Trilateral cooperation on our common resource; the Atlantic salmon in the Barents region (KO197)

***"Kolarctic salmon* 2011-2013"**

FINAL SEMINAR 10th December 2013

PROGRAM and ABSTRACTS

AGENDA - FINAL SCIENTIFIC SEMINAR, December 10th 2013

Kolarctic ENPI CBC Project – *"Trilateral cooperation on our common recourse; the Atlantic salmon in the Barents region (KO197)"*

Venue: Bioforsk Svanhovd, Svanvik Norway

Time: 8:30-18:00 **Seminar language:** English

Session 1 (time: 8:30-12) – Presentation of the project results: Ecology, fisheries, fishing effort and long-term changes in sea temperatures

Chair: Ms Bente Christiansen, Office of the Finnmark County Governor (FMFI)

- Welcome, opening of the seminar and short project retrospective – Ms Bente Christiansen (FMFI) (5 min)
- Summary of results from the coastal fisheries 2011-2012, salmon resource description and presentation of catch statistics in Northern Norway – Mr Eero Niemelä (FGFRI) (50 min)
- Summary results from coastal and estuarine salmon fisheries in the White Sea: fisheries management and catches, ecology and biological parameters of salmon – Mr Sergey Prusov (PINRO) (30 min)

Questions and discussion (coffee break at approx. 10:30-10:45)

- Incidence of farmed salmon along the North-Norwegian coast – Mr Martin Svenning (20 min)
- Review of four reports on salmon growth and management – 1) Modeling and long-term variation for salmon growth, 2) Effects of major management changes to Tana salmon – Ms Salla Kaartinen (FGFRI) (30 min)
- Review of three reports on the timing of salmon catches and temperature variations – 1) Changes in timing of the salmon catch in Finnmark , 2) A scale space multiresolution method for extraction of sea temperature in Barents and Norwegian Sea - Ms Päivi Laukkanen (FGFRI) (30 min)

Questions and discussion

Lunch 12-13

Session 2 (time: 13-18) – Presentation of the project results – Genetics, mixed- stock fishery and management

Chair: Mr Pentti Pasanen, Centre for Economic development, Traffic and the Environment (ELY-centre)

- Population structure for northern salmon stocks – Mr Vidar Wennevik (IMR) (15 min)
- Assignment of salmon caught in the coastal fisheries 2008-2012 - Mr Juha-Pekka Vähä (UTU-Kevo) (30 min)
- Review of the scientific publications – 1) Technical study on SNPs and 2) Simulation study on genetic stock identification using population-informative SNPs – Mr Mikhail Ozerov (UTU-Kevo) (15 min)

Questions and discussion (coffee break at approx. 14:30-14:45)

- Coastal migratory patterns of the Barents Sea salmon – Mr Martin Svenning (NINA) (50 min)
- Coastal migratory patterns related to available catch statistics in northern Norway – Mr Eero Niemelä (FGFRI) (20 min)
- Exploitation model – Mr Morten Falkegård (NINA) (50 min)

Questions and discussion

Take home messages – summing up the seminar

Miscellaneous

Closure of the seminar

FMFI – Office of the Finnmark County Governor, Norway
IMR – Institute of Marine Research, Norway
NINA – Norwegian Institute for Nature Research – Tromsø
PINRO – Knipovich Polar Research Institute of Marine Fisheries and Oceanography, Russia
UTU-Kevo – University of Turku Kevo Research Station, Finland
FGFRI – Finnish Game and Fisheries Research Institute, Finland

Summary results from the coastal and fjord salmon fishery in the years 2011 and 2012 in Nordland, Troms and Finnmark: timing of the salmon catches, wild and escaped salmon, sea- and freshwater ages, sex distributions and other biological parameters

Eero Niemelä, Esa Hassinen, Pauli Aro, Jari Haantie, Jorma Kuusela, Sergey Prusov, Elena Samoylova,Tiia Kalske, Bente Christiansen, Juha-Pekka Vähä, Mikhail Ozerov, Rogelio Diaz Fernandez, Vidar Wennevik, Martin A Svenning, Morten Falkegård

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Aim of the study was to find out migratory pattern and ecology of salmon in the last phase of the marine life for wild and escaped salmon in Northern Norway and in White Sea in Russia. Huge coastal area in Northern Norway from Lofoten in Nordland County over Troms County to the easternmost Finnmark County in the border area between Norway and Russia was covered by 39 and 53 professional salmon fishermen in the years 2011 and 2012, respectively, fishing salmon from early May to early September. There are some hundreds of salmon rivers in this Kolarctic salmon project area (Nordland, Troms, Finnmark in Norway; tributaries of the River Tana and upper areas of the River Neiden in Finnland; Kola, Archangelsk, Karelia, Komi in Russia) with their genetically different stocks. Therefore the sampling of salmon was decided to cover spatially and temporally from May to September to cover the migration periods of all the stocks although it is recognized that most of the stocks are migrating simultaneously within the narrow time frame. Fishermen collected information from each individual salmon in their catches and they took scale samples from salmon for genetic, age- and growth analysis and for wild salmon or escaped salmon detection. Based on the timing of 8 300 and 11 200 salmon collected in the years 2011 and 2012, respectively, belonging to 1SW (one sea-winter) 2SW, 3SW, 4SW, previous spawners and escaped salmon in the catches we can describe the time of the migration periods for salmon in outermost coastal areas as well as in fjords. Spatial and temporal sea-age distributions and timing of wild and escaped salmon with other biological parameters are presented in the separate reports for the years 2011 and 2012 and summary from the work is presented in this report. Sampling from salmon fishery in 2011-2012 covered altogether 19 524 salmon distributed to Nordland, Troms and Finnmark with 5%, 29% and 66% respectively. The total mass of salmon caught in Kolarctic project in the years 2011 and 2012 was in Nordland, Troms and Finnmark 4, 25 and 54 tons, respectively.

