmon populations were modelled.

On average, 30% (annual mean 0-47%) of the upstream migrating salmon that were captured at the mouth of Umeälven and marked with radio-, PIT- or Carlin-tags in 1995-2005 (n = 2651), reached the fish-ladder 32 km upstream. The migration took, on average, 44 days from the river mouth to the fish-ladder. Salmon were hindered or delayed at the power-station outlet, waterfalls and the fish-ladder area. At the turbine outlet area, salmon generally responded to increased bypass flows by upstream migration. In total, a 70 % average loss of potential spawners to the catchment area was estimated. Predictions based on population modelling showed that if 75 % of the females passed the regulated section successfully and reached spawning areas in the tributary Vindelälven, the population could increase by about 500 % over a ten-year period.

Radio-tagged smolts (n = 206) of Atlantic salmon and brown trout released upstream of the power-stations at Umeälven and Piteälven in 2002-2004 migrated downstream in the main flows at a speed of about 2 body length s^{-1}, eventually leading them to the turbine intakes. Migrating smolts were observed surface oriented at depths of 1-3 m. Flow modelling estimated relatively low fish guidance efficiencies for the spillways at natural flows. About 13 % of the smolts at Piteälven were hindered as they approached the power-station, and mortality of smolts at turbine passage was positively related to body size. By using the data for radio-tagged smolts and data from Carlin-tagged smolts (*n* = 7450) in 1998-1999, the overall average mortality for smolts at the power-station was estimated to 17%. Population modelling predicted a potential increase in the escapement return from 5-30 % to 70-120 % in ten years if the smolts had no losses as they passed the power-station.

Attraction channel as an entrance to fish ladders at hydropower plants

Elianne Wassvik
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Abstract

Migrating fish that swim upstream in rivers for reproduction need to overcome obstructions, such as power plants or similar. If a fishway is used to help the fish pass such an obstacle, water needs to be taken from the dam without first passing through the turbines. Also, the fish may have difficulties finding the fishway, due to dominating flow from the turbine tailrace.
An attraction channel, that uses turbine tail water to entice the fish into the channel and further on to a fishway, is studied. The attraction device is a shallow open channel that uses a small fraction of the tail water. A local acceleration of the flow is created by changing the cross sectional area of the channel. This velocity increase has been investigated in a lab-scale model and an increase of 38 % was reached.
In the summer of 2004 and 2005, a full-scale prototype of the attraction channel was tested at the Sikfors hydropower plant (40 MW) in the Pite river in Sweden. The channel was equipped with underwater cameras to monitor and record the fish swimming through the channel. The test shows that the fish do swim through the attraction channel. In 2004, 50 fishes swam through the channel and in 2005, 340 fishes swam through it, during the same time period. In 2005 the equipment was painted dark. In the presentation, the setup of the test and results will be discussed.

Use of motion-sensitive radio tags to record the behavioral patterns and activity of spawning Atlantic salmon

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Abstract

In recent decades, radio telemetry has become an increasingly common method in the study of fish behaviour. Monitoring of fish movements and activity has usually been based on location tracking of fish tagged with standard transmitters. However, location tracking offers only limited possibilities for studying the behaviour and activity of fish.

In recent years, the use of electromyogram (EMG) transmitters has become the prevailing telemetric method for studying the physical activity of fish. While studies employing EMG – technology have become more common, the use and development of methods based on other types of transmitters seems to have diminished, and only few studies have reported the use of e.g. motion-sensing radio tags. Electromyogram transmitters require implantation of electrodes into the fish muscle and are thus relatively difficult to mount. Transmitters with motion-sensors require no complicated surgery to deploy, and may be attached externally or implanted intra-peritoneally or gastrically.

A method for recording the behavioural patterns and activity of spawning Atlantic salmon (*Salmo salar* L.) by telemetry employing motion-sensing radio transmitters is described. Signal recordings conducted in the field show distinguishable activity patterns originating from behaviours such as fighting, nest digging and quivering. Simultaneous underwater video monitoring of the radiotagged salmon spawning under natural conditions verified many of these recorded behaviours.

Does selection occur at microgeographical scales? A comparison of genetic differentiation at neutral and MHC-linked microsatellite loci in Danish brown trout (Salmo trutta, L.) populations.

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Abstract

Analysis of neutral genetic markers such as microsatellite DNA provides insights into the role of migration, drift and mutation in shaping the genetic structure of populations. However, neutral markers do not provide direct information about the possible adaptive significance of genetic differentiation. Obviously therefore, genes known to be influenced by natural selection could provide more direct information on local adaptations in natural populations. Genes within the Major Histocompatibility Complex (MHC) offer a particularly promising avenue to this approach. The central role of these genes to the specific immune system suggests that the selective agents influencing this polymorphism are the parasites and pathogens in the environment.

We analysed the spatio-temporal distribution of genetic variation in Danish brown trout (*Salmo trutta*) populations at two MHC-linked microsatellite loci and eight neutral microsatellite loci in order to investigate the role of selection at the MHC-linked loci.

The analyses revealed that selection plays a significant role in forming the population structure of Danish brown trout. This was the case at even very small geographical scales. Also, the selective regimes can be highly variable at localities across very short time spans.

MHC and Mate Choice in Brown trout

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Abstract

The genes of the major histocompatibility complex (MHC) are involved in antigen presentation in the immune system. These genes are highly polymorphic and present an excellent model system for testing varying aspects of evolutionary theory. Clearly, these genes play a major role in every individuals defence against an evolving pathogentic fauna. Studies on several species, such as Mice, Human and Sticklebacks, has revealed that MHC-genes are involved in the process of mate choice as well.

To make a long story short, many species are able to recognize MHC-genotypes of potential mates through olfactory cues and to some extent base their mate choice on this information.

In my studies I use Brown trout (*Salmo trutta*) as model system. In this fish the MHC is not as complex as in previously studied species. Further, they do not provide parental care for their offspring, the males only contribute sperm to the females at reproduction, so that I can exclude many confounding factors in the mate choice.

I've found that females prefer males of intermediate Mhc-dissimilarity and these results are in the process of publication.

This study is important in a conservational context since the widespread stocking (artificial rearing of fish for enhancement of natural populations) of today leaves no consideration for MHC genotypes and natural mate choice.

Genetics of stream resident trout: one or several populations?

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Abstract

There is a large number of population genetic studies addressing the population structure of the brown trout (*Salmo trutta*). Most papers dealing with differentiation in stream resident brown trout have compared fish collected above and below waterfalls or dams, whereas little is known about population structuring in continuous sections in environments where obvious barriers to migration are lacking.

