Tana Monitoring and Research Group

Status of the Tana/Teno River salmon populations in 2018

Report from the Tana Monitoring and Research Group 2/2018

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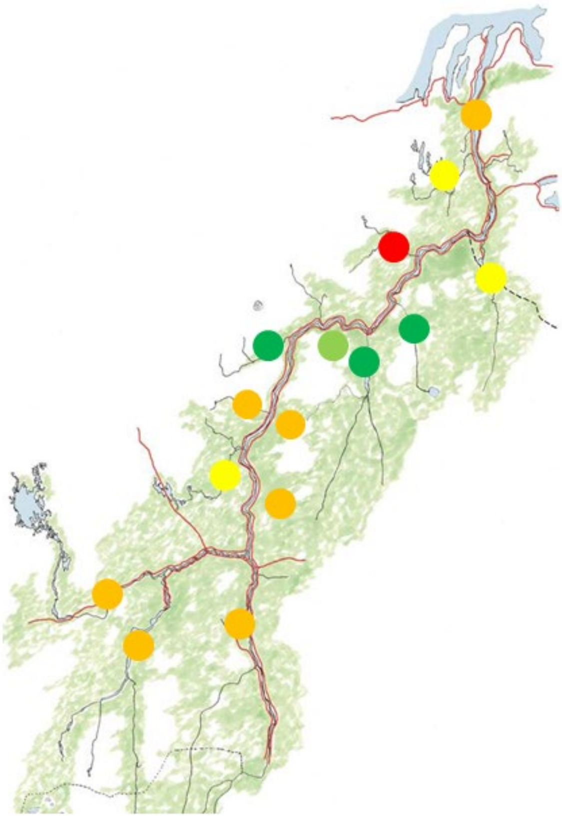
Summary

Anon. 2018. Status of the Tana/Teno River salmon populations in 2018. Report from the Tana Monitoring and Research Group nr 2/2018.

This report is the second status assessment of the re-established Tana Monitoring and Research Group (MRG) after the new agreement between Norway and Finland. After a summary of salmon monitoring time series in Tana/Teno, we present an updated status assessment of 15 stocks/areas of the Tana/Teno river system. All stocks are evaluated in terms of a management target defined as a 75 % probability that the spawning target has been met over the last four years. A scale of four years has been chosen to dampen the effect of annual variation on the status.

The map below summarizes the 2015-2018 stock status of the evaluated parts of the Tana/Teno river system. Symbol colour designates stock status over the last four years, classified into five groups with the following definitions:

1) Probability of reaching the spawning target over the last four years higher than 75 % and attainment higher than 140 % (dark green color in the summary map below)
2) Probability higher than 75 %, attainment lower than 140 % (light green)
3) Probability between 40 and 75 % (yellow)
4) Probability under 40 %, at least three of the four years with exploitable surplus (orange)
5) Probability under 40 %, more than one year without exploitable surplus (red)



Stock status over the last four years (2015-2018) was poor (probability of reaching management target < 40 %) in 8 of the 15 stocks that we evaluated. The best status was found in Veahčajohka/Vetsijoki, Ohcejohka/Utsjoki, Goahppelašjohka/Kuoppilasjoki, and Leavvajohka. The status of the Máskejohka stock decreased from the previous year, indicating a probability of reaching

the spawning target over the past four years being now between 40 and 75 %, a change from light green to yellow.

Of the stocks with poor status, the most important thing to note is the status of the upper main headwater areas of Kárášjohka, Iešjohka and Anárjohka/Inarijoki and of the Tana/Teno main stem. These areas had low target attainment and low exploitable surplus. These four areas constitute 84 % of the total Tana/Teno spawning target and over the last four years, these areas together have lacked an average of 30 000 kg female spawners to reach their combined management targets.

One of the evaluated tributaries, Lákšjohka, was placed in the poorest stock status category due to three years of no exploitable surplus. Of the last four years, there was no exploitable surplus in 2015, 2017 and 2018 and all the coastal, main stem and tributary catch in these three years represent overexploitation. Of the other evaluated stocks, Anárjohka/Inarijoki had no exploitable surplus in 2018. Overexploitation was identified as a significant problem for the Kárášjohka, Iešjohka, Anárjohka/Inarijoki and Tana/Teno main stem areas.

Sonar counts from the Tana/Teno main stem in 2018 for the first time give direct estimates of total run size and improve the estimated exploitation rates for both the Tana/Teno mainstem and the tributaries. In addition, salmon ascending to the Anárjohka/Inarijoki were counted using sonar for the first time in 2018.

Overall, a major result of the present status report is that the exploitation estimates show decreasing exploitation for all individual salmon stocks in the mixed-stock fishery in the Tana/Teno mainstem following the newly implemented agreement between Norway and Finland.

The table below summarizes the stock-specific management targets and status numbers for 2018 and previous four years, and the probability for reaching the 75 % level in attainment of spawning target in previous 4 years (=the management target).

	2018 target attainment	2018 probability	4-year target attainment	Management target probability
Tana/Teno MS	68 %	2 %	57 %	0 %
Máskejohka	79 %	7 %	112 %	71 %
Buolbmátjohka/Pulmankijoki	126 %	81 %	112 %	65 %
Lákšjohka	55 %	0 %	53 %	0 %
Veahčajohka/Vetsijoki	103 %	51 %	148 %	97 %
Ohcejohka/Utsjoki (+tributaries)	317%	100 %	221 %	100 %
Goahppelašjohka/Kuoppilasjoki	146 %	95 %	132 %	87 %
Leavvajohka	406 %	100 %	387 %	100 %
Báišjohka	95 %	37 %	90 %	29 %
Njiljohka/Nilijoki	108 %	62 %	88 %	22 %
Váljohka	99 %	53 %	110 %	60 %
Áhkojohka/Akujoki	41 %	0 %	49 %	0 %
Kárášjohka (+tributaries)	59 %	0 %	42 %	0 %
Iešjohka	46 %	0 %	39 %	0 %
Anárjohka/Inarijoki (+tributaries)	34 %	0 %	39 %	0 %

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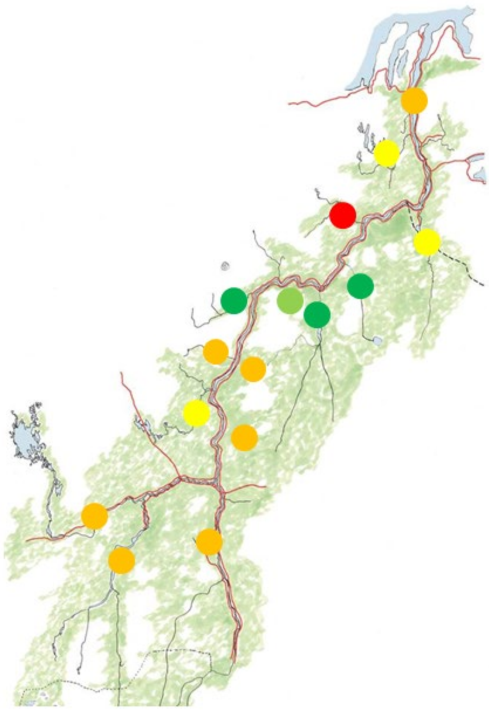
Sammendrag

Anon. 2018. Status for laksebestandene i Tanavassdraget i 2018. Rapport fra overvåkings- og forskergruppen for Tana nr 2/2018.

Denne rapporten er den andre statusvurderingen fra den reetablerte overvåkings- og forskningsgruppen for Tana etter at det ble ny avtale mellom Norge og Finland. Etter en oppsummering av tidsseriene for overvåking av laks i Tana, presenterer vi en oppdatert statusvurdering av 15 bestander/områder i Tanavassdraget. Alle bestandene er evaluert etter et forvaltningsmål definert som 75 % sannsynlighet for at gytebestandsmålet er nådd over siste fire år. En skala på fire år er valgt for å dempe effekten av variasjon mellom år i statusvurderingen.

Kartet nedenfor oppsummerer bestandsstatus i 2015-2018 i de evaluerte delene av Tanavassdraget. De ulike symbolfargene viser status over siste fire år, klassifisert i fem grupper etter følgende definisjon:

1) Sannsynligheten for å nå gytebestandsmålet siste fire år er over 75 % og måloppnåelsen er over 140 % (mørkegrønn farge i kartet nedenfor)
2) Sannsynlighet over 75 %, måloppnåelse under 140 % (lysgrønn)
3) Sannsynlighet mellom 40 og 75 % (gul)
4) Sannsynlighet under 40 %, minst tre av fire år med beskattbart overskudd (oransje)
5) Sannsynlighet under 40 %, mer enn ett år uten beskattbart overskudd (rød)



Bestandsstatus over siste fire årsperiode (2015-2018) var dårlig i 8 av de 15 evaluerte bestandene. Best status ble funnet i Veahčajohka/Vetsijoki, Ohcejohka/Utsjoki, Goahppelašjohka/Kuoppilasjoki og Leavvajohka. Status i Máskejohka ble dårligere siden forrige vurdering gjennom at sannsynlighet for å nå gytebestandsmålet over siste fire år nå ligger mellom 40 og 75 %, en endring fra lys grønn til gul på kartet.

Av bestandene med dårlig status er det viktigste trekket av betydning at de store kildeelvene Kárášjohka, Iešjohka og Anárjohka/Inarijoki samt selve Tanaelva har svak status. Disse områdene har lav måloppnåelse og lavt beskattbart overskudd. Disse fire områdene utgjør til sammen 84 % av det totale produksjonspotensialet i Tana (uttrykt gjennom gytebestandsmålene) og over de siste fire årene har disse områdene manglet totalt 30 000 kg hunnlaks med tanke på å nå forvaltningsmålet.

En av de evaluerte sideelvene, Lákšjohka, ble plassert i den dårligste bestandsstatuskategorien på grunn av at tre av fire år var uten beskattbart overskudd. Av de siste fire årene var det ikke beskattbart overskudd i 2015, 2017 og 2018 og alt fiske av laks fra denne elva i sjøen, hovedelva og selve Lákšjohka var derfor overbeskatning disse åren. Av de andre evaluerte bestandene ble overbeskatning identifisert som et betydelig problem i Kárášjohka, Iešjohka, Anárjohka/Inarijoki og selve Tanaelva.