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Salmon resources and management in Kolarctic area

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Atlantic salmon has a high socio-economic value in northern Barents Sea areas both through commercial and subsistent coastal fisheries and recreational fisheries in rivers. The fisheries in these areas represent a significant cultural heritage from indigenous people employing traditional knowledge and old harvesting methods. Presently, the salmon stocks in the Barents Sea area are highly important, as stocks elsewhere on both sides of the Atlantic have declined greatly in the last 50 years while the Barents Sea stocks still retain a high level of production. Salmon have a complicated life cycle, spending their first years as juveniles in rivers, and then migrating out into the open sea to feed and grow large for one up to five years before returning to their home river to spawn. After spawning some salmon succeed to survive and migrate as kelts (post spawners) to sea for recondition and then after one to three years they are migrating along the coast back to their river of origin as previous spawners. Within the huge Kolarctic project area, from Nordland in Norway to Petchora in Russia, there are almost 200 genetically different salmon stocks out of which alone in the River Tana with its tributaries there is c. 35-40 stocks. During their return migration salmon are exploited in coastal and river fisheries. These rivers in northernmost Norway, Finland and Russia support the world's largest wild Atlantic salmon stocks and resources. The major management measures to protect wild salmon stocks were the NASCO convention in 1984 prohibiting the high seas salmon fishery (like in Faroe Islands), the prohibition of driftnet fishery since 1988 in Norway, introduction of new regulatory measures to fjords and coastal areas in Norway since 2010, the restricted estuary and coastal salmon fishery in White Sea area in Russia based on the quotas and total prohibition of the coastal fishery in Barents Sea area in Russia. Also in the border rivers Tana and Neiden there are bilateral agreements for salmon management since 1989 (Tana). Returning salmon are exposed to diverse, intensive exploitation along their journey including coastal, fjord, estuarine and finally in-river fisheries. Salmon resources can be measured as catches. In NEAC North area the catch of salmon was still in the middle of 1980s' c. 2500 tons but now c. 1000 tons. Catch in Kolarctic area makes c. 45% from the total catch in NEAC North areas (Norway, Sweden, Denmark, Iceland, Russia, Finland). In recent years salmon catches have been in Kolarctic area c. 400 tones out of which in Norway c. 300 tones, in Russia c. 60 tones and in Finland c. 40 tones.

Long-term salmon catches at sea and in the rivers in salmon districts in Finnmark and Troms for fish below and above 3 kg

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In the Kolarctic salmon project application it was stated that the final beneficiaries &/or target groups of all the data collected and reported within this project are ministries, management authorities, national, regional and local authorities (Counties and Municipalities), research institutions, fishers organizations, fishermen (recreational/ professional), International governmental organization (like NASCO, ICES), Indigenous peoples, tourism operators, tourists, local people, NGOs and politicians. Therefore in this project it was decided to collect basic data from the reported salmon catches to illustrate long-term changes and possible trends in the catches and catch components which are describing the salmon resources. Knowing and recognizing the status of salmon stocks it is important that management authorities are in smaller or larger geographical areas regulating salmon fishery to reach higher spawning stock levels if needed-at sea and in the rivers. In general reported salmon catches have been considered to represent the size of salmon stocks in the rivers. The modern calculations of the annual spawning stock estimates and especially of the expected needs for the numbers of spawners (target attainment) highlights the need of exact catch reporting. Salmon catches have been collected in Norway since the end of 1800's and since the year 1993 the catch reporting system has been improved and since the year 2004 the reporting of salmon catches also in the river fishery was obligatory. The data presented here gives at least the best overview of the long-term changes although it still remains a question on the real total salmon catches because all the fishermen have not reported or the reported catches are smaller than the real catch. It has not been estimated catches for those fishermen who have not sent information. The total catches most likely are larger than the reported catches. In Senja salmon district salmon catch has fluctuated at sea between 5 and 15 tons and especially after early 2000s' catches have clearly declined down to couple tons. Throughout all the years large salmon has dominated in the catches at sea and its proportion has even increased since the beginning of 1990s'. In the rivers in Senja salmon district, however, salmon catches have increased since early 1990s' but still being in low levels between 1 and 1.5 tons annually. In Troms salmon district salmon catch has fluctuated at sea between 10 and 100 tons and especially after early 2000s' catches have clearly declined down to c. 20 tons. Extremely high reported catches just after the mid-1980s' are caused by the extensive drift net fishery and partly by increased bend net fishery in Troms salmon district. Salmon catches at sea in Alta salmon district have clearly increased since early 1980s' and the proportion of catch caught at sea has been quite stable, around 75%, since the early 1990s'.