The purpose of the present project is to test for the existence of multiple populations in a c. 3 km continuous section of a small stream located in the Province of Jämtland, Sweden. This work constitutes a follow-up of previous results indicating a very small effective population size in a subsection of this creek coupled with an apparently large actual size.

Fish are collected by angling at four localities within the section during 3 consecutive years. Phenotypic information is collected and genetic variation is assessed at 17 allozyme loci and 4 (or more) microsatellite loci. F-statistics will be used to describe genetic variation between and within sample sites while accounting for temporal variation. The question whether or not spatial autocorrelation may be helpful in a situation like the present one will also be addressed.

Genetic population structuring of Atlantic salmon within the subarctic Teno river system

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Keywords: population structure, microsatellite, within river, Atlantic salmon

Abstract

An important issue for designing any conservation program aimed at preserving genetic diversity is determining the scale at which genetic structuring occurs. For species such as Atlantic salmon, which have a tendency to home to their natal river to spawn, the scale of genetic structuring can be at the within-river level. Due to its remote location, one of the most productive wild salmon river systems in the world, the river Teno, in northeastern Finland/Norway, has only been minimally affected by human activities and thus provides an ideal system for studying the natural within-river population genetic structure of Atlantic salmon. We studied the genetic structuring of Atlantic salmon sampled from 16 distinct sites, each representing putative independent breeding unit from main channel or tributary of the Teno river system using 29 microsatellite markers. The genetic diversity and differentiation level was compared to the sample from a nearby Näätämö river. Preliminary analyses indicated that significant genetic differentiation between tributary samples was commonly observed and the level of pairwise F_{ST} values within the river system was comparable to that normally observed between Atlantic salmon populations from different rivers. These and more recently generated results, as well as their conservation implications will be discussed.

Spawning and intragravel habitat requirements of Atlantic salmon (Salmo salar) and brown trout (Salmo trutta)

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Abstract

The poor reproductive success of salmonids is considered to be one of the main reasons for the decline in their native stocks. Although many stream enhancement projects have increased the amount of habitat suitable for salmonids, the general spawning habitat requirements of salmonids are largely unknown. This paper reviews the spawning habitat characteristics of Atlantic salmon (*Salmo salar*) and brown trout (*Salmo trutta*). We created the generalized suitability curves for depth, water velocity, and substrate size by combining the data available in literature. In addition, minimum oxygen concentrations and critical sediment compositions for intragravel stages are summarized.

Viewed across drainage basin, salmon tend to spawn in larger stream sections, whereas trout mostly preferred spawning habitats in smaller tributaries. At the within-reach scale, habitats used for spawning were characterized by a large variation of depth, water velocity, and substrate size. Salmon spawned mostly in relatively deep, swift-velocity habitats (30-40 cm, 45-55 cm s^{-1}), whereas trout selected slightly shallower and slower-flowing spawning sites (20-30 cm, 25-40 cm s^{-1}).

Salmon preferred substrates from coarse pebbles to cobbles (32 – 128 mm) for spawning. Slightly finer substrates (16 – 64 mm) dominated in spawning grounds for trout. Because the interstitial oxygen concentration is related to permeability of the gravel, the excessive amount of fine sediment (<2,0 mm), however, on the spawning ground can reduce the survival of eggs. On the other hand, coarser sediments (>2,0 mm) may inhibit the emergence of alevins from redd.

Hatching eggs require a much higher oxygen concentrations than early eggs. In addition to the stage of development, minimum oxygen concentration (mg l^{-1}) for successful incubation of eggs depends on water temperature. Because of the major role of spawning habitats in the survival of salmonid populations, and the complexity of factors affecting the spawning and intragravel habitat conditions, more information is needed to understand the circumstances to ensure the highest amount of viable fry.

Restoration of brown trout (Salmo trutta) spawning and nursery habitats, effects on egg survival, fry displacement and juvenile density

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Abstract

Lotic freshwater habitats in northern Scandinavia were heavily effected by anthropogenic manipulations, such as stream clearing and canalization, during the timber floating era, 1870-1980. Increased water velocity and reduced physical heterogeneity resulted in loss of spawning and nursery habitat whereby salmonid production was significantly reduced. In 2002 a large scale restoration program was started to improve juvenile rearing conditions. In order to evaluate the effects of spawning and nursery habitat restoration on juvenile brown trout, two streams in northern Sweden were intensively monitored. By combining egg survival experiments, drift studies and electro-fishing, detailed information was collected. Egg to fry survival was six times higher in restored compared to unrestored spawning habitats. Post emergence displacement caused by high water velocities was reduced from 20 to 3% and young-of-the-year densities increased by 420% in restored areas. These results imply that restoration of streams and rivers is an important tool to improve and preserve future salmonid production in northern Scandinavia.

Shelter availability affecting size-dependent winter performance of juvenile Atlantic salmon

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Abstract

Here, we test whether shelter availability changes performance and size selection gradients of juvenile Atlantic salmon (*Salmo salar* L.) by manipulating embeddedness in semi-natural stream channels without altering substrate composition. We thereby isolate the effect of habitat complexity from associated factors such as flow patterns and food availability. We measured the mean number and depth of interstitial spaces in the substrate using rubber tubes of varying diameter. Each stream channel was stocked with ten juvenile Atlantic salmon (Salmo salar L.) and we visually counted the number of fish not able to hide during daytime. Measured number and mean depth of interstitial spaces explained a large proportion of the between channel variation in number of fish not able to find shelters (13 mm tube, $R^2 = 0.68$). All fish lost weight during the experiment. However, shelter availability positively affected performance and mass-loss was negatively related to number of measured interstitial spaces. Furthermore, size-dependent performance was related to shelter availability and large fish was more severely affected by shelter reduction than smaller fish. Our study demonstrates that decreasing habitat complexity and sheltering opportunity affects the mean performance of the population and is likely to alter the adaptive landscape by reducing the relative benefits larger sized juveniles have with regard to winter survival.

Influence of the physical habitat on Atlantic salmon parr in a small, natural river.

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Abstract

Freshwater habitat utilization of juvenile Atlantic salmon (JAS; *Salmo salar* L.) has been extensively studied over the last two decades, particularly in relation to summer conditions. Although it has been suggested that winter is a bottleneck for the survival of JAS, the number of studies under winter conditions are few. Furthermore, there has been a general increased focus on the interaction between the physical habitat and the behaviour of JAS in recent years. Yet, only few studies have attempted to link physical winter habitat conditions using hydraulic variables and ice conditions with behaviour and habitat utilization of JAS in natural flow environments. Ice formation significantly alters the physical habitat and may thereby affect the distribution, mobility and survival of JAS. Further knowledge on the behavioural adaptations of JAS to different ice conditions is therefore required to increase our comprehension of behaviour and survival of JAS in relation to winter conditions.