Sonartellingen av laks i Tanaelva i 2018 ga for første gang direkte estimat på totalt antall laks og forbedrer estimatet av beskatnignsratene for både hovedelva og sideelvene. I tillegg ble oppvandrende laks i Anárjohka/Inarijoki telt med sonar for første gang i 2018.

Et viktig resultat i statusevalueringen er at beskatningsestimatene nå viser klart minsket beskatning for alle bestander i fisket på blandete bestander i selve Tanaelva etter innføringen av den nye avtalen mellom Norge og Finland.

Tabellen nedenfor oppsummerer de bestandsspesifikke forvaltningsmålene og statustallene fra 2018.

	2018 måloppnåelse	**2018 sannsynlighet**	**4-års måloppnåelse**	**Forvaltningsmål sannsynlighet**
Tana hovedelva	68 %	2 %	57 %	0 %
Máskejohka	79 %	7 %	112 %	71 %
Buolbmátjohka/Pulmankijoki	126 %	81 %	112 %	65 %
Lákšjohka	55 %	0 %	53 %	0 %
Veahčajohka/Vetsijoki	103 %	51 %	148 %	97 %
Ohcejohka/Utsjoki (+sideelver)	317%	100 %	221 %	100 %
Goahppelašjohka/Kuoppilasjoki	146 %	95 %	132 %	87 %
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Báišjohka	95 %	37 %	90 %	29 %
Njiljohka/Nilijoki	108 %	62 %	88 %	22 %
Váljohka	99 %	53 %	110 %	60 %
Áhkojohka/Akujoki	41 %	0 %	49 %	0 %
Kárášjohka (+sideelver)	59 %	0 %	42 %	0 %
Iešjohka	46 %	0 %	39 %	0 %
Anárjohka/Inarijoki (+sideelver)	34 %	0 %	39 %	0 %

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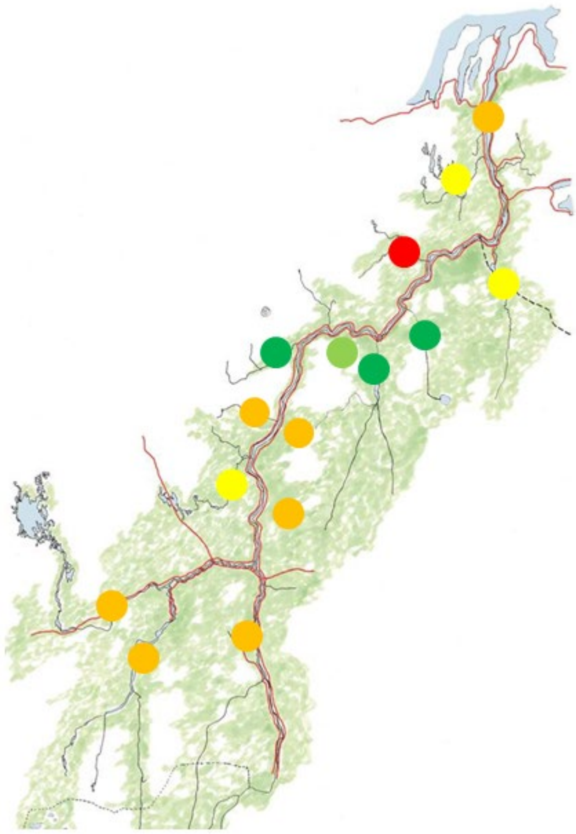
Yhteenveto

Anon. 2018. Tenojoen lohikantojen tila 2018. Tenon seuranta- ja tutkimusryhmän raportti nr 2/2018.

Tämä raportti on uudelleen asetetun Tenojoen seuranta- ja tutkimusryhmän toinen Tenon lohikantojen tila-arvio, joka on tehty Suomen ja Norjan välisen uuden kalastussopimuksen voimaansaattamisen jälkeen. Keskeisten seurantatulosten esittämisen jälkeen esitellään lohikantojen tila-arviot 15 eri lohikannalle. Lohikantojen tila on arvioitu suhteessa hoitotavoitteeseen, jonka mukaan kutukantatavoitteen saavuttamiselle neljän edellisen vuoden aikana on oltava 75 % todennäköisyys. Tarkastelujaksoksi on valittu neljä vuotta, jotta vuosien välinen vaihtelu kantojen tilassa voidaan ottaa huomioon.

Oheinen karttakuva vetää yhteen lohikantojen tilan vuosina 2015-2018 Tenon vesistön erin osissa. Merkkien väri kuvastaa kannan tilaa neljän edellisen vuoden aikana seuraavasti:

1) Kutukantatavoitteen saavuttamisen todennäköisyys neljän viime vuoden aikana yli 75 % ja kutukantatavoitteen täyttymisaste yli 140 % (tumman vihreä symboli oheisessa kartassa)
2) Kutukantatavoitteen saavuttamisen todennäköisyys yli 75 % ja kutukantatavoitteen täyttymisaste alle 140 % (vaalean vihreä)
3) Kutukantatavoitteen saavuttamisen todennäköisyys 40-75 % (keltainen)
4) Kutukantatavoitteen saavuttamisen todennäköisyys alle 40 %, lohikannassa hyödynnettävää ylijäämää (oranssi)
5) Kutukantatavoitteen saavuttamisen todennäköisyys alle 40 %, lohikannassa ei hyödynnettävää ylijäämää (punainen)



Kantojen tila viimeisen neljän vuoden aikana (2015-2018) oli huono kahdeksassa 15:stä arvioidusta lohikannasta. Paras kantojen tila oli Veahčajohka/Vetsijoessa, Ohcejohka/Utsjoessa, Goahppelašjohka/Kuoppilasjoessa ja Leavvajohkassa. Máskejohkan tila-arvio laski yhden luokan verran verrattuna vuoteen 2017 (vaaleanvihreästä keltaiseksi), eli kutukantatavoitteen saavuttamisen todennäköisyys viimeisen neljän vuoden aikana on nyt 40-75 %.

Heikompien kantojen osalta on tärkeää huomata latvajokien (Kárášjohka, Iešjohka and Anárjohka/Inarijoki) ja Tenon pääuoman tilanne. Näillä alueilla kutukantatavoitteen saavuttaminen oli heikkoa ja hyödynnettävä lohikannan ylijäämä oli pieni. Nämä neljä lohikantaa muodostavat kuitenkin 84 % koko Tenon vesistön kutukantatavoitteesta, ja viimeisen neljän vuoden aikana alueilta on jäänyt puuttumaan yhteensä noin 30 000 kg naaraslohia, joka olisi tarvittu kutukantatavoitteen täyttymiseen.

Lákšjohka on arvioitu kuuluvaksi huonoimpaan kannan tilaluokkaan (punainen) koska siellä ei ole ollut hyödynnettävää lohikannan ylijäämää kahteen vuoteen. Viimeisen neljän vuoden aikana ylijäämää ei arvioitu olevan lainkaan vuosina 2015, 2017 ja 2018, joten kaikki kalastus, sekä rannikolla, Tenon pääuomassa ja itse sivujoessa on määritelty lohikannan ylikalastukseksi. Muista arvioiduista lohikannoista Kárášjohkan, Iešjohkan, Anárjohka/Inarijoen ja Tenon pääuoman kantojen ylikalastus arvioitiin merkittäväksi ongelmaksi.

Tenojoen pääuoman kaikuluotaus kesällä 2018 mahdollisti ensimmäistä kertaa arvion Tenoon nousevasta lohimäärästä, joka myös auttoi arvioimaan Tenon pääuoman ja sivujokien lohikantojen kalastuskuolevuutta. Myös Inarijokeen nousevaa lohimäärää arvioitiin kaikuluotaimella vuonna 2018 ensimmäistä kertaa.

Tärkein tämän raportin uusi tulos on kaikkiin Tenojoen vesistön lohikantoihin kohdistuvan kalastuskuolevuuden on pienentyminen Tenon pääuoman sekakantakalastuksessa. Tämä johtuu pääasiassa uuden Tenon kalastussopimuksen mukaisesti pienentyneestä kalastuspaineesta.

Oheinen taulukko esittää kantakohtaisesti kutukantatavoitteen saavuttamisen vuonna 2018 ja edellisenä neljänä vuotena sekä kutukantatavoitteen saavuttamisen todennäköisyyden neljänä edellisenä vuonna (hoitotavoite = 75 %).

	2018 kutukantatavoitteen saavuttaminen	**2018 kutukantatavoitteen saavuttamisen tod.näk.**	**4 vuoden kutukantatavoitteen saavuttaminen**	**4 vuoden kutukantatavoitteen saavuttamisen tod.näk.**
Teno pääuoma	68 %	2 %	57 %	0 %
Máskejohka	79 %	7 %	112 %	71 %
Buolbmátjohka/Pulmankijoki	126 %	81 %	112 %	65 %
Lákšjohka	55 %	0 %	53 %	0 %
Veahčajohka/Vetsijoki	103 %	51 %	148 %	97 %
Ohcejohka/Utsjoki (+sivujoet)	317%	100 %	221 %	100 %
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Njiljohka/Nilijoki	108 %	62 %	88 %	22 %
Váljohka	99 %	53 %	110 %	60 %
Áhkojohka/Akujoki	41 %	0 %	49 %	0 %
Kárášjohka (+sivujoet)	59 %	0 %	42 %	0 %
Iešjohka	46 %	0 %	39 %	0 %
Anárjohka/Inarijoki (+sivujoet)	34 %	0 %	39 %	0 %

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Contents

1 Introduction

The new Tana Monitoring and Research Group (hereafter MRG) was formally appointed in 2017 based on a Memorandum of Understanding (MoU) signed by Norway and Finland in December 2017. The mandate of the MRG is:

1) Deliver annual reports within given deadlines on the status of the salmon stocks, including trends in stock development.
2) Evaluate the management of stocks considering relevant NASCO guidelines.
3) Integrate local and traditional knowledge of the stocks in their evaluations.
4) Identify gaps in knowledge and give advice on relevant monitoring and research.
5) Give scientific advice on specific questions from management authorities.

The MoU is based on the Agreement between Norway and Finland on the Fisheries in the Tana/Teno Watercourse of 30 September 2016. This agreement outlines a target- and knowledge-based flexible management regime for salmon fisheries in the Tana.