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Previous spawned salmon improves the catches and widens diversity of the Atlantic salmon life history in Kolarctic area

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In the Kolarctic salmon project salmon catches included the sea ages of wild 1SW (SW=sea winter), 2SW, 3SW and 4SW and a large variety of sea-age groups of previous spawners. Salmon can survive the post-spawning period as a post-spawner by staying in the river or by migrating straight after the spawning time into the sea. From smaller rivers, without places like deep pools or small lakes, post spawners must migrate to sea soon after the spawning took place. Maybe in most of the rivers, especially in large rivers with suitable overwintering habitats like in the rivers Neiden, Tana, Lakselv and Alta salmon is migrating as post spawner into the sea after staying 7-8 months in rivers. These post spawners are called to be kelts. After kelts have arrived into the sea they start the reconditioning for the next spawning. It is not known where kelts are migrating from the rivers in Finnmark after their arrival into the sea. After surviving the reconditioning period of one, two or even three years they are migrating towards their river of origin. Some, but very few salmon are reconditioning in short period during the summer when they left the river as kelt and then ascending into their river of origin. Previous spawning salmon can have two distinct groups; reconditioning takes place in short time like in some months followed the spawning in previous autumn and that group of salmon is called to be consecutive spawners. Post spawners that need one or more years to recondition for the following spawning are called to be alternate spawners. In first time spawning salmon there were 4 sea-ages of salmon (1SW-4SW), in addition we found reconditioned salmon with 18 different sea-age groups of salmon. The highest previous spawner catches occurred in June in all the counties and then in July the catches were one third of the catches in June. The catches developed the same way in all the counties through the summer and in September fishermen didn't get any previous spawner. Previous spawners contributed important numbers and weights into the catches especially early in the beginning of the official fishing season in June. Especially in the year 2012 previous spawners made up to 10 % in the catches in terms of mass and a little less in terms of numbers fish caught early June. The importance of previous spawners in the declared catches will be highlighted in those years when the stock abundance of especially multi-sea-winter maiden salmon is low due to natural fluctuations.

Escaped salmon, its abundance and timing in the research fishery and in the reported salmon catches in Nordland, Troms and Finnmark in 2011 and 2012

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In the Kolarctic salmon project one of the main goals is to study the migration patterns of wild and escaped salmon along the outermost coastal areas as well as in the fjords. This due to make proposals for tailored management measures to catch escaped salmon at sea without increasing exploitation towards wild salmon. Traditional knowledge from the old salmon fishermen tells that there is some salmon migration early in the spring. Some fishermen have told that there has been also escaped salmon available to be caught in May before the official fishing season. Salmon cage culture has increased during the last 30 years not only in Nordland and Troms but also in Finnmark and the production will most probably increase in the next future with increased farming sites and with the increased production volumes. In North-West Russia salmon cage culture production has also increased in recent years. Salmon which were kept at sea for cage culture purposes and which has been escaped from the net pens were occurring in the catches through the research period from early May to the end of September in the Kolarctic- project area. Early in May escaped salmon made even 25% from the catches at that time of the summer when wild salmon has not started the migrations along the coastal areas. The proportions of escaped salmon naturally declined in the salmon catches after wild salmon migrated into the coastal and fjord areas although also the numbers of escaped salmon in the catches increased. Escaped salmon contributed in the Kolarctic area into the catches c. 10% during that time when most of wild salmon are on their way to the rivers of origin between the weeks 22 and 28, from the late May to the middle of July. After that period the numbers of escaped salmon still increased during a couple weeks' time. In August escaped salmon made in the catches up to 25-35% from all salmon caught. After the official fishing season from the beginning of the second week in August the effort of salmon fishermen in the research to catch salmon dramatically declined which weakens the results in August. Anyhow, the results are indicating that escaped salmon are available to be caught the entire wild salmon migration period close the shorelines in Northern Norway and they made 50% in salmon catches in terms of weight in the middle of August. Salmon fishermen recognized only 57% from the real escaped salmon in 2012 and researcher recognized the lacking 43% from the salmon scale structure. Very seldom fishermen made wrong recognizing that his salmon was not escaped fish. Percentages of escaped salmon from the numbers of salmon in the reported official salmon catches during the ordinary fishing season in Nordland, South Troms, North Troms, North Cape, Lebesby and Sør-Varanger were 44%, 17%, 10%, 13%, 7% and 3% in the year 2012, respectively.

Summary results from coastal and estuarine salmon fisheries in the White Sea: fisheries management and catches, ecology and biological parameters of salmon

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The anadromous Atlantic salmon (*Salmo salar* L.) occurs in five regions in the northwest of the Russian Federation. The Federal Law "On Fisheries and Conservation of Aquatic Biological Resources" (No. 166-FZ, 2004) prioritizes the conservation of aquatic biological resources and their rational exploitation to their utilization as an object of the right of property or other rights. The Total Allowable Catch (TAC) for Atlantic salmon should be established annually. A regional TAC is distributed as quotas to fisheries and allocated to users. TAC is a threshold for catch-and-take fisheries and not established for catch-and-release fisheries. Recreational and commercial fisheries, Sami net fisheries are allowed at fishing sites only. Fishing sites are allotted to users on the basis of competitive tenders. Salmon fisheries are licensed and conducted in accordance with the Fishing Regulation in force.

The biggest Atlantic salmon catch in Russia was recorded in 1960 and was 1,100 tonnes. Over last 25 years the effort in commercial fisheries has been dramatically reduced which aimed at conserving Atlantic salmon stocks and enhancing recreational fisheries. In 2012 the total declared catch of Atlantic salmon was 82.4 t, below the catch for 2011 (89.4 t) but at the same level as the mean for previous 10 years. 46.5 t was harvested by commercial fishermen, whereas 26.7 t was caught by rod and nets in recreational fisheries, 5.9 t was taken for scientific and enhancement purposes and 3.2 t by Sami communes. Catch taken in the coastal areas was 37.9 t while in-river catch was 44.5 t (ICES, 2013).