In this study, mobility and habitat use of Atlantic salmon parr was monitored in a small, natural river throughout the winter using two 100 m river sections; one characterised by low (0.3 %) gradient and one by high gradient (2 %). Passive Interactive Transponder (PIT) technology was used to collect data on 139 parr implementing both fixed antennas and mobile tracking devices. Meteorological and physical conditions were continuously monitored throughout the season. Variable physical conditions between the two respective sections resulted in differences in the mobility patterns of parr between the two river sections. In the low gradient section, static ice formation dominated giving stable conditions and increasing cover availability. In the high gradient section, dynamic ice formation occurred periodically leading to a highly variable environment. The results from this study imply different behavioural adaptation strategies during winter within the population in relation to local, physical winter habitat conditions. Furthermore, the obtained results underline the importance of considering the physical habitat when monitoring fish behaviour and movement in lotic environments.

Presence of shelter reduces maintenance metabolism of juvenile salmon

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Abstract

Shelter is of major importance to many animals in providing protection both against the physical environment and potential predators. We hypothesised that animals without shelter suffer metabolic costs associated with a need for increased vigilance and preparedness to escape attacks from predators or competitors. This possibility was tested by comparing the standard metabolic rates of inactive post-digestive juvenile Atlantic salmon held either with or without a shelter, which took the form of a semi-circular ledge under which the fish could fit snugly.

The ledges were semi-transparent (so did not substantially reduce light levels) and provided no protection against the minimal water velocities in the testing arena. Nonetheless, absence of ledge shelter resulted in a 30% higher rate of oxygen consumption.
Fish without a ledge shelter typically positioned themselves against vertical walls of the observation arena, which presumably afforded the best available sheltering option, and adopted a significantly darker coloration (indicative of greater stress) than those under ledges. Fish with ledges rested outside and adjacent to rather than beneath the shelter. Therefore, it seems that awareness that a shelter is readily available, rather than the act of sheltering, results in reduced metabolism.

It is concluded that the presence of appropriate shelter not only reduces the risk of predation but also provides a metabolic benefit to fish that is likely to have implications for growth performance and activity budgets. Standard metabolic rate can be a function of habitat structure.

Coping with divided attention: effects of the social and physical environment on salmonid performance.

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Abstract

In their natural environment salmonids have to deal with complexity both at the physical and social level. It is essential for them to react appropriately to assimilated information during tasks such as predator vigilance, foraging and mate acquisition. Cognitive skills like perception, learning and memory are therefore expected to be important with regards to their fitness.

However, an individual can not allocate unlimited attention to cognitive tasks, and often choices need to be made. These constraints on cognitive skills can be observed when a single task becomes more complex or if attention is divided among several tasks, thereby impairing the animal's performance.

During my PhD study I plan to investigate how the social and physical environment influences the ability of salmonids (*Salmo trutta* and *Salmo salar*) to learn to perform critical behavioral tasks in a complex environment. In doing so, I will focus on two questions concerning the interplay between limited attention and the individual's environment: (1) Does limited attention increase the cost of aggression in a complex environment? (2) Does the degree of structural complexity in the individual's rearing environment influence its behavioral efficiency? During my talk I will present the outline of this PhD study and discuss data on cognitive task performance measured in hatchery and wild brown trout.

Development, application, and validation of habitat suitability criteria (using brown trout) for use in habitat modeling under Danish conditions.

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Abstract

The European Water Framework Directive (WFD), through its requirements to manage and protect groundwater and surface waters with respect to the natural ecosystems, has provided the local and regional water managing authorities within its member countries a challenge. The water managers need to develop new and accurate methodologies or upgrade existing management tools with the vision of interlinking the methods to help satisfy the requirements of both domestic laws and EU directives. Habitat modelling is a management tool that water managers are employing to help satisfy these requirements. Habitat models that are able to assess instream physical habitat availability for fish and other species are probably the most important component of physical habitat modelling.

For Denmark and many other European countries the single biggest problem when using habitat modelling approaches that involves habitat suitability criteria is the lack of reliable locally derived habitat suitability curves (HSCs). Both the selection of habitat suitability criteria and the method by which HSCs are devised have been criticised by some aquatic ecologists as they are seen as excluding other physical factors that influence fish population density, and as being dependant on site, stream and time of collection. Physical factors such as macrophyte cover probably plays an integral role in population density of lotic fish species in Danish streams, and the microhabitat preferences of theses species change within a 24 hour period and seasonally. Traditional development of habitat suitability criteria would exclude these factors, and other factors such as temperature and water quality that need to be considered in such modelling especially in a country such as Denmark where monitoring data for these factors is available.

Denmark does have some HSCs for brown trout, but these have only been modified from North American HSCs for brown trout and these only represent the microhabitat variables of velocity, depth, and substrate. Research has shown that the use of different HSCs in habitat modelling on the same stream can lead to very different results and therefore it is imperative that the HSC used are accurate for the area they are being applied in.
The main aims of this PhD are to develop, apply, and validate locally derived HSCs for different stream types in Denmark, using brown trout as the indicator species.
The PhD will be broken down into approximately even major sections and will be adjusted accordingly as the PhD progresses. They include:

1. Review of habitat modelling in Europe; in particular to usage of habitat models in Denmark's ecoregion 14.

2. Assessment and application of habitat suitability criteria collection methods and establishment of 'best practise' method for microhabitat data collection for Denmark
3. Microhabitat suitability testing for Danish conditions in relation to predicting fish population density.
4. Spatial and temporal testing of brown trout microhabitat use and applicability to deriving accurate HSCs.
5. Development of HSCs for brown trout under pristine conditions.
6. Development of habitat-spatial model and HSC inclusion.
7. Application of model under Danish conditions, and validation of model results.

The effect of light and input of terrestrial invertebrates on a boreal stream food web, with special regards in brown trout (Salmo trutta).

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Abstract

The link between riparian vegetation and aquatic life in adjacent streams and rivers is well known. It is also documented that forestry management can alter the physical and biological linkage between the two ecosystems. A decrease in riparian vegetation will increase the amount of sunlight that reaches the stream and may through accelerated photosynthetic activity lead to an increase in temperature and in-stream production. This may lead to an alteration of the composition of species. Further, a decreased input of both living and dead organic material can exert its effect through the aquatic food web. For example, studies have shown that during late summer and fall when aquatic invertebrates are scarce, the proportion of terrestrial invertebrate in the trout diet is very high. Therefore, under certain circumstances, this resource may play a very important role in the maintenance of growth of the trout. Consequently, a physical alteration in riparian zones may dramatically influence the brown trout by both bottom-up and top-down forces.