According to the MoU, the MRG shall consist of four scientists, two appointed by the Ministry of Agriculture and Forestry in Finland and two by the Ministry of Climate and Environment in Norway. The currently appointed members are:

- Jaakko Erkinaro (Finland, scientist working at Natural Resources Institute Finland (Luke) in Oulu)
- Panu Orell (Finland, scientist working at Luke in Oulu)
- Morten Falkegård (Norway, scientist working at Norwegian Institute for Nature Research (NINA) in Tromsø)
- Anders Foldvik (Norway, scientist working at NINA in Trondheim)

1.1 Report premises

1.1.1 The Precautionary Approach

Both Norway and Finland (through EU) are members of the North Atlantic Salmon Conservation Organisation (NASCO; www.nasco.org). This is an international organization, established by an inter-governmental Convention in 1984, with the objective to conserve, restore, enhance and rationally manage Atlantic salmon through international cooperation. NASCO parties have agreed to adopt and apply a Precautionary Approach (Agreement on Adoption of a Precautionary Approach, NASCO 1998) to the conservation and management and exploitation of Atlantic salmon to protect the resource and preserve the environments in which it lives. The following list summarizes the approach outlined in the Precautionary Approach:

1) Stocks should be maintained above a conservation limit using management targets.
2) Conservation limits and management targets should be stock-specific.
3) Possible undesirable outcomes, e.g. stocks depleted below conservation limits, should be identified in advance.
4) A risk assessment should be incorporated at all levels, allowing for variation and uncertainty in stock status, biological reference points and exploitation.
5) Pre-agreed management actions should be formulated in the form of procedures to be applied over a range of stock conditions.

6) The effectiveness of management actions in all salmon fisheries should be assessed.
7) Stock rebuilding programmes should be developed for stocks that are below their conservation limits.

The conservation limit is defined as the minimum number of spawners needed to produce a maximum sustainable yield (NASCO 1998).

The above process is highly demanding in terms of knowledge, evaluation and implementation. A follow-up document from 2002 (Decision Structure for Management of North Atlantic Salmon Fisheries, NASCO 2002) helps systematizing the approach as a tool for managers by providing a consistent approach to the management of salmon exploitation. Further deepening elaborations and clarifications have been given in a document from 2009 (NASCO Guidelines for the Management of Salmon Fisheries, NASCO 2009).

All assessments and evaluations found in this report have been done to comply with the Precautionary Approach.

1.1.2 Single- vs. mixed-stock fisheries

The management of salmon fisheries should be based on advice from the International Council for the Exploration of the Sea (ICES). These advices primarily imply that salmon fisheries should exploit stocks that are at full production capacity, while exploitation of depleted stocks should be limited as much as possible. In this context, it becomes important to distinguish a single-stock fishery from a mixed-stock fishery.

NASCO defines a mixed-stock fishery as a fishery that concurrently exploits stocks from two or more rivers. A mixed-stock fishery might exploit stocks with contrasting stock status, with some stocks well above their conservation limits and others well below. The fishery in the Tana main stem is an example of a complex mixed-stock fishery. NASCO (2009) has emphasized that management actions should aim to protect the weakest stocks exploited in a mixed-stock fishery.

1.1.3 Management and spawning targets

It follows from the Precautionary Approach that managers should specify stock-specific reference points that then should be used to evaluate stock status. The conservation limit is important, and management targets should be defined to ensure that stocks are kept above their conservation limit. The management target therefore designates the stock level that safeguards the long-term viability of a stock.

The spawning target is founded on the premise that the number of recruits in a fish stock in some way is depending on the number of spawners and that each river has a maximum potential production of recruits. The number of spawners necessary to produce this maximum number of recruits is the spawning target of a river.

1.2 Definition and explanation of terms used in the report

Accumulated/sequential/total exploitation. This term is used to describe a sequence of fisheries which together exploit a salmon stock. The sequence that impact salmon stocks in Tana is the following: (1) Coastal fisheries in the outer coastal areas of Nordland, Troms and Finnmark; (2) Coastal fishery in the Tana fjord; (3) Tana main stem; and (4) home tributary (only applies to tributary stocks in the system). In such a sequence the exploitation pressures add up.

An example: 100 salmon are returning to a stock in one tributary in Tana. 10 are taken in the outer coastal fisheries, 10 are taken in the fjord, 10 in the Tana main stem and 10 in the tributary. A total of 40 out of 100 salmon are taken, which gives an accumulated exploitation rate of 40 %. The exploitation efficiency in each fishing area is much lower, e.g. 10 % in the outer coastal area in this example.

Exploitation rate/efficiency. The proportion of fish taken in an area out of the total number of fish that is available for catch in the area. For example, if 10 out of 50 fish are taken, the exploitation rate is 20 %.

Exploitation estimate. See exploitation rate above. Ideally, we want to have a direct estimate of the exploitation rate using catch statistics and fish counting. Such estimates are available only in rivers with a detailed monitoring. In most cases, indirect estimates of exploitation rates must be used. Such estimates must be based on available data in rivers of comparative size and comparative regulation. A closer discussion on the estimation of exploitation rates in data-poor rivers can be found in Anon. (2011).

Management target. The management target, as defined by NASCO, is the stock level that the fisheries management should aim for to ensure that there is a high probability that stocks exceed their conservation limit (spawning target, see definition below). The management target is defined as a 75 % probability that a stock has reached its spawning target over the last 4 years.

Maximum sustainable exploitation. This is the amount of salmon that can be taken in each year while ensuring that the spawning target is met. The maximum sustainable exploitation therefore equals the production surplus in a year.

Overexploitation. This refers to the extent of a reduction in spawning stock below the spawning target that can be attributed to exploitation.

Pre-fishery abundance. This is the number of salmon that is available for a fishery. For example, the total pre-fishery abundance of a stock is the number of salmon coming to the coast (on their spawning migration) and therefore is available for the outer coastal fisheries. The pre-fishery abundance for a tributary in the Tana river system is the number of salmon of the tributary stock that have survived the coastal and main stem fisheries and therefore are available for fishing within the tributary.

Production potential. Every river with salmon has a limited capacity for salmon production. The level of this capacity is decided by environmental characteristics and river size.

Spawning stock. These are the salmon that have survived the fishing season (both coastal and river fisheries) and can spawn in the autumn. Usually the spawning stock estimates focus only on females.

Spawning target. The spawning target is defined as the female biomass needed to make sure that the salmon stock reaches its production potential. As it is used in Tana/Teno, the spawning target is analogous to NASCOs conservation limit.

2 Salmon stock monitoring

Monitoring of the salmon stocks in the Tana/Teno started back in the 1970s and is based on long-term surveys carried out and funded jointly by Finnish and Norwegian research bodies and authorities. The long-term monitoring programme with the longest time series includes:

- Catch and fishery statistics (present form since 1972)
- Catch samples (since 1972)
- Estimating the juvenile salmon abundances at permanent sampling sites (since 1979)

Following the NASCOs Precautionary Approach and Decision Structure, the need for a closer and more detailed monitoring of the mixed-stock fisheries has become evident. Therefore, several monitoring programmes for individual tributaries have been established in later years.

Monitoring activities that have been at use for a shorter period include counting of:

- Ascending adult salmon and descending smolts by a video array in Ohcejohka/Utsjoki (since 2002) and Lákšjohka (since 2009)
- Spawning adult salmon by snorkelling in three tributaries (Áhkojohka/Akujoki, Buolbmátjohka/Pulmankijoki, since 2003 and Njiljohka/Nilijoki, since 2009)
- Ascending adult salmon by a sonar in Kárášjohka (in 2010, 2012, 2017-2018)

These fish counts have provided useful information on tributary-specific salmon abundance and diversity. In addition, counts of adult salmon combined with catch data have been used in estimating compliance with the tributary-specific spawning targets (see chapter 3).

Fish counts have also been carried out at some tributaries in single years, e.g. Váljohka (video, 2015 and some snorkelling counts), Veahčajohka/Vetsijoki (sonar+video, 2016) and Anárjohka/Inarijoki (sonar+video, 2018). These pieces of information have also been useful as reference levels for estimating the stock status, which in most years make use of catch data only. In 2018 sonar counting of ascending salmon was also launched in the Tana/Teno main stem, at Polmak, c. 55 km from the river mouth. This data set is valuable, enabling estimation of the total salmon run to the Tana/Teno system (upstream of the sonar site).

A brief overview of the current monitoring activities and their recent results is presented below.

2.1 Catch sampling

Catch samples (i.e. scale samples) have been collected since 1972 with the aim of covering the river system, different fishing gears and user groups, and the fishing season as well as possible. Dozens of local fishermen using traditional netting methods and rods, and many tourist outfitters collecting samples from their clients have participated in sample collection over the years. The samplers have been equipped with standard measuring boards (length) and scales (weight) and carefully instructed to carry out the sampling. Samples reveal the distributions of salmon size, sex and age in catches, and the distinction between wild salmon and escaped farmed fish. The scales are used primarily for age and growth analyses, but recently also for other purposes, such as stock identification by genetic analyses and stable isotope studies.

Scale sampling in 2018 resulted in 3042 salmon samples, which was significantly more than in 2017 (Figure 1). The reason behind the increase in sample numbers was probably due to higher abundance of 1SW salmon ascending the Tana/Teno system and favourable fishing conditions compared to 2017.

Based on scale reading the proportion of escaped farmed salmon among the samples have varied between 0 and 0.6 %, the long-term average (1985-2018) being 0.20 %. In 2018 the proportion was 0.07 %.