In Russia samples for Kolarctic salmon project were collected from traditional Pomor salmon fisheries in coastal waters of the White Sea in Murmansk (Terskiy Bereg) and Archangelsk (Zimniy Bereg) regions and from research fishing in the estuaries. No coastal fisheries were allowed in the Barents Sea. In total 2305 salmon were sampled, 1529 of them were from coastal areas and 776 were from estuaries.

Analysis of samples from Terskiy Bereg showed that the great bulk of catches consisted of 1SW salmon (95%) whereas catches from Archangelsk and from Pechora had rather high proportion of MSW salmon including 4SW fish. The majority of fish in Archangelsk were 2SW salmon (over 70%) and only 14% of salmon were grilse in Pechora. None of farm escapees were registered in coastal and estuarine catches. Sampled salmon had smolt age 2+, 3+, 4+ and 5+. The proportion of fish spent two years in fresh water was relatively high in Terskiy Bereg (25%). Over 90% of salmon in Archangelsk region had smolt age 3+. The size distribution of salmon in Terskiy bereg represented well the size distribution of autumn run salmon from White Sea rivers of Murmansk region. The presence of bigger fish in Zimniy Bereg could be explained by age structure of salmon populations from White Sea rivers of Archangelsk region.

The incidence of farmed salmon in the sea fishery along the North-Norwegian coast

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A multistock Atlantic salmon (*Salmo salar*) sea-fishery operates off the North-Norwegian coast, where the average annual landings the last 15-20 years have been 250-300 tonnes, constituting more than 50 % of the total catch of Atlantic salmon in Norway. This sea-fishery has been under strong debate, due to the complexities involved in the potential mixed stocks harvesting, especially since Russian salmon may also be harvested during their homeward spawning migration.

Between early May and late August (2008-2012), ca. 25 000 salmon captured (hook net and keyway) by local sea-fishermen along the North-Norwegian coast were measured and weighted, and their sex, maturity and potential farmed origin were defined. Scales were sampled from all fish for age determination and verification of farmed origin. Sampling was conducted in Finnmark for four years (2008, 2009, 2011 and 2012), and in Nordland and Troms county for two years (2011 and 2012).

The proportion of escaped farmed salmon in the catches (2011 and 2012) was significantly higher in Nordland (22 %) compared to the catches in Troms (14 %) and in Finnmark (9 %). The proportion of farmed fish in Finnmark was twice as high in 2011/2012 compared to 2008/2009. The proportion of farmed fish was higher in the outer coastal areas than in fjords.

The estimated number of farmed salmon captured per fishing day (CPUE) was highest in Southern Troms, and lowest in Eastern Finnmark. CPUE increased strongly throughout the season, i.e. was significantly higher in July/August compared to May/June. The fishermen, although being very well experienced, detected less than 40 % of the farmed fish.

The results are discussed in relation to geographical distribution of catch sites, distance to farming activity and reported number of escaped salmon.

Juvenile salmon (*Salmo salar*) growth differences between rivers in Troms and Finnmark

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Aim of the study was to find out if the salmon (Salmo salar) rivers in Troms and Finnmark could be grouped into clusters according to the growth of the salmon juveniles. Hierarchical clustering was performed in R using hclust algorithm. Function hclust performs a hierarchical cluster analysis using a set of dissimilarities for the *n* objects being clustered. Each object is initially assigned to its own cluster and then the algorithm proceeds iteratively, at each stage joining the two most similar clusters, continuing until there is just a single cluster. Distances between clusters are recomputed at each stage by the Lance–Williams dissimilarity update formula according to the particular clustering method being used (http://stat.ethz.ch/R-manual/R-patched/library/stats/html/hclust.html). In this analysis the complete linkage method was used as a clustering method. The complete linkage or furthest neighbor finds similar clusters and it has a tendency to produce compact bunches as the complete link minimizes the spread within the cluster (Oksanen 2012).

Grouping with first and second year growth increments produced four distinct clusters where group A has the lowest growth, groups B and C grow slightly faster than group A and group C has a larger median growth than group B. Rivers in group D has the fastest growing salmon juveniles. Only those rivers that had at least 10 individuals with a known growth increment in second year were used in hierarchical clustering analysis (*n*=79). Hierarchical clustering was done also using third year median growth increments for those rivers that at least 10 individuals with a known third year growth (n=72). Four groups were found also in this analysis representing the differences between the growth increments. According to the two hierarchical clustering analysis there are marked differences between the growth rate of juvenile salmons in different rivers. River groups differ on how the growth rate changes between first two and the third year. There are 10 rivers where growth rate remains slow i.e. rivers were grouped in cluster group A. in first analysis and cluster group a. in the second. There are also rivers where there is a growth spurt at the year three compared to previous years (n=20) and in 17 rivers the growth seems to slow down. In 35 rivers the growth rate of the juvenile salmons seems to be rather stable over the three year period.

Long-term variations in the juvenile salmon (*Salmo salar*) growth and the temperature effects in the River Tana between 1990-2012

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The aim of this study was to find out, how does the changing water temperature in River Teno effect the growth of the salmon juveniles of different age groups in different years. We had data on the growth increments of the first, second and third year river juveniles from 1976 to 2011 and river temperature data for River Teno from the year 1976 onwards. We only analyzed the data from 1991 onwards as it seems that there has been a bias in river temperature sampling until the year 1990, since the river temperatures did not follow the pattern of the air temperature measurements made by the Finnish Meteorological Institute in the same area.