Our purpose with the upcoming study is to investigate both short- and long term individual and combined factorial effect of light and terrestrial prey input on a stream food web, with special concern in the diet and growth of brown trout (Salmo trutta). This will be done by conducting a large-scale field experiment to test the effects of artificially increased PAR-light and reduced input of terrestrial invertebrates on periphyton, benthic macro invertebrates and brown trout in a small boreal stream. We will manipulate the terrestrial prey input and the light regime in a 2 x 2 factorial design, with three replicates of the four treatments: control (normal light and normal input of terrestrial invertebrates), a plastic greenhouse cover that reduces the terrestrial prey input to the stream, artificial light added, and both greenhouse cover and artificial light added. We have designed the experiment to test two different hypotheses: a) the adding of artificial PAR-light to a shaded stream will cause an increase of periphyton biomass through bottom-up forces. This will indirectly change the composition and biomass of benthic macro invertebrate species in the stream food web and subsequently even affect the trout; b) The reduced input of terrestrial invertebrate to the stream will by top-down cause a change in the diet of the trout which may lead to an increased predation of macro invertebrates and subsequently an increased periphyton biomass. As the experiment continues over a longer period the experiment will also reveal the interactions between the two factors and their effect on the stream ecosystem in general and brown trout in particular.

Effects of rearing density and physical structure on the pre- and post release performance of hatchery reared salmonids

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Abstract

The development of essential life-skills in supplementary reared fish is generally constrained by standard hatchery conditions, where fish are confined at unnaturally high densities in environments lacking the variability normally found in nature. We manipulated these factors in a series of studies in hatcheries using Atlantic salmon (*Salmo salar*) and brown trout (*Salmo trutta*) to evaluate the effects on pre- and post-release performance. Overall, while the physical structure had inconsistent effects on performance, the effects of rearing density were clear and consistent. In particular, behavioural studies demonstrated that fish reared at low densities had a competitive advantage due to higher food intake than fish reared at high densities. Consequently, fish reared at reduced density reached a larger size both in culture and when released in a natural stream. However, the treatments had no effects on post-release survival. In the hatchery, fish kept at reduced density had less fin damage compared to fish reared at standard densities. In addition, density negatively affected the effective population size (*Ne*), where high density increased variance in survival among families during the first period of life. Our results suggest that modifications of density in supplementary rearing may increase pre- and post-release growth, welfare and genetic diversity.

The impact of nutrient enrichment on salmonid ecology in Irish streams

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Abstract

Diffuse input of nutrients and in particular, phosphorus into watercourses leading to eutrophication is a common and growing problem in most developed countries. Eutrophication can have many negative effects on running waters, the most obvious of which is the great increase in algal abundance. The respiration and subsequent death and decay of these primary producers can then lead to widespread and ecologically damaging stream anoxia.

Nutrient supply can have strong effects on river communities and at low levels, trophic enrichment of running waters can potentially increase the productivity of nutrient-limited systems. At excess nutrient levels however, deterioration of ecosystem health is widely reported, largely associated with low oxygen concentrations. Salmonids, particularly the younger life stages, have been shown to have a relatively weak tolerance to low oxygen concentrations and are thus particularly vulnerable to organic pollution.

However, a recent study in Ireland has found that salmonid populations may be more robust than previously thought to poor water quality, particularly during wet years, resulting in salmonids dominating fish communities of many moderately polluted streams. Although there are many accounts of salmonid decline in eutrophicated waters, there has been little investigation into the role of moderate enrichment of streams at levels too low to cause serious harm to ecosystem health. The aim of our research therefore, is to investigate the effects of organic pollution on primary, secondary and tertiary productivity in Irish streams across a trophic gradient, with particular emphasis on brown trout and Atlantic salmon (*Salmo salar*) and their interaction.

Spawning and glochidiosis in the freshwater pearl mussel

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Abstract

The freshwater pearl mussel has disappeared from more than 35% of the Swedish streams inhabited 100 years ago, and in 50% of the populations in south-central Sweden juvenile mussels are missing. Water turbidity and siltation are lower in streams where juvenile mussels are found. Also, juvenile mussels are found at sites in streams where the density of adult mussels is higher compared to non-recruitment sites. This investigation relates abiotic and biotic factors to larvae and parasitic stages of the mussel. Mussels were gravid between July and August, with maximum proportions of gravid mussels ranging from 33 to 100%. Maximum proportion of gravid mussels was negatively correlated to ammonia and total phosphorous, but showed no significant correlation to biotic factors. Trout was infected by glochidia larvae in all investigated streams, and the variation of glochidial infection on individual trout was large. Mean glochidial infection was positively correlated to mussel density but seemed to be uncoupled from trout density and abiotic factors. Also, size of trout was positively correlated to glochidial infection. Thus, mussel larvae development on mussel gills may be negatively affected by enhanced nutrient levels, while infection of host fish mainly seem to be regulated by density of spawning mussels.

Hypoxia tolerance; comparing performance of transgenic and wild Coho salmon eggs.

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Abstract

Environmental risks associated with escapes of transgenic fish are largely unknown, and an important factor influencing such risks is whether offspring from transgenic spawners are capable of surviving unpredictable conditions during critical life-stages in the wild. For salmonids, oxygen level is a critical factor for egg survival, and we have addressed this issue experimentally by exposing transgenic and wild coho salmon eggs to hypoxic conditions (2.37±0.57 (sd) mg L-1) for 0, 12, 36, and 72h, and observed the survival rate and growth until the presumed emergence time. A half sibling approach was used, where eggs from each wild female were fertilised by a wild and a transgenic male. This approach enabled us to minimize maternal effects and hence reveal the effect of the transgene. There was a general decrease in survival rate for both transgenic and wild eggs with increasing exposure to hypoxic conditions. However, transgenic eggs responded stronger to longer intervals of hypoxia than wild eggs, with a significantly lower survival rate in the 36 and 72h treatment, but not in the 0 and 12h treatment. Fry weight decreased with increasing exposure to hypoxia, but transgenic fry were significantly larger than wild fry in all time periods. Given optimal oxygen conditions transgenic eggs achieve the same survival rate as wild salmon eggs. However in strongly hypoxic environments differential egg survival is expected to select against transgenic salmon. Financed by the FUGE-program of the Norwegian Research Council and the Canadian Regulatory System for Biotechnology.