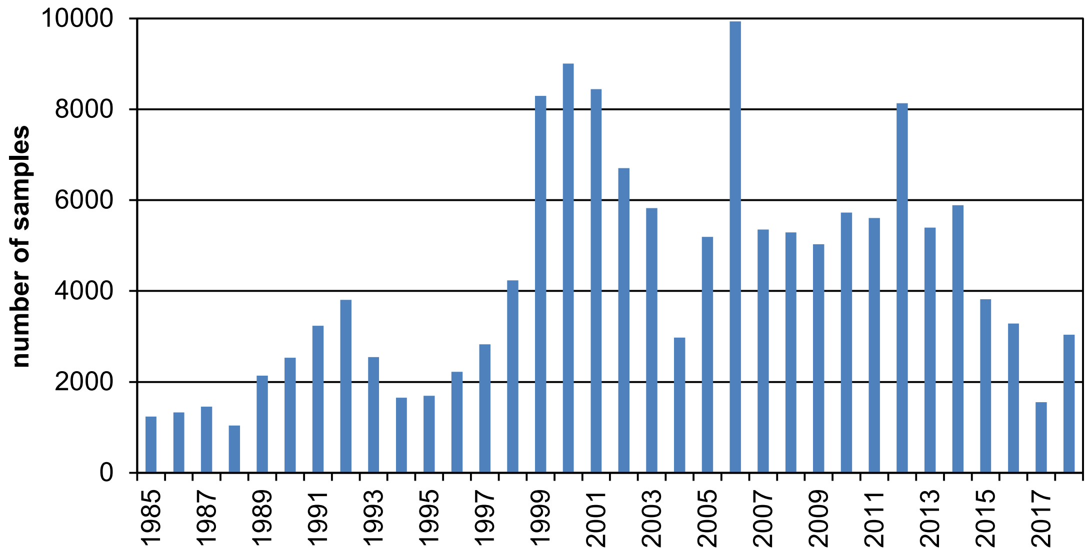


Figure 1. Number of salmon scale samples collected annually from the Tana/Teno system in 1985-2018.

2.2 Catch and fishery statistics

Catch statistics have been systematically collected since early 1970s with some amendments in methods over the years. Major changes include the introduction of mandatory log books for fishers in Norway in 2004 and mandatory catch reporting in Finland since 2017.

The estimated total salmon catch in 2018 was the lowest in the time series, c. 49 tons in total, which equals to c. 15 600 salmon (Figure 2). The Finnish catch was 43 % (21 t) and Norwegian catch 57 % (28 t) of the total catch. The rather low salmon catches in 2017-2018 are partly explained by the new Tana/Teno fishing agreement, which has considerably reduced the fishing effort in both countries.

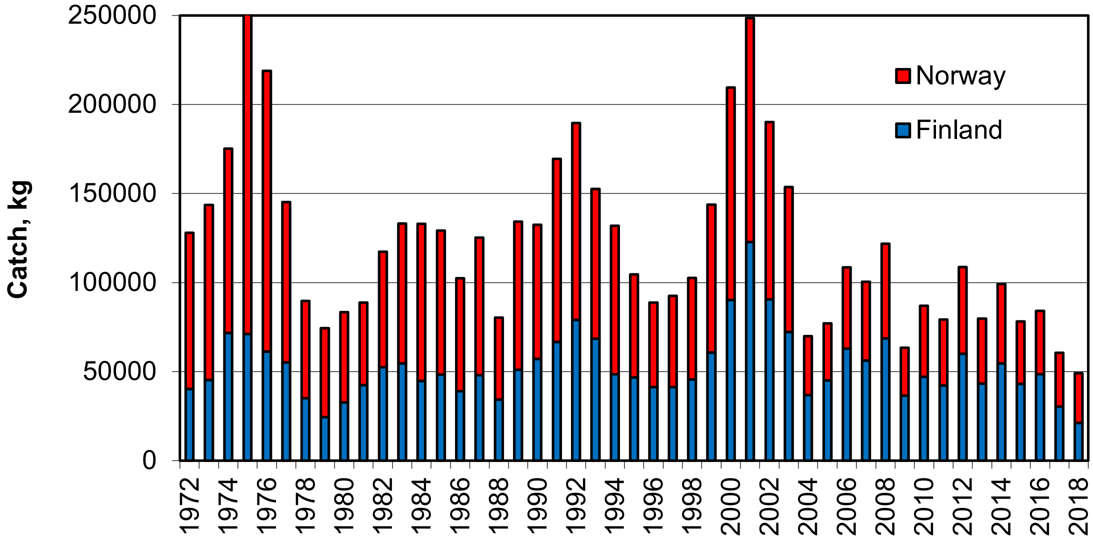


Figure 2. Estimated total salmon catch (kg) in the Tana/Teno river system in Norway and Finland in 1972-2018.

In 2018 catches of small 1SW salmon increased considerably from previous year and they constituted c. 74 % of the salmon catch in numbers. There was also an increase in numbers of repeat spawners (PS), and their proportion of the catch was 9% (Figure 3). Instead, numbers of large 2-4SW salmon decreased from previous year (Figure 3). Together they constituted only 17% of the catch in numbers. There is a long-term decreasing trend in catches of large salmon, 3-5SW fish (Figure 3).

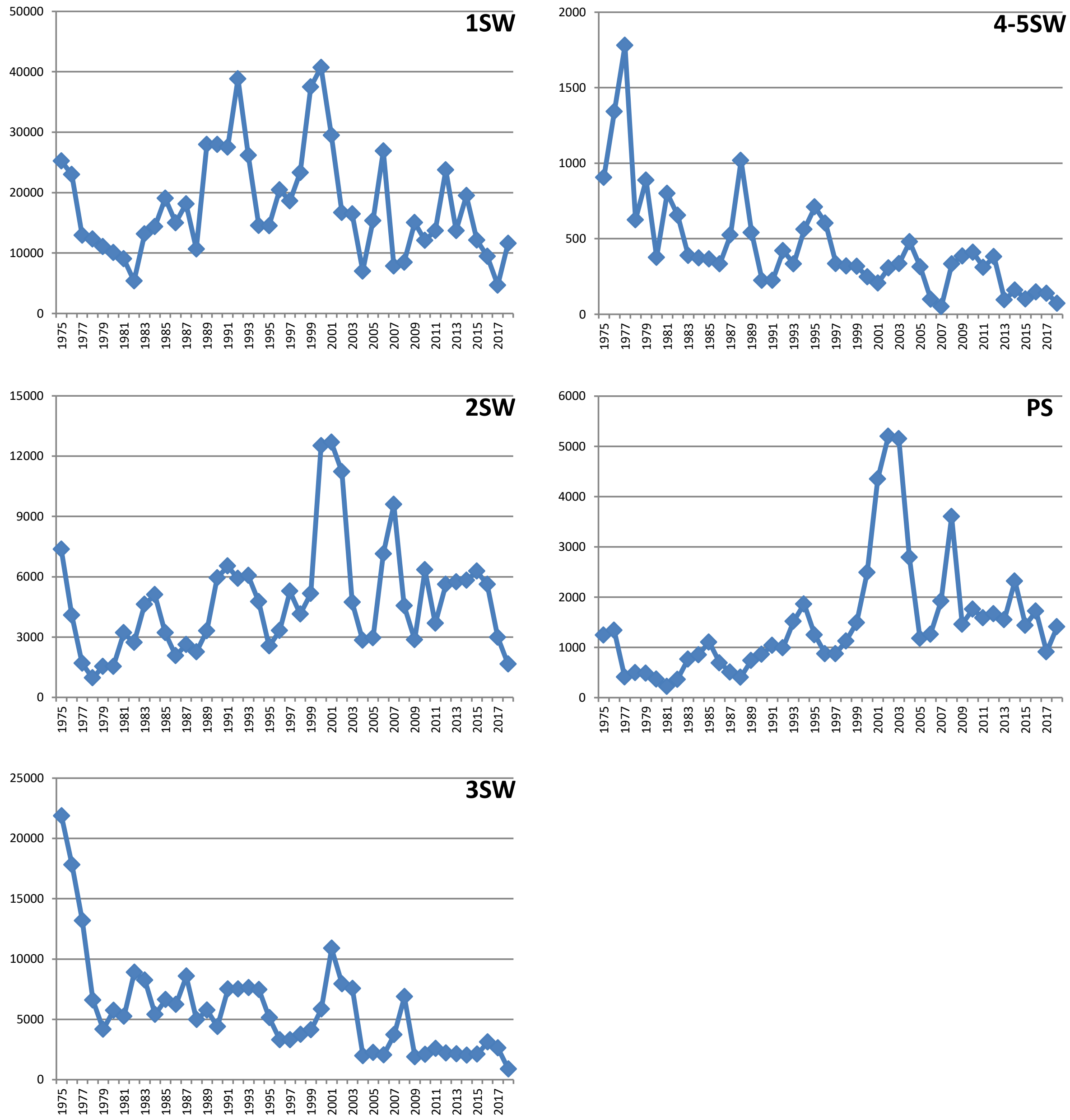


Figure 3. Estimated total salmon catch (number of fish) of different sea-age groups (SW) in the Tana/Teno river system in the years 1975-2018. Note the different scales in vertical axes (PS=previous spawners).

In addition to catch statistics, yearly information on number of fishers and fishing licences have been collected that provide a good measure of fishing effort especially for the recreational tourist fishing, but to some extent also for local fishing.

Because of the new fishing agreement in 2017, the numbers of tourist licences sold for the Tana/Teno main stem and Anárjohka/Inarijoki in Finland in 2017-2018 decreased dramatically from the earlier years, being 10 567 day licences and 2 586 fishers in 2018 (Figure 4). In Norway, a total of 5 994 tourist fishing days were sold for the border reach of the Tana/Teno main stem and Anárjohka/Inarijoki in 2018. Additionally, 1 039 fishing days were sold for the Norwegian lower Tana area. There has been a clear increase in tourist fishing days in Norway since the new agreement.

The number of local fishermen in Finland was 505 in 2018, being clearly less than the average figure over the previous five years (703). In Norway, a total of 1 452 local fishermen bought licences in 2018.