Growth increments of the individual salmon juveniles do not correlate between consecutive years, so it seems that the intrinsic factors alone will not explain the growth rate of the different aged river juveniles. However the median growth increments between first year and second year growers and second and third year growers in the certain years do correlate and so there is some extrinsic factor(s) that explains the growth rate of the juveniles. There is no significant correlation between the median growth increments of the first and third year growers, which might be caused by the different growth requirements of the juveniles at a different age.

We calculated the average over five 10 days period from the end of June to the beginning of August to study the effect of river temperatures to river juvenile growth. Explanatory variables used were: aver_June3 (average water temperature 21.6.-30.6.), aver_July1 (average water temperature 1.7. – 10.7.), aver_July2 (average water temperature11.7. – 20.7.), aver_July3 (average water temperature 21.7. – 30.7.) and aver_Aug1 (average water temperature 31.7.-9.8.). The average temperatures of consecutive time periods were correlated for the all age groups and were not used in the same model. We also tested the effect of the year and accumulated water temperature (awt) over July on the juvenile salmon growth at different age. In all the GAM (Generalized additive model) based analysis we used mgcv-package (version 1.7-22.) of the R program (R Core Team 2013).

Different age groups (0+, 1+ and 2+ -juveniles) had slightly different temperature requirements. For all age groups the average water temperature at July was the most significant factor for growth, but the timing and optimal temperatures were different. Also all the age groups most likely have also other significant factors determining the growth that were not taken into account in this study.

Effects of major management changes to Tana salmon (*Salmo salar*)

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Aim of the study was to evaluate the effects of the major fishing regulations on Atlantic salmon populations i.e. the ban of the Norwegian coastal drift net fishery in 1989 on the salmon population of a large northern River Teno system. Over all the catches of the salmon in the River Teno system increased from period 1 (1973 - 1988) to period 2 (1989-2012), but there were differences between the age groups. For the 1SW and 2SW maiden salmon and for repeat spawners the catches increased for both sexes but declined for 3SW and 4SW salmon both in numbers and in relative proportions in the catches.

As well as the numbers, also the median size of the fish fished in Teno changed between two periods. The size of 1-4SW salmon had a considerable yearly variation over the 40 years study period (1973-2012), but there were marked differences between the two periods both in median growth and median size of the salmon of different age groups that cannot be explained by the yearly variations alone. The median size of the 1SW salmon of both sexes was larger after the regulations, while in contrast, the median size of the 2SW male and female salmon was smaller. The difference in median size in 2SW salmon was larger for males than females. The median sizes of 3SW and 4SW did not significantly change between the periods. This indicates the strong size-selection in the coastal drift net fishery. Interestingly there is also marked difference in the median growth of the salmon between the two periods. Growth increment of the first summer (SS1 growth) was larger for all age groups (1-4SW) and for both sexes in the period 2 while the growth increment of the second summer (SS2 growth) was smaller for all age groups (2-4SW). This indicates that together with the strong influence of the cessation of the size-selective marine drift net fishery, there is a concurrent change in marine environment affecting the growth of the salmon.

Modelling the long-term variation for salmon growth in River Teno system

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Aim of the study is to find out, do the sea water temperatures affect the growth of Salmon in the Barents Sea region. Since the growth of the different aged salmon is likely affected by different factors we modeled the growth increments separately. At the moment SS1 and SS2 growths have been modeled at some extent.

As temperature variable we used the Kola section mean monthly surface (0-50m) water temperatures. Since the temperatures are strongly correlated we could not use the temperatures from consecutive summer months in the modelling, instead we calculated the summer mean from May to September water temperature values that was used to in SS2 growth models. We also calculated the mean of July and August temperatures to be used in SS1 growth models because these months are most important to survival of the smolts, which have migrated to the sea. In the models we also took into account the year as there is yearly variation both in growth and temperature and period after and before the ban of the Norwegian coastal drift net fishery as it alone had a marked effect on the size of the caught fish. Other factors that affect the growth are sex, age, smolt length for the SS1 growth and SW1 length for SS2 growth. The population from where the individual salmon came from was accounted for by adding the river into a model and we also took into account the fresh water fishing method as different sized salmon may be caught by different method. Preliminary results of the SS1 and SS2 growth show that temperature has had an effect on changes in salmon growth in River Teno salmon population. As there was a major change in fishing regulations in 1989 in the form of ban of coastal drift net fishery, we looked at the growth in two parts – before and after the ban. The effect of sea water temperatures seem to have been stronger before the ban for SS1 growth than after the regulatory measurements. For SS2 the rising temperatures seem to have had decreasing effect after the coastal drift net fishery ban. Changes in the effect of temperature for the growth of the salmon may be caused by the regulatory measurements, but there has been also change in the seawater temperatures. The average summer temperatures were lower during the period before the regulatory measurements i.e. before 1989. From the late eighties onwards the temperatures have been rising and this likely has had an effect on salmon growth. More work should be done in modeling the growth effects of temperature as current models do not satisfactorily explain the changes in the salmon growth.