Cortisol action and corticosteroid receptors in Atlantic salmon (S. salar) and Sea trout (S. trutta) gill

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Abstract

Cortisol is the major corticosteroid in teleost fish and apart from its catabolic role; cortisol has been proven to be important in acquiring SW tolerance in several euryhaline fish. This is somewhat peculiar given that the hormone mainly responsible for salt and water homeostasis in mammals is the mineralocorticoid, aldosterone. Aldosterone is not present in teleost fish and cortisol has therefore been hypothesized to manage both the glucocorticoid and the mineralocorticoid signalling, since cortisol bind well to both the glucocorticoid receptor (GR) and the mineralocorticoid receptor (MR). The rainbow trout GR and MR have recently been cloned, which suggests that the sometimes opposite glucocorticosteroid effect can be mediated through both GR and MR. Therefore it is plausible that this effect can be differentiated on the receptor level.

Cloning of the rainbow trout 11β hydroxysteroid dehydrogenase type 2 (11βHSD2), the enzyme that protects the MR from cortisol binding by converting cortisol to the inactive corticosterone, supports this model. However, very recently 11-deoxycorticosterone a precursor in the synthesis of cortisol from cholesterol was identified as a potential agonist for the MR in rainbow trout. Taken together this opens up a whole lot of exiting schemes about the glucocorticoid role in osmoregulation.

This work focuses on the effect of cortisol on regulation of important ion transporter genes such as the Na^+,K^+ATPase, the CFTR channel and the Na^+,K^+,$2Cl^-$ cotransporter (NKCC). Which genes are transcriptionally activated and repressed by administration of cortisol and through which receptors are the signals mediated? An ex vivo gill block system is used for investigation of the interaction of cortisol with GR or MR and the hormone receptor target genes. Differential regulation of these target genes under different circumstances such as developmental state (smoltification) or physiological environment (fresh water or salt water) are investigated.

Preliminary results suggest that cortisol directly activates transcription of important ion transporters working in osmoregulation in the gill and that this activation is specifically mediated through the two hormone receptors, GR and MR. Furthermore, differences in cortisol potency and signal pathway between FW and SW acclimated fish have been observed.

Competitive and behavioral differences between native brown trout (Salmo trutta) and non-native brook charr (Salvelinus fontinalis) – implications on the invasiveness of brook charr?

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Abstract

Intentional introduction of non-native salmonids have threatened native salmonids all over the world. Non-native brook charr (*Salvelinus fontinalis*) have been successfully introduced in Sweden and negatively influenced the abundance and distribution of native brown trout (*Salmo trutta*) in small headwater streams. Competitive and behavioural differences between brook charr and brown trout were studied in a semi-natural environment. No clear differences in competitive ability were found between them, although differences existed. The agonistic behaviour between them consisted of three clearly separated phases and interactions were very fast and generally over within 5 minutes, with no difference in dominance between species. During exploitation competition brook charr were more active, achieved higher feeding rate, and a feeding strategy more close to the streambed than brown trout. During the anti-predatory treatment both species reacted similar by fleeing in panic. However, brook charr were less sensitive to disturbance from an avian predator and continued feeding earlier and more often than brown trout, i.e. brook charr had more prone risk behaviour. The competitive and behavioural differences found in this study may elucidate the ability of non-native brook charr to establish source populations in cool pool dominating habitats with possible implications on the invasiveness in small Swedish boreal headwater streams.

Effects of gyrodactylosis in the two rivers Skibotnelva and Signaldalselva in northern Norway

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Abstract

Like monogeneans in general, most species of the genus *Gyrodactylus* Nordmann are little harmful to their host. However, *Gyrodactylus salaris* Malmberg is an exception as it has had, and still has a devastating effect on Norwegian stocks of wild Atlantic salmon parr (*Salmo salar*).

The two rivers Signaldalselva and Skibotnelva in northern Norway are both infected with *G. salaris*, and the occurrence and effects of this parasite on the different populations of salmonids is the subject of this study.

In the two infected rivers Vefsna and Driva in mid-Norway it has earlier been recorded a high proportion of hybrids between Atlantic salmon and Brown trout (*Salmo trutta*), and it is suspected that this is a result of a long infection history with *G. salaris*.

Also in Skibotnelva and Signaldalselva hybrid-like fish has frequently been observed, and an genetic investigation of these fish has been undertaken. Results from this work will be presented.

In addition, and as an attempt to reveal some of the mechanisms behind the maintenance of the parasite populations in the two rivers, long-term investigations of the dynamics in the parasite metapopulations are undertaken both through a sampling program and an in-situ experiment (with Arctic charr). Some results from these surveys and the experiment, along with some thoughts about what consequences a long-term gyrodactylosis will have on the Atlantic salmon populations will also be presented.

The work is supported by the NRC Wild Salmon Program, co-funded by NFH, University of Tromsø, Norway (project NFR 159386/S40).

Why are salmon so badly designed for feeding at night?

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Abstract

Up until about 15 years ago the conventional wisdom was that juvenile salmon were diurnal foragers, which more or less went to sleep at night and which 'hibernated' under stones in the streambed in winter. Then Jan Heggenes discovered that in winter the fish emerged from under the stones to feed at night, so effectively became nocturnal. Our experiments showed that this response was controlled by temperature: as the temperature dropped, the fish became more and more dependent on nocturnal foraging. We concluded that the fish were switching from being diurnal in summer to nocturnal in winter. However, we also found that the fish were terrible foragers in the dark, being far less efficient than when they feed in daylight. Moreover, more recent work has found that salmon are sometimes nocturnal even at warm temperatures, and in some situations only smaller or hungrier fish feed during the day even in summer. So what is going on? In this talk I will discuss why salmon appear to change their activity patterns in this manner, and will link empirical observations on a range of species to theories of risk sensitivity. I will (probably) come to the conclusion that many species of fish should really be considered as being primarily nocturnal (but only if they live in rivers, not lakes, and only if they are from high latitudes). However, the highly seasonal environment in which they live means that they cannot become well-adapted to a nocturnal lifestyle. I will finish with some predictions that will probably turn out to be completely wrong, as usual.

Member list

Members of NoWPaS; "Nordic Workshop for PhD students on *Salmo salar* and *Salmo trutta* research".