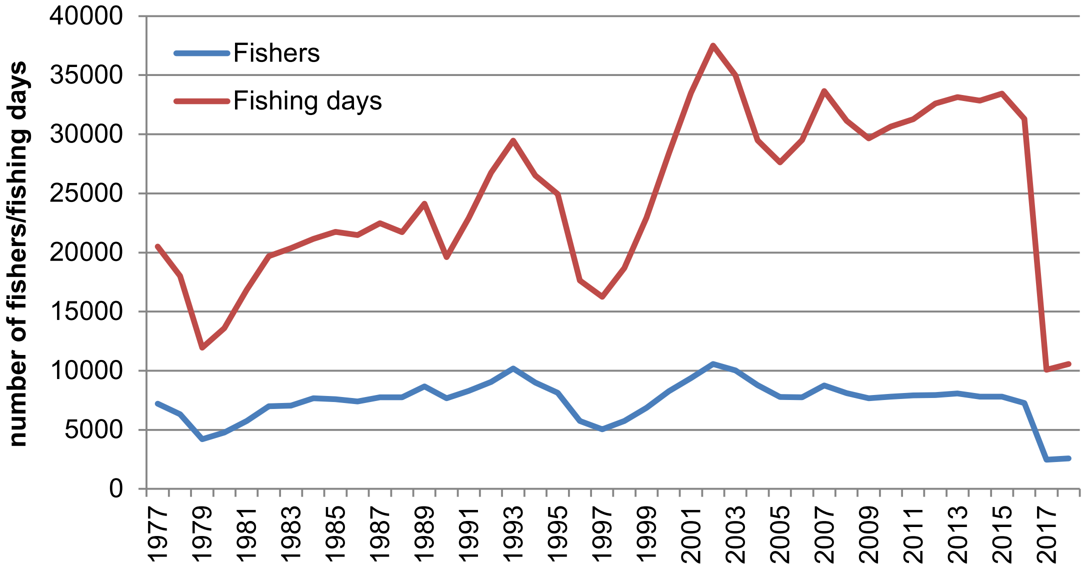


Figure 4. Number of tourist fishers (blue) and daily fishing licences (red) in the Tana/Teno river system on the Finnish side in 1977-2018.

2.3 Juvenile salmon monitoring

The juvenile salmon densities are estimated in a long-term monitoring programme started in 1979. This programme includes 32 sampling sites in the Tana/Teno mainstem, 12 in the Ohcejohka/Utsjoki and 10 in the Anárjohka/Inarijoki. Each site has been fished with standardized methods once a year in a strict rotation, so that the fishing took place on almost the same date in successive years. Although the juvenile salmon abundance is not used directly in assessing stock status for individual populations (chapter 3), information on juvenile abundance is still an important index of spatial distribution of spawning and juvenile production and its yearly variation.

The juvenile salmon densities in the main stem and two large tributaries appear to fluctuate with no apparent clear trend, although the densities of salmon fry (0+) in Anárjohka/Inarijoki and Ohcejohka/Utsjoki have been somewhat higher in recent years than before. However, in Ohcejohka/Utsjoki rather low densities of both salmon fry and older parr (≥1+) were observed in 2018 (Figure 5). Not all the electrofishing sites were covered in 2018 because of lack of permission from one Finnish fishing right owners association to conduct the monitoring. In the Tana/Teno main stem electrofishing was conducted in 26/32 sites in 2018, and in Anárjohka/Inarijoki electrofishing was done in 8/10 sites. However, in Ohcejohka/Utsjoki all the sampling sites (12) were surveyed in 2018 (Figure 5).

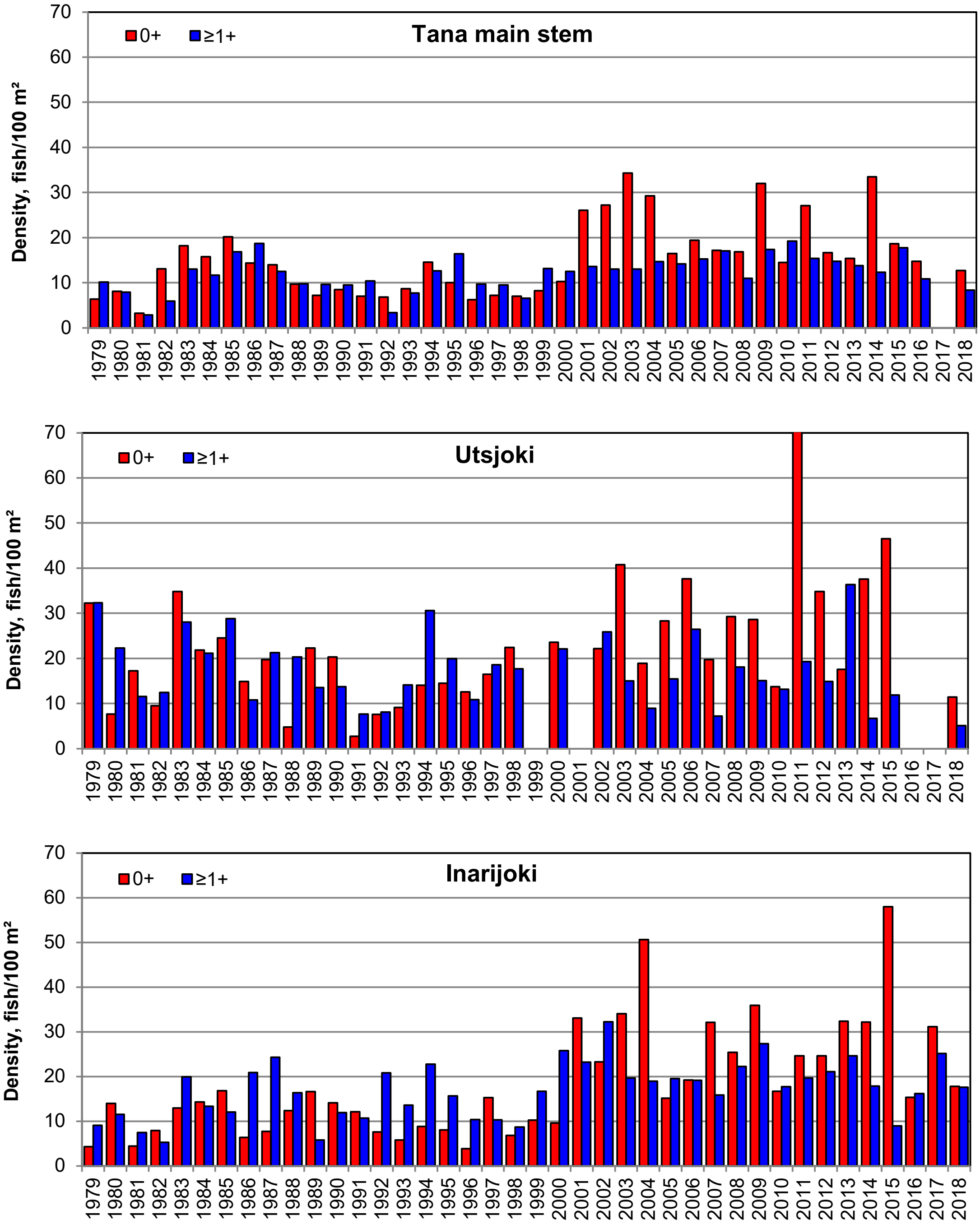
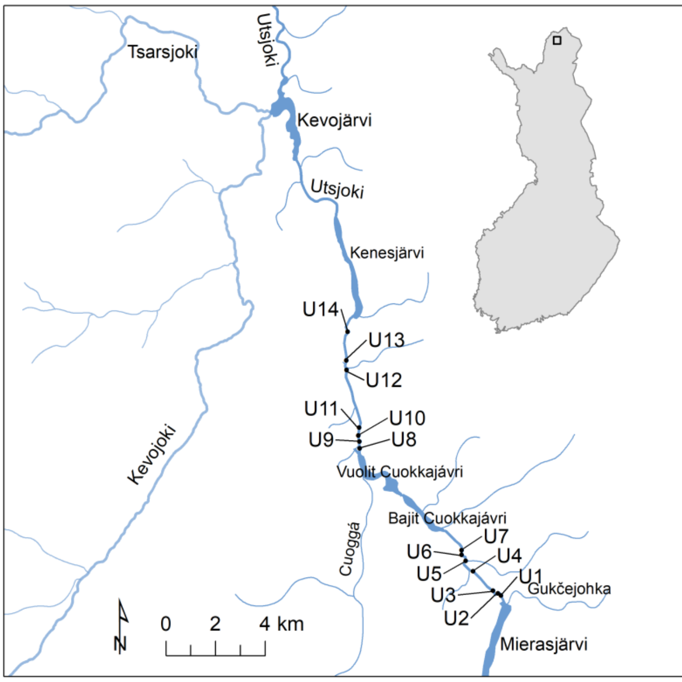


Figure 5. Juvenile salmon densities (fish/100m^2; one pass) at permanent electrofishing sites in the rivers Tana/Teno, Anárjohka/Inarijoki and Ohcejohka/Utsjoki in the years 1979-2018.

In addition to the electrofishing of long-term monitoring sites, a survey in the upper Ohcejohka/Utsjoki main stem was conducted in 2018 including 14 sampling sites (Figure 6). The aim of this electrofishing was to get an updated overview on the juvenile densities in the Upper Ohcejohka/Utsjoki area, where salmon spawning population is estimated to be or have been rather low. The juvenile densities in the upper Ohcejohka/Utsjoki were surprisingly high compared to the densities in the permanent monitoring sites of Ohcejohka/Utsjoki in 2018 (see Figures 5 and 6). The densities within the permanent sites were, however, among the lowest in the time series (Figure 5), partly because of a fast water level increase during the survey.



Upper Utsjoki

Sampling site	2018	
	0+	≥1+
U1	4.8	0.0
U2	2.8	1.4
U3	0.0	0.9
U4	19.2	7.2
U5	2.8	9.7
U6	16.2	12.9
U7	30.2	11.0
U8	11.8	6.7
U9	39.1	7.5
U10	6.3	3.8
U11	20.8	1.4
U12	22.9	10.4
U13	25.0	12.5
U14	2.4	21.2
Mean density	**14.6**	**7.6**

Figure 6. Juvenile salmon densities (fish/100m^2; one pass) in the upper Ohcejohka/Utsjoki area between Mierasjärvi and Kenesjärvi in 2018.

2.4 Adult salmon counting

Counting of adult salmon ascending the tributaries or being present at spawning areas has been carried out in several tributaries of the Tana/Teno using multiple methods, including video monitoring, sonar counts and snorkelling counts (Figure 7).

In 2018 adult salmon counts were performed at the following sites: Tana/Teno main stem (sonar), Lákšjohka (video), Ohcejohka/Utsjoki (video), Anárjohka/Inarijoki (sonar), Kárášjohka (sonar), Gáregasjohka/Karigasjoki (video), Buolbmátjohka/Pulmankijoki (snorkelling), Njiljohka/Nilijoki (snorkelling) and Áhkojohka/Akujoki (snorkelling).