The timing of salmon catches at sea in 1993-2012

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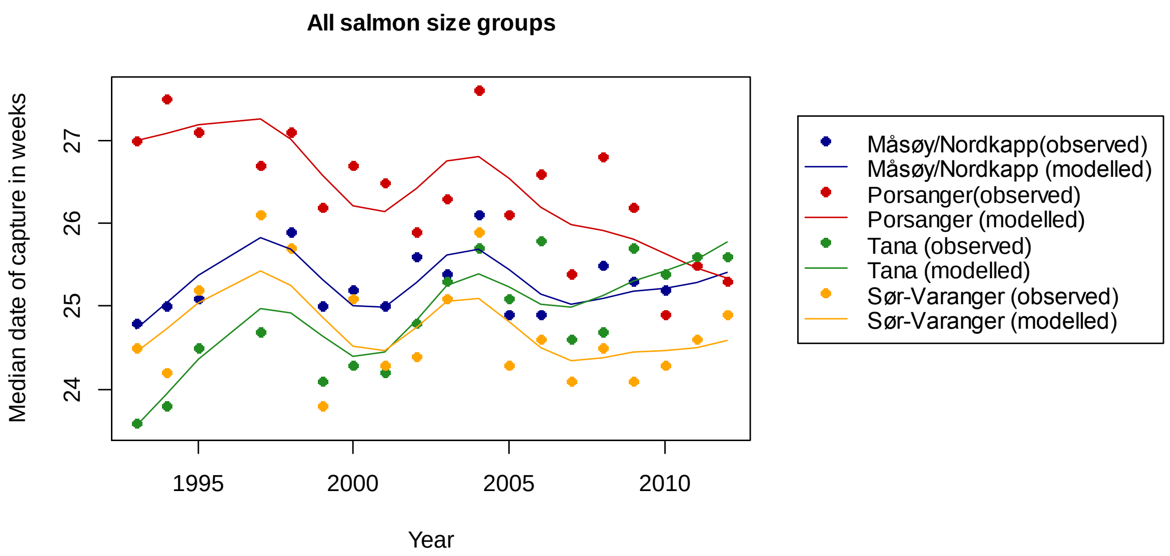
The timing of salmon catches was measured as the median date of capture in each municipality of Finnmark separately. The median date of capture was excluded if salmon catch was less than 700 salmon during the summer in particular municipality. The municipalities were clustered according to the median date of capture. In Finnmark, the municipalities included in the hierarchical clustering were Loppa/Hasvik (combined), Alta, Hammerfest, Kvalsund, Måsøy/Nordkapp, Porsanger, Lebesby Tana, Berlevåg and Sør-Varanger. Four municipalities were selected for detailed modeling (Måsøy/Nordkapp, Porsanger, Tana and Sør-Varanger). The generalized additive model for the median date of capture included the selected municipality, a spline smoothed function of year and an interaction term of the variables. For all municipalities in Finnmark, the linear change was estimated by a linear regression model, and 95 % confidence interval (CI) of the linear change was calculated.

Alta, Kvalsund and Porsanger formed one group as a result of the hierarchical clustering and all the other municipalities formed another group. For the median date of capture of all salmon weight groups, the generalized additive model (fitted curves in the figure) explains 80.5 percent of the deviance. In 2000, the estimated median date of capture is around week 26.7 for Alta, Kvalsund and Porsanger. However, in 2000 the estimated median date of capture is from week 24.9 to 25.5 for all the other municipalities. Only for Porsanger the estimated linear change is negative, -1.81 weeks over 20 years (95 % CI -2.66; -0.96) and only for Tana the change is positive, 1.67 weeks respectively (95 % CI 0.85; 2.48). The median date of capture has no linear trend in all the other municipalities.



The linkage between changes in sea temperature and the timing of salmon catches

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The timing of salmon catches was measured as the median date of capture in Alta, Hammerfest, Tana and Varanger separately. The means of sea temperature for each month were available for Fugløya-Bjornøya section, Laksefjord, Varangerfjord and Kola section. In generalized additive models (GAM) several modifications from the original measurements of sea temperatures were analyzed aiming to found the best predictors for the median date of capture in each location.

The best fitting GAM-models was found for the median date of capture in Varanger. Either differences between means of sea temperatures in January and February in Kola section or differences between means of sea temperatures in January and March in Fugløya-Bjornøya section affects the outcome. The more cooling from January to February in sea temperatures in Kola section the later median date of capture is observed. The other model results in opposite effect, the more cooling from January to March in Fugløya-Bjornøya section the earlier the median date of capture (week) is observed. Both GAM models included also the predictors of differences between the means of sea temperatures in March and April as well as in May and June in Kola section. The difference of means in March and April has threshold value from -0.2 to 0. If the sea is cooling slightly from March to April (the difference is around -0.2), the median date of capture is observed earlier, around week 24.5, but if there is no change in the temperature of sea the median date of capture is observed slightly later, week 25.3. The effect of the difference of means in May and June is almost linear. The more warming from May to June the later is the median date of capture observed.

A scale space multiresolution method for the extraction of sea temperature in Barents and Norwegian Sea