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Johan Östergren	090-136695, 070-3461429	Department of Aquaculture, Swedish University of Agricultural Sciences, Sweden	johan.ostergren@vabr.slu.se	Migration biology and genetic population structure of anadromous trout (Salmo trutta L.) in two northern Swedish rivers
Johan Spens		Department of Aquaculture, Swedish University of Agricultural Sciences, Sweden	johan.spens@vabr.slu.se	Biologist
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Kai Korsu	+358400 822 439	University of Oulu	kai.korsu@oulu.fi	alien species - native brown trout versus alien brook trout

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Mikko Kiljunen	+358 14 260 4231	Finland, Jyväskylä University	mikkilj@bytl.jyu.fi	Accumulation of dioxin-like organ chlorines in Baltic salmon and salmon bioenergetics (*Salmo salar*)
Martin Österling	+46-54-700 18 02	Department of Biology, Karlstad University, Sweden	Martin.osterling@kau.se	Interactions between trout and parasitic larvae of freshwater mussels.
Monica Haugland	+ 47 92484277	Norway, University of Bergen	monika.haugland@ramson.org	Feeding ecology and growth of Atlantic salmon postsmolts
Morten Stickler	+4773598388	Norway, NTNU, Trondheim	Morten.stickler@ntnu.no	Physical winter habitat for Atlantic salmon (*Salmo salar*)
Olle Calles	+46 54 7001454	Department of Biology, Karlstad University, Sweden	olle.calles@kau.se	Migration and remedial measures in regulated rivers
Panu Orell	+358205751419	Finland, Finnish Game and Fisheries Research Institute, Oulu	panu.orell@rktl.fi	Atlantic salmon, migrations (both adult and smolts), stock evaluation (underwater video survaillance, surface diving), conservation spawning limits, etc.
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Pauliina Louhi	+358205751877	Finland, Finnish Game and Fisheries Research Institute, Oulu	pauliina.louhi@rktl.fi	Spawning and intragravel stages of Salmo sp. with emphasis on habitat restoration
Peter Borsanyi	+47 7289 6577	Norway, NTNU	Peter.Borsanyi@bygg.ntnu.no	A scaling method for evaluation of effects of river regulation based on biotopes
Peter Rivinoja	+46-705426700	Sweden	peter.rivinoja@vabr.slu.se	Salmon migrations in regulated rivers (work on both adult + smolts with tagging + tracking + echo sounding)
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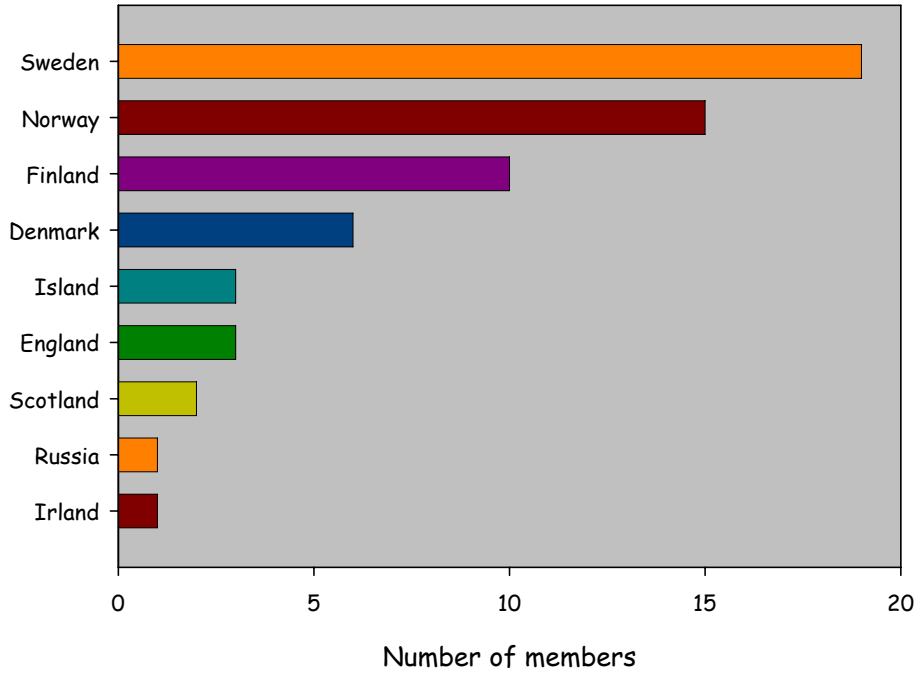
Pia Kiilerich	+45 65502762	Institute of Biology, Department of Biochemistry and Molecular Biology, University of Southern Denmark, Odense	Pia.k@biology.sdu.dk	Role of glucocorticoid and mineralocorticoid receptors in smoltification in Atlantic salmon
Rasmus Kaspersson	+ 46 (0) 31 773 36 96	Gothenburg University, Section of Animal Ecology, Gvteborg, SWEDEN	rasmus.kaspersson@zool.gu.se	Inter- and intra-cohort competition in brown trout.
Rolf Sivertsgård		Norway , Fiskerihøgskolen,	rolfsi@nfh.uit.no	
Saija Koljonen		Finland	Saija.Koljonen@bytl.jyu.fi	Winter biology of Salmo salar

Sofia Brockmark	+46 31 7733636	Department of Zoology, Animal Ecology, Göteborg, Sweden	sofia.brockmark@zool.gu.se	Effects of environment and density on performance and development in Atlantic salmon and trout
Tommi P. Linnansaari	+ 1 506 447 3373	New Brunswick, Canada	tommi.linnansaari@unb.ca	Effects of winter conditions, particularly ice, on the biology and habitat of juvenile Atlantic salmon (Salmo salar L.) in small Rivers
Torstein Kristensen	+ 47 2218 5100	NIVA, Norway	torstein.kristensen@niva.no	Physiological and respiratory responses in Atlantic salmon to metals and varying gas pressures
Tore Svendsen	+45 22117226	Denmark, University of Aalborg	ts@bio.auc.dk	PCB concentrations in Salmo salar in relation to migrations
Vidar Wennevik	+47 55236378	Norway, University of Bergen	Vidar.Wennevik@imr.no	Genetic interaction of farmed and wild salmon
Wendy Fernandes	+44 7950 146728	UK, 1) Cardiff University, 2) Centre for Ecology and Hydrology, Dorset.	wfe@ceh.ac.uk	Interactions between family traits and environment affect growth, survival and migration strategies in Atlantic Salmon.
Øyvind Garmo		NTNU, Norway	Oyvind.garmo@chem.ntnu.no	



Statkraft

Statkraft; Environment and hydropower

- focus on the environment at hydropower plants and regulated river systems

Our vision is to be a European leader in environment-friendly energy. While all energy production affects the environment in one way or another, Statkraft strives to reduce any negative environmental consequences to a minimum. We work to understand the environmental impact of our hydropower operations and how to use this knowledge to implement cost-effective environmental protection measures.