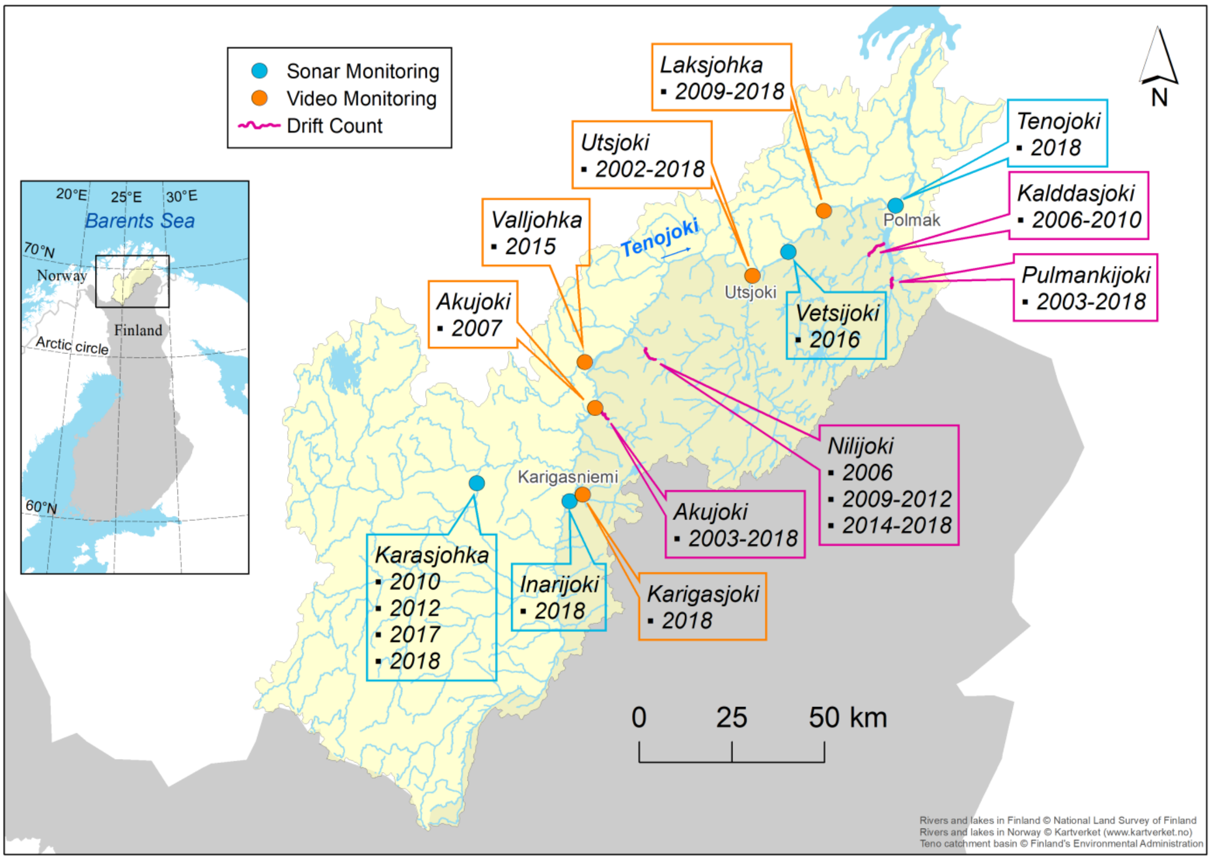


Figure 7. Map of the Tana/Teno river system indicating the most important adult salmon counting sites and counting methods between 2002 and 2018.

2.4.1 Long-term video monitoring

Monitoring of ascending adult salmon and descending smolts has been conducted in Ohcejohka/Utsjoki since 2002 by an array of eight video cameras below the bridge close to the river mouth (Orell et al. 2007). Numbers of ascending salmon have varied between 1 300 and 6 700 over the years (Figure 8). In 2018 the counting was performed successfully in good environmental conditions. The adult salmon run estimate in 2018 is c. 4 750 individuals (Figure 8), which is clearly more than the long-term average of 3 580 individuals. Preliminary estimated proportions of 1SW, 2SW and MSW salmon were 66%, 33% and 1%, respectively.

Monitoring of ascending adult salmon and descending smolts has been conducted in Lákšjohka since 2009 by an array of four video cameras close to the river mouth. Numbers of ascending salmon have varied between 255 and 1 086 over the years. In 2018 the counting was performed successfully in good monitoring conditions. The adult salmon run in 2018 was 559 individuals (Figure 8), a little less than long-term average (617). Estimated proportions of 1SW and 2SW salmon was 86% and 14%, respectively.

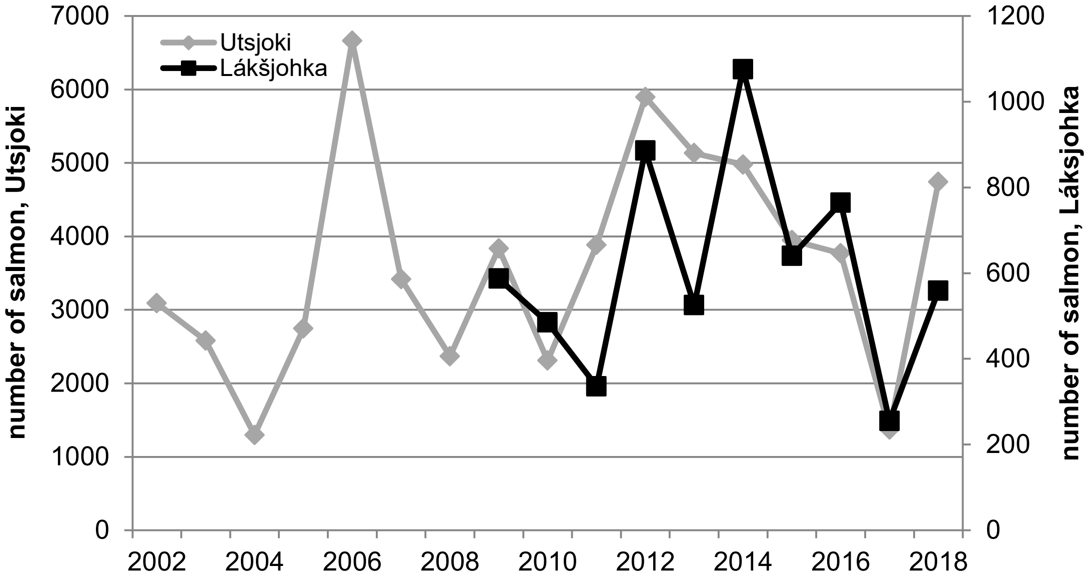


Figure 8. Video counts of ascending adult salmon at the video monitoring sites in the Ohcejohka/Utsjoki and Lákšjohka in 2002-2018. Sea age groups are combined. Note: the data in 2017 is not fully comparable to other years because of challenging environmental conditions affecting the count accuracy in both locations. The Ohcejohka/Utsjoki 2018 adult count is an estimate, as a small fraction of the data is still being analysed when writing this report.

2.4.2 Snorkelling counts

Salmon spawners have been counted by snorkelling on a yearly basis in rivers Áhkojohka/Akujoki and Buolbmátjohka/Pulmankijoki since 2003 (Figure 9). In Áhkojohka/Akujoki, the counting area covers the entire salmon production area below an impassable waterfall, whereas a stretch of 4 km in the central spawning areas of the Buolbmátjohka/Pulmankijoki has been snorkelled every year. In addition, counts have been conducted in shorter time spans or individual years in some other small tributaries as well; the best data is available from the river Njiljohka/Nilijoki, where a 5 km stretch on the upper reaches has been counted almost annually since 2009 (Figure 9).

The number of spawning salmon has varied between 38 and 171 in Áhkojohka/Akujoki, between 34 and 215 in Buolbmátjohka/Pulmankijoki and between 63 and 216 in Njiljohka/Nilijoki (Figure 9). In 2018 the numbers of spawning salmon increased substantially compared to previous year, reaching all-time high in the Njiljohka/Nilijoki (Figure 9). Most of the salmon observed in 2018 were small 1SW fish and numbers of larger 2SW salmon decreased considerably from 2017.

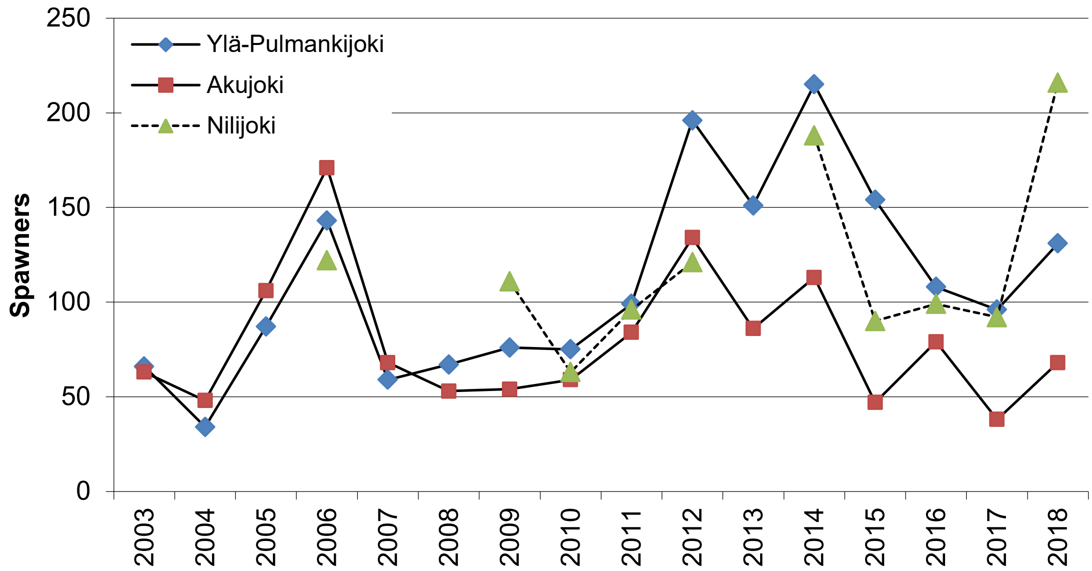


Figure 9. Snorkelling counts of spawning salmon in the rivers Buolbmátjohka/Pulmankijoki, Áhkojohka/Akujoki and Njiljohka/Nilijoki in 2003-2018. Sea-age groups are combined.