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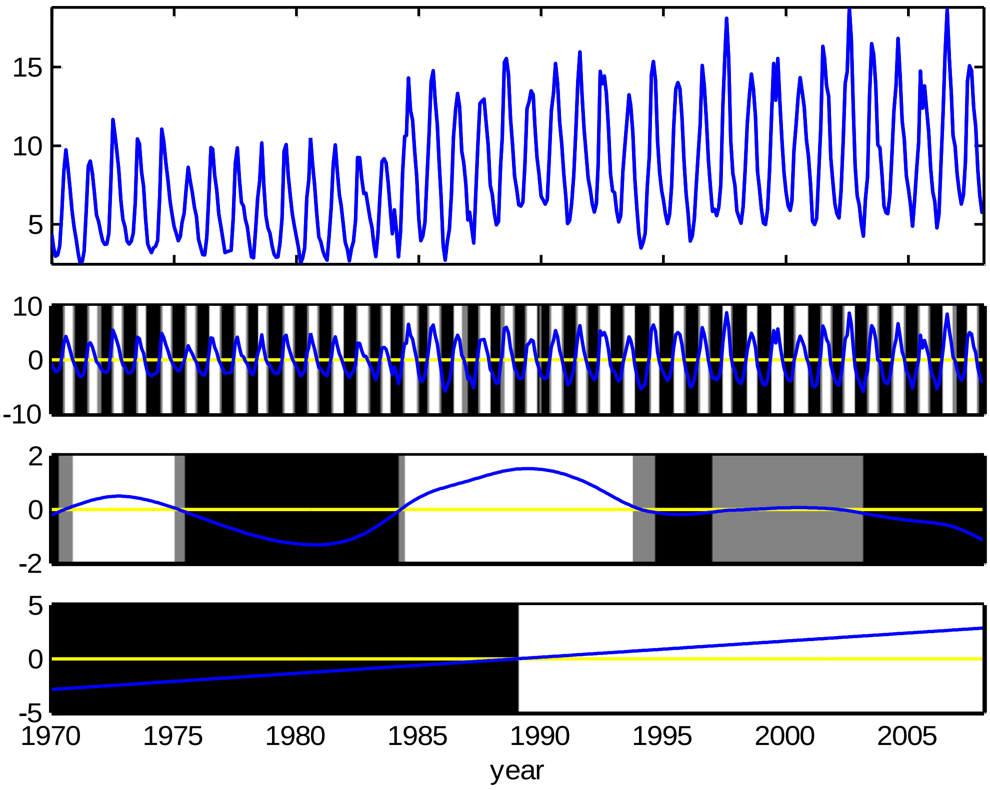
A scale space multiresolution method has been developed for the extraction of time series features (http://onlinelibrary.wiley.com/doi/10.1002/sta4.35/pdf). The traditional decomposition of time series is usually limited to the random, seasonal and trend component. The new method reveals all scale-dependent components, not only three of them.

The scale space multiresolution method was applied to sea temperatures from Ingøy, Laksefjord, Varangerfjord and Kola section. Credibility analysis was performed to find warm and cool periods. Simulation-based Bayesian inference was applied for credibility analysis. In the figure, the highest panel represents the observed sea temperature of Laksefjord, second is the seasonal component, third is a long time-scale component and lowest is the linear component which was included to the extraction. In the long time-scale component, two warm periods (white background) and three cool periods (black background) are found by the credibility analysis.



Population structure for northern salmon stocks

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While a number of population genetic studies have included Atlantic salmon populations from the northernmost reach of the European distribution range, this is the first comprehensive study to include all major populations in this area. The genetic data set generated through the activities in this project probably constitutes the most extensive and detailed, as well as the largest data set existing for any fish species. Analysis of this comprehensive baseline has demonstrated genetic structuring at both local and regional scales, reflecting the phylogenetic history of the species in this region. Major transitions in genetic structure appear between the easternmost river Pechora, and other rivers of northern Russia, and also between the White Sea rivers and the rivers of the Barents Sea coast of the Kola Peninsula. Further west, the Tana/Teno river system constitutes a distinctive genetic region setting it apart from other rivers in northern Finnmark. Other regional structures are also apparent and have allowed for the definition of regional groups of populations for assignment purposes. In addition to Tana/Teno, internal structure within major river systems such as the Pechora and Ponoi river systems has been demonstrated. The northern rivers of the Kolarctic area, display strong structuring with inter-river differences being on a different scale form rivers further south in Europe. They also are some of the best-preserved rivers still retaining their phylogenetic character and for the most part relatively undisturbed by problems arising from human activities.

Genetic analyses of coastal fishery samples 2008-2012

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Fisheries commonly exploit mixed stocks and thereby their efficient management requires assessment of population composition of catches. Traditionally external tagging and recapture surveys have been employed to study fish migration routes and patterns. More recently, genetic stock identification (GSI) of individuals has been widely applied tool in the management of commercial fisheries of salmon. The power of genetic stock identification essentially depends on 1) the number of potential stocks of origin and 2) the level of genetic differentiation among them. In addition, 3) the number of reference samples collected from each population to describe their allele relative frequencies, 4) the number and features of applied genetic markers as well as 5) the statistical methods are key factors that define the level of accuracy of individual assignment tests.

Within the Kolarctic project, 23235 samples from the Barents and White Sea coastal fisheries and 12 659 baseline samples from more than 150 rivers were analyzed with 31 microsatellite markers expressing a total of 675 alleles (6-44/locus). The global level of genetic differentiation among stocks was FST= 0.055. Populations in the Eastern Barents and Teno reporting groups were most diverged, while western Kola and eastern Finnmark populations had lowest divergence.

Finally, we determined the statistical method of choice and assessed the power of assigning individuals to their stock of origin or 'reporting' group of stocks. We found the Bayesian method for estimating mixture proportions
and assigning individuals in a mixture sample to the baseline population to outperform other methods. Power analyses were performed by analyzing test samples from the baseline without replacement (10/stock) jointly with real fishery mixtures. For the tested Western Kola, Eastern Finnmark and Teno populations correct assignment to population varied from 0% (1) to 100% (6) averaging 68%, 78%, and 89% respectively. Correct assignments to the reporting groups were 93%, 95% and 96%, respectively.