We are convinced that environmently friendly solutions will be preferred in the future. As we see it, taking care of the environment is a must if Statkraft is to be a leading player in the energy projects of tomorrow.

Which is why we …

… constantly monitor the river systems we regulate and take part in analysis and research projects to find modern solutions to the problems that arise.

… look for solutions that are acceptable to all parties through close contact and collaboration with the regulatory authorities, local government administrations and other parties with a legitimate interest in the various river systems.

… have implemented an environmental management system (ISO 14001) which helps us to keep a check on the potential environmental consequences of our operations and constantly improve our environmental performance.

Fish conservation

An important objective of our fishery strategy is to have self-recruiting fish populations in our regulated waterways. Measures to protect fish populations and fishing in general are among the most important environmental measures associated with the operation of hydropower plants. Measures are implemented as a result either of directives from the authorities or of Statkraft's own efforts to identify needs and opportunities for improvement. In either case, measures are implemented in cooperation with the relevant authorities.

Example of fish-related measures in Jostedøla

In Jostedøla, which is located in Luster, Sogn og Fjordane, measures have been implemented to increase the natural recruitment of sea trout and salmon. Two obstacles to migration up the river have been removed such that the fish now have access to 7 km of new spawning grounds. Eggs have also been planted in the areas above the former migration obstacles to achieve a more rapid establishment of fish populations there. During the autumn of 2004 a number of spawners were recorded in the newly available areas.

Restocking

Statkraft is both a major producer and purchaser of juvenile fish for restocking. Each year we plant around 600,000 juvenile salmon, sea and inland trout. We operate two of Norway's three gene banks to conserve the unique genetic material of the country's salmon populations.

Monitoring fish populations

Test fishing is normally undertaken in hydropower reservoirs every eight to ten years. In rivers with salmon and sea trout populations it may be necessary to conduct surveys of fish biology more often and over several years. The findings of such surveys are available to all, and the results are presented and discussed in meetings with the scientists, relevant authorities and other directly affected parties.

Compensation and fishing funds

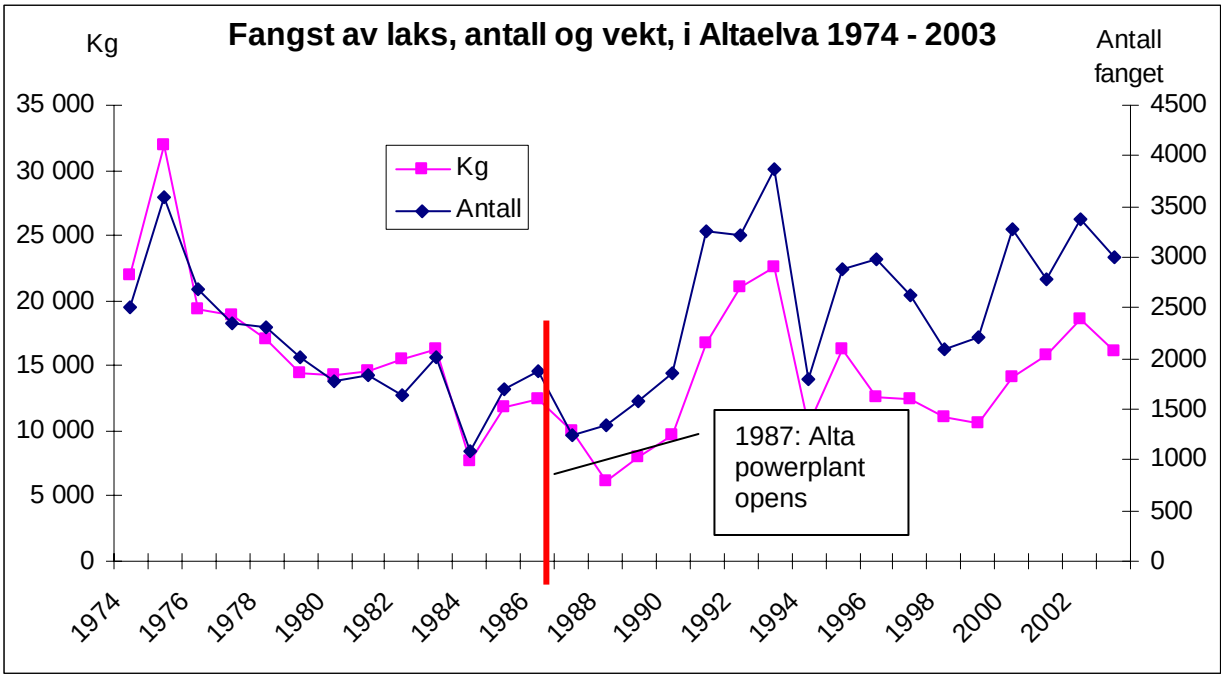
The value of private fishing rights was estimated at the time the rivers were initially regulated. As a result of these estimates, several million Norwegian krones (NOK) is paid out each year to trust funds, or in direct compensation to individuals, landowner associations and local authorities.

Salmon fishing in regulated river systems

As a result of favourable water-flow conditions and effective conservation measures, several regulated waterways are counted among the country's best fishing rivers. Of the ten river systems that produced the largest catches of salmon and sea trout in 2003, eight were regulated for hydropower purposes. Among these eight were the Numedalslågen and Alta rivers.

Catches of salmon (number and weight) in the Alta river 1974 – 2003

———	No. caught
———	Weight in kg



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Environmental contact person : Vilde Eriksen (vilde.eriksen@statkraft.co

SINTEF Energy Research

-Division of Water resources

SINTEF Energy Research, division of water resources, focus primary on environmental issues related to hydropower in a physical aspect. Our division aim at following two main directions:

Research within Environmental aspects of water resources

Research within Hydrology

During recent decades developments of computerized one- and multi dimensional modeling tools of physical environments have increased. Our division has been a leading part of development and use of such tools. Therefore, one main part of our research is hydraulic and hydrological modeling. We use and develop new techniques in order to cope with today's and future challenges in our work. An example of hydraulic modeling followed by habitat modeling of anadromous salmonids rivers is given below. Here, modeling of a Norwegian river reach was conducted in order to reveal knowledge of how physical alterations of the site resulted in habitat changes for juvenile Atlantic salmon (Salmo salar).