2.4.3 Sonar and video counts

Echosounders or sonars have been used in counting the ascending salmon at some tributaries of the Tana/Teno in certain years, but long-term time series have not been established so far. In 2018 sonar counts were performed in Kárášjohka, in the Tana/Teno main stem and in Anárjohka/Inarijoki. Additionally, video monitoring with a new Simsonar stereo camera system were tested in Gáregasjohka/Karigasjoki, a tributary of Anárjohka/Inarijoki, in 2018.

In the sonar data, a minimum size for fish considered a salmon was 45 cm for the Tana/Teno and Anárjohka/Inarijoki and 47.5 cm for Kárášjohka. This cutting point was chosen to account for other fish species like grayling and sea trout, which are mostly smaller than these lengths. In addition, species distribution (proportion of salmon) were estimated based on nearby catch information, e.g. the distribution of rod catches in the Norwegian Tana bru-Lákšjohka area was used for the Tana/Teno main stem data.

In the River Kárášjohka, sonar technology to count ascending salmon has been used in 2010, 2012, 2017 and 2018. The counting site is in Heastanjárga, close to the bridge (69 23’50’’N, 25 08’40’’E). The Kárášjohka counting has been conducted by one sonar unit and with different types of guiding fences. In recent two years the monitored river width has been c. 35 m.

In total 3 730 salmon were estimated to pass the sonar counting site in Kárášjohka between 1.6. and 3.9. (Figure 10). It is obvious that some salmon migrated past the counting site also before and after the survey period, but their proportion is estimated to be rather small. It should be acknowledged, however, that large MSW salmon are the earliest migrants in the Tana system and some of these large fish may have been ascending during the latter half of May before the counting started. The most intensive salmon migration occurred during the first three weeks of July, the peak occurring at 6th of July (Figure 10).

The length distribution data of salmon passing the sonar site indicated that 57% of salmon were <65 cm fish, 35% were fish between 65 and 90 cm and 8% were fish ≥90 cm. The length distribution data includes some uncertainty because of a rather long sonar window used in the survey.

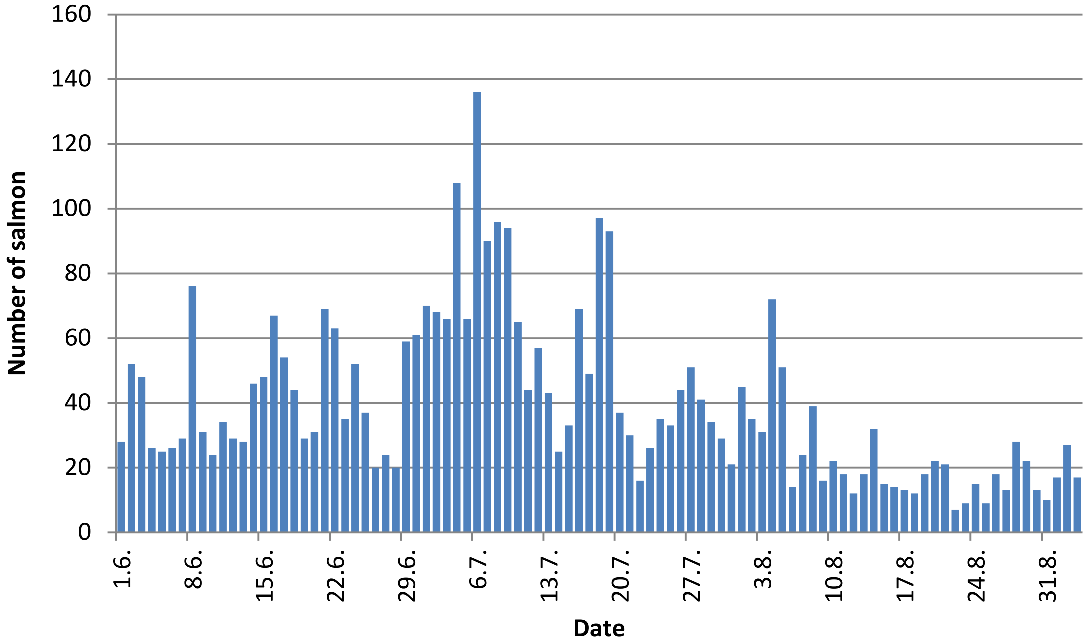


Figure 10. Estimated daily numbers of ascending salmon (≥47,5 cm) in the Kárášjohka sonar count in 1.6.-3.9.2018. All size categories are combined. The estimate of the total ascendance through the site was 3 730 salmon.

The Kárášjohka run size in 2018 was the largest observed within the four counting seasons (Table 1). It indicates that more salmon entered the river compared to other years. However, the counting in 2018 was slightly longer than in other years and it was conducted with optimal equipment and in good environmental conditions, which was not the case in all earlier years.

Table 1. Sonar counts of ascending salmon in the Kárášjohka in 2010, 2012, 2017 and 2018.

Time period	1SW	MSW	All	Note	Equipment
9.6.-31.8.2010	1016	661	1677	Missing time estimated	Didson
6.6.-27.8.2012	1038	1589	2627	Missing time not estimated	Simsonar
7.6.-31.8.2017	371	492	863	Missing time not estimated	Aris/Simsonar
1.6.-3.9.2018	2117	1613	3730	Missing time not estimated	Aris

A pilot sonar survey was conducted in the Tana/Teno main stem, at Polmak, c. 55 km from the river mouth in 2018 (Figures 11-12). The aim of this survey was to estimate the total salmon run of the Tana/Teno at this 130 m wide site. Two sonars units were used, one on each shore. By using guiding fences on both shores the width of the river was narrowed to c. 100 m, out of which the two sonars covered c. 80 m (Figures 11-12). Salmon run through the unmonitored area (20 m) was estimated based on the data from the two sonars. Species distribution (proportion of salmon) of the sonar count was estimated based on the distribution of rod catches in the Norwegian Tana bru-Lákšjohka area.

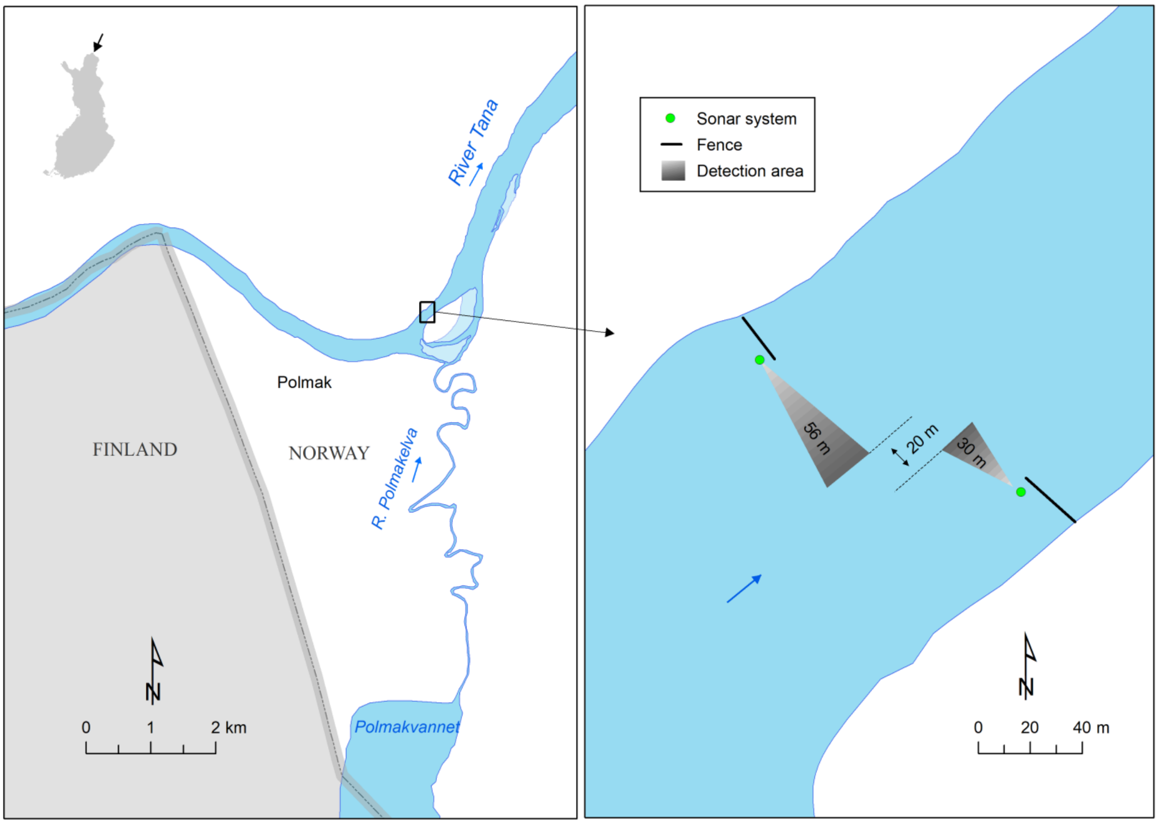


Figure 11. Map of the Tana/Teno main stem sonar counting site including the locations of the sonar units and guiding fences. The map also shows the c. 20 m wide unmonitored area.

Figure 12. An aerial photo from the Tana/Teno main stem sonar counting site at Polmak. The sonar units within the green ovals were used in producing the salmon run estimate. Flow direction is indicated by the red arrow. Photo: Jari Lindeman (Luke).

In total 32 500 salmon were estimated to pass the sonar counting site at Polmak between 1.6. and 31.8. (Figure 13). It is obvious that some salmon migrated also before and after the counting period, but their proportion is estimated to be rather small. It should be acknowledged, however, that large MSW salmon are the earliest migrants in the Tana system and some of these large fish may have been ascending during the latter half of May before the counting started. The most intensive salmon migration occurred between mid-June and early August, with peak migration in late June (Figure 13).