Finding markers that make a difference: DNA pooling and SNP-arrays identify population informative markers for genetic stock identification

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Genetic stock identification (GSI) using molecular markers is an important tool for management of migratory species. Short tandem repeats (STR), or microsatellites, have been the marker of choice for GSI applications for nearly two decades. Numerous advantages of single nucleotide polymorphism (SNP) over STRs increase the possibility to adopt them as marker of choice for GSI applications. High-throughput screening of numerous SNP loci enables the identification of highly informative ones, remaining however quite expensive for large set of individuals. Determination of allele frequencies from pooled DNA, i.e. 'allelotyping', has been demonstrated as a cost-effective alternative to individual genotyping.

We estimated allele frequencies of 2880 SNPs from DNA pools of 23 Atlantic salmon populations using Illumina SNP-chip. We evaluated the performance of four common strategies (global F_{ST}, pairwise F_{ST}, Delta and outlier approach) for selection of the most informative set of SNPs and tested their effectiveness for GSI compared to random sets of SNP and microsatellite markers. For the majority of cases, SNPs selected using the outlier approach performed best followed by pairwise F_{ST} and Delta methods. Up to 150 top-ranked SNPs were sufficient to achieve > 90% of correct individual assignments in all tested populations. Overall, the selection procedure reduced the number of SNPs required for accurate GSI by up to 53% compared with randomly chosen SNPs. However, GSI accuracy was more affected by populations in the ascertainment group rather than the ranking method itself. Moreover, we demonstrated for the first time the compatibility of different large-scale SNP datasets by compiling the largest population genetic dataset for Atlantic salmon to date. Finally, we showed an excellent performance of our top SNPs on an independent set of populations covering the main European distribution range of Atlantic salmon. Taken together, we demonstrate how combination of DNA pooling and SNP arrays can be applied for conservation and management of salmonids as well as other species.

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Coastal migratory patterns of the Barents Sea salmon

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The salmon sea-fishery in North-Norway has long cultural traditions, but has been under strong debate the last 10-15 years, due to the complexities involved in the potential mixed stocks harvesting. Thus, the aim of this study was to define and quantify the amount of different salmon stocks contributing in the coastal catches along the North-Norwegian coast, and try to develop a stock-specific migration model for some of the largest Barents Sea salmon populations. To determine the home or river origin of the Barents Sea salmon in this study, the genetic data of more than 20 000 adult salmon caught at more than 70 localities along the North-Norwegian coast in the years 2008-2012, where compared to a database of genetic profiles from nearly 200 rivers in North-Norway and Russia, including 31 microsatellite markers covering all rivers. The study revealed that many of the salmon stocks, even from Eastern Finnmark and Russian rivers, may be exploited at most fishing localities spread along the ca 1 000 km long coast line from South-Western Nordland to North-Eastern Finnmark. The results from this study will assist a more precise and informed regulatory measures in the Barents Sea area, to improve the management of salmon stocks homing to Barents Sea rivers.

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Exploitation model

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The salmon management regime in Norway is based on a system of regions, effectively dividing the coastline into outer coastal areas and inner fjords. This system is based on two presumptions: (1) that the fisheries along the outer coastline is a mixed-stock fishery effectively exploiting lots of stocks that can be located far away from the fishing spot, and (2) that a fjord fishery is mainly exploiting stocks belonging to local rivers. The region-based system then open up an opportunity to differentiate the fisheries regulations. If the spawning target attainment of all stocks in a fjord is good, then the fisheries within that fjord should be regulated less strongly than the fisheries in a fjord in which some stocks have poor spawning target attainment. The decision-making about the regulation of fjord fisheries therefore is locally based, while the decision-making about outer coastal regulations involve an evaluation of target attainment for stocks situated both close and far away from each outer coastal region.

The project data demonstrate that the above two presumptions are reasonable for most of the Northern Norway coastline. For most fjords, the catch diversity is much lower than in the outer coastal regions outside the fjords and the fjord catches are dominated by local stocks. The one major exception to this is the Varanger fjord, where there is both a high diversity and a high incidence of salmon from stocks situated both close by and far away. For this reason, it might be necessary to reevaluate the region definition in Varanger.

For most stocks (or stock regions) the majority of the coastal catch were taken relatively close to each stocks home river. There are some major exceptions here, however. Salmon from the Tana river system were, in particular, taken all over the Kolarctic investigation area, both to the east and to the west of the Tana fjord, all the way down to Nordland. This demonstrates the strong position and potentially high value of the Tana stock complex. Salmon from the river Alta were also taken in several regions both east and west of the Alta fjord. In a striking comparison, salmon from the river Målselva were mostly taken in the inner part of Troms, and very few Målselva salmon were taken in outer coastal regions in Nordland and Finnmark.

Russian salmon was also exploited over a large area, all the way down to Nordland. There were three main areas of exploitation of Russian salmon: the middle and eastern part of the outer Finnmark coastline, and the Varanger fjord. Very few Russian salmon were taken in the other fjords.

Combining the Kolarctic data with coastal and river catch statistics, we are able to examine exploitation patterns of different stocks. Of particular interest is the ability to estimate pre-fisheries abundances which can then be used to infer coastal exploitation rates of different stocks. There are some interesting variations here, even between neighbouring rivers, and some examples of this will be demonstrated.

Participants Kolarctic salmon FINAL SEMINAR and 4th Steering group meeting 9th-11th December 2013

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Sturla Brørs	Norwegian Environment Agency	steering group member
Veikko Guttorm	Utsjoki Municipality	steering group member
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