Figure 1: Research on winter habitat for Atlantic salmon has gained focus the recent

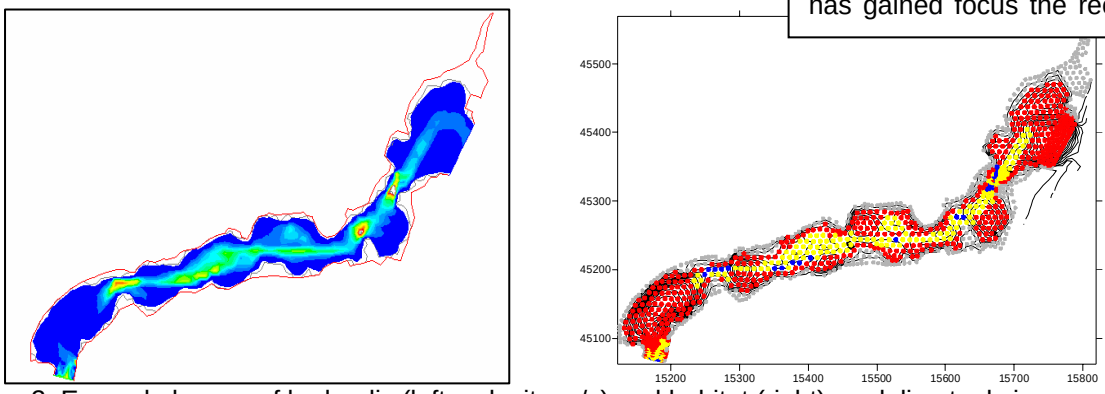

Figure 2: Example by use of hydraulic (left; velocity m/s) and habitat (right) modeling tools in a Norwegian river.

Other examples of conducted and ongoing projects are given below.

Environmental water resource planning and operation

Fish habitat and hydropower production

New environmentally friendly overhead lines

Rapid changes in flow

Contact person: Hans Petter Fjeldstad, phone: +47 73597224

Environmental adaptation of hydropower

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Vattenfall is one of the largest energy groups in Northern Europe. Vattenfall produces, distributes and sells electricity, heat and other kinds of energy services and solutions mainly on the Swedish, German, Finnish and Polish markets. The company also conducts lignite mining in Germany. Vattenfall accounts for about 20 % of electricity production in its markets and is the largest electricity supplier in Sweden and among the three largest in Finland, Germany and Poland. The Group has grown considerably during the last five years and has now some 30 000 employees.

Electricity generation within the Group amounts to around 170 TWh per year, about 25 % hydropower, 35 % nuclear power, 40 % fossil power, and about 0.5 % wind power and combustible renewables.

Most of our hydropower stations in Sweden was developed in the period from 1950 to 1980. Vattenfall is one of the leading producers of hydropower in the Nordic region. Power is generated in about 50 large-scale and about 40 small-scale hydropower plants in Sweden and Finland. Normal annual power generation is more than 33 TWh/year.

Mitigation measures
It is a fact that hydropower developments cause more or less severe impairments on both freshwater and terrestrial ecosystems. The extent and severity of these damages depends on both the designs of the power stations and the environment in which they are built.

In the early days of hydropower, the awareness and concern of environmental issues was far from as widely spread as it is today. Therefore, many of the older hydropower stations are designed in a way that would never be accepted nowadays.

In modern hydropower developments, both the designs of the stations and the way they are operated, normally has a higher degree of environmental adaptation. Today we have access to a large number of various environmental tools, both used for remediation of old damages and for avoiding some of the large-scale ecological disturbances when designing new developments.

Flow management
In order to gain head, it is very common that the water is lead in a tunnel from an intake to the turbines located further downstream. This can make the river stretch between the intake and the outlet devoid of water, at least periodically. This naturally causes extinction of those species dependant on continuous flow on this stretch.

In some cases, it is possible to determine a so-called instream flow to mitigate this problem. This means that the flow never goes below a decided minimum level.
The instream flow can be adjusted over time so that it mimics the variations of the natural flow, but at a lower level. This favours most aquatic life but also the vegetation on the riverbanks.

Habitat adjustments
A combination of an instream flow and weirs, or other physical adjustments, can often be very efficient at enhancing the conditions for the aquatic organisms. This way, the area of suitable fish habitat increases and the flow gets a more diverse pattern, which altogether benefits the production of e.g. benthic fauna and fish. Re-creating spawning and kinder-garten areas is another possibility to favour the fish population.

Fish passages
Hydropower dams, as well as other types of obstacles, stops migratory fish from reaching their spawning grounds. The construction of new fish passages as well as improvements of older fish ways are both important measures to ensure the long-term survival of the natural stocks of anadromous fish. A variety of passages are available today; for single-species or multi-species purposes.

Tributary management
Within a catchment developed for hydropower purposes, it is common that most of the smaller tributaries has been left untouched. The tributaries are very important for the river's ecosystem values and processes in the entire catchment. They often act as spawning grounds for fish, and are thus a precondition for fishing further downstream, e.g. in the reservoirs. But fish are by far the only species dependant on tributaries; several redlisted species of flora and fauna are also closely attached to small watercourses.

Therefore, proper treatment of the tributaries of a developed river can be of utmost importance to maintain the biodiversity within the catchment. The measures can be of very different kinds; from no actions at all (i.e. conservation) to constructions of fish passages, addition of nutrients to enhance fish production, habitat adjustments etc.

Landscape conservation
When constructing erosion protection the aim is to retain or create as much of the natural vegetation as possible. Erosion protection can also be designed in a way that new habitats are created.

The same applies to the handling of surplus material left over from e.g. tunnel excavations. Material that cannot be used within the facility must be dumped elsewhere. Then it is important that the dumps are adapted to the feature of the landscape and treated so that the natural vegetation of the area is able to colonise the area.

Fish breeding and release
Sometimes it is not possible to ensure a fully sustainable fish production, e.g. when the suitable spawning grounds have been inundated or made inaccessible in other ways. In these cases, as a compensatory measure, fish can be artificially breeded and released. Also in popular fishing areas, supplementary release of fish can be necessary.

When artificial breeding of salmon and sea trout began, little thought was given to the genetic aspects. But today we know better and accurate selection of breeds, where local breeds are favoured as far as possible, is now considered a key for reaching success.

Conclusion

It is clear that the growing awareness of environmental issues has put new demands on the hydropower industry. This has led to a development of several mitigation measures that enables vastly more benign power projects than before. This is an ongoing process, and new tools will continuously be put in action; seeking at improving the environmental performance of hydropower. Some tools will, of course, affect the generation capability of the stations. Another possible effect of further increased environmental demands is that an increasing number of power stations with borderline economic capacities will be dismantled.

Altogether, this might cause a decrease in power supply, which in turn could raise demands for additional power generation of some sort. If this is the case, new environmental issues will turn up. Then the obvious question is; has the environment really gained from our mitigation efforts?

Notes

Notes