The length distribution data of salmon passing the sonar site indicated that 62% of salmon were <65 cm fish, 32% were fish between 65 and 90 cm and only 6% were fish ≥90 cm. The length distribution data is, however, based on only one sonar unit and it includes considerable uncertainty because of a long sonar window used.

The Tana/Teno main stem sonar count, in addition to giving the total salmon run size, allows estimating exploitation rates for the main stem. These numbers also improve total exploitation estimates for the tributary populations. This first year of sonar monitoring indicates that this provides valuable information for stock status evaluation.

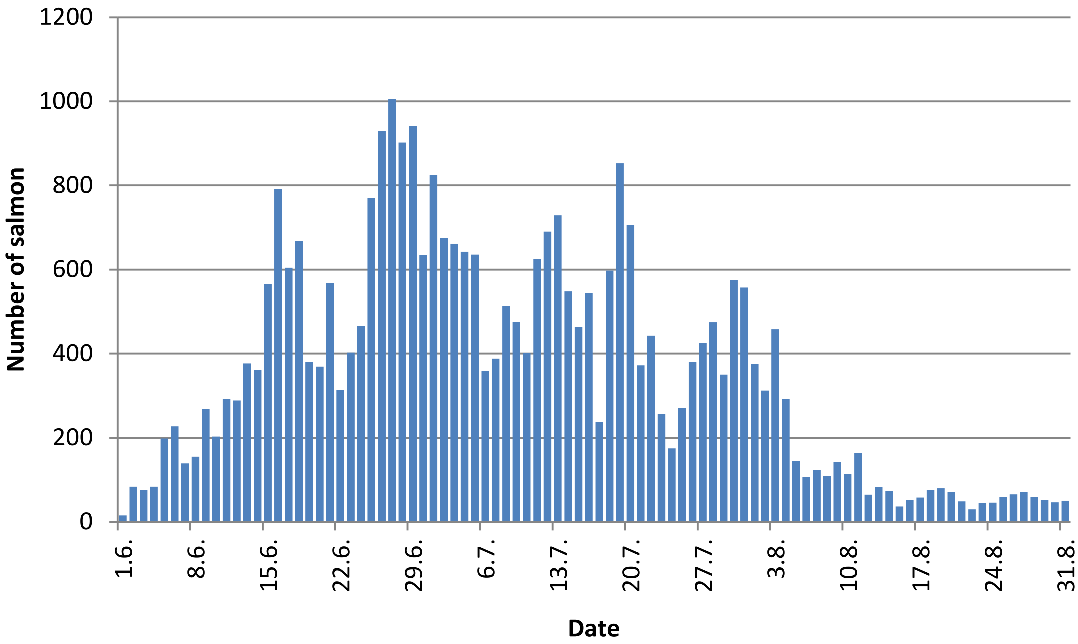


Figure 13. Estimated daily numbers of ascending salmon (≥45 cm) in the Tana/Teno main stem sonar count at Polmak in 1.6.-31.8.2018. All size categories are combined. The estimate of the total run through the site was 32 500 salmon.

A pilot sonar survey was also conducted in the Anárjohka/Inarijoki, just above the Gáregasjohka/Karigasjoki confluence, c. 220 km upstream from the Tana/Teno river mouth (Figure 14). One sonar unit was placed to the river, pointing from the Norwegian side to the Finnish side. Guiding fences were installed on both shores to narrow the river for accurate sonar monitoring (Figure 14). The sonar window fully covered the narrowed river (c. 25 m). Species distribution (proportion of salmon) of the sonar count was estimated based on data from four underwater cameras installed at the sonar counting line.

In total 2 850 salmon were estimated to pass the sonar counting site in Anárjohka/Inarijoki between 26.5. and 10.9. (Figure 15). The most intensive salmon migration occurred in July and early August with the highest peak taking place on 4th August. The migration continued clearly to September and probably also continued after the counting period (Figure 15). In addition to salmon a considerable amount of sea trout ascended to Anárjohka/Inarijoki.

The length distribution data of salmon passing the sonar site indicated that 78% of salmon were <65 cm fish, 20% were between 65 and 90 cm and only 2% were fish ≥90 cm.

Figure 14. An aerial photo from the Anárjohka/Inarijoki sonar counting site, just above the confluence of the Gáregasjohka/Karigasjoki. The sonar unit is located inside the green oval pointing to right. Flow direction is indicated by the red arrow. Photo: Jari Lindeman (Luke).

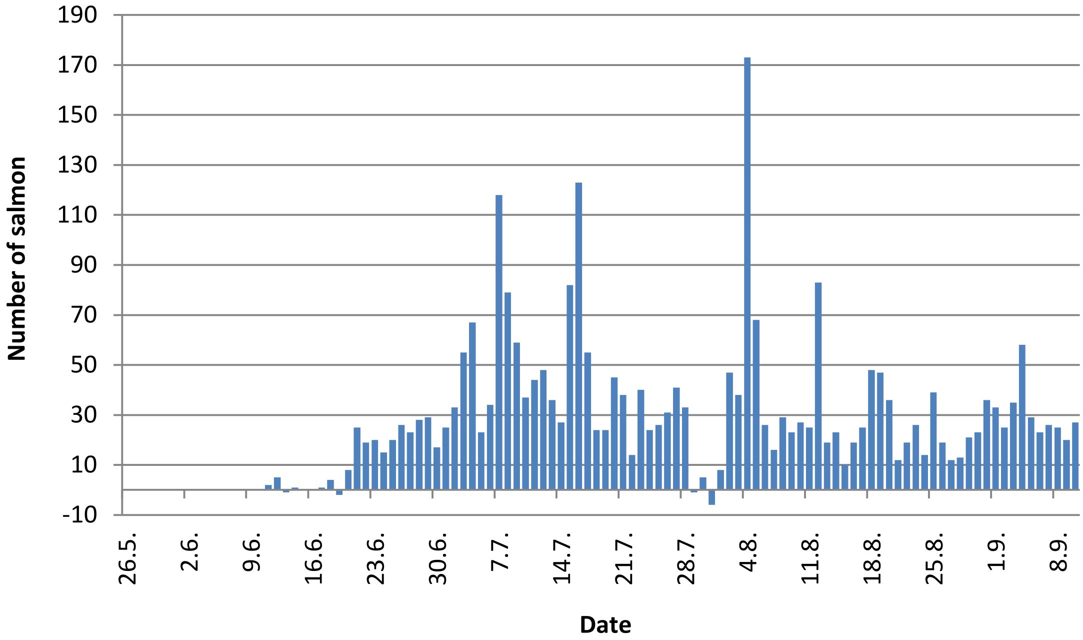


Figure 15. Estimated daily numbers of ascending salmon (≥45 cm) in the Anárjohka/Inarijoki sonar count in 26.5.-31.8.2018. All size categories are combined. The estimate of the total number of salmon was 2 848 salmon.

3 Status assessment

3.1 Tana/Teno main stem

The Tana/Teno main stem starts with the confluence of Kárášjohka and Anárjohka/Inarijoki, from which the main stem flows 211 km in a northern direction towards the Tana fjord.

3.1.1 Status assessment

The spawning target for the Tana main stem (MS) salmon stock is 41 049 886 eggs (30 787 415-61 574 829 eggs). The female biomass needed to obtain this egg deposition is 22 189 kg (16 642-33 284 kg) when using a stock-specific fecundity of 1 850 eggs kg^{-1}.

The following basic formula estimates the annual spawning stock size for Tana MS stock:

*Spawning stock size = ((Catch / Exploitation rate) - Catch) * Female proportion*

The data input for the variables in this formula are summarized in Table 2. Female proportions in Table 2 in the years 2006-2008 and 2011-2012 are based on Tana main stem stock-identified samples from the Genmix project, while female proportions in other years are based on the size composition of the main stem catch and the 5-year Genmix average female proportion of different size groups.

We have no spawning stock counts from the main stem before 2018, so the exploitation estimates for the prior years must be based on other sources of information. Based on a combination of the 5 years of comprehensive genetic stock identification of main stem samples and fish counting, it is possible to set up a model that estimates the proportion of catches of different stocks in various parts of Tana. Back-calculating then from spawning stock estimates and tributary catches, we can obtain estimates of pre-fishery abundances and stock-specific exploitation rates in the main stem. The main stem exploitation estimates range from around 20 % for the lowermost tributaries (Máskejohka, Buolbmátjohka/Pulmankijoki) up to 60 % for the stocks located in the main headwater rivers. The latter salmon must pass the full length of the Tana main stem before reaching their respective home rivers and therefore likely provide an accurate estimate of the main stem exploitation experienced by the Tana MS stock. An exploitation rate of 60 % was therefore selected for the Tana MS stock for the years 2006-2016. For 2017, monitoring results indicated that the new fishing rules had reduced exploitation by approximately 10 %, and the main stem exploitation rate estimate was therefore set to 55 %. For 2018, the combined information from the main stem and tributary counting indicate a further reduced exploitation rate, and the exploitation estimate for 2018 was therefore set to 40 %, representing a 33 % reduction in exploitation with the implementation of a new agreement (Table 2).

To account for uncertainty, the exploitation rate and female proportion estimates in Table 2 were treated as modal values, with a 20 % uncertainty used to estimate minimum and maximum values of exploitation and 10 % uncertainty used for female proportions. The modal, minimum and maximum values were then used to construct a triangular probability distribution for exploitation and female proportion, and these distributions in combination with catches result in triangular probability distributions for the spawning stock estimates. A similar triangular probability distribution was constructed for the spawning target, using 22 189 kg as the mode, 16 642 kg as the minimum and 33 284 kg as the maximum value.

A Monte Carlo simulation with 10 000 iterations was then used to compare the spawning stock distribution with the spawning target distribution. For each iteration, one number is randomly drawn from the spawning stock distribution and one number drawn from the spawning target distribution.

The average extent that the spawning stock distribution exceeds the spawning target distribution becomes the spawning target attainment. The proportion of the iterations where the random spawning stock size exceeds the random spawning target becomes the probability that the stock had enough spawners.

Table 2. Summary of stock data used to estimate annual spawning stock sizes of the Tana MS stock.

Year	Total main stem catch (kg)	Tana MS proportion	Tana MS catch (kg)	Exploitation rate	Female proportion
2006	88 873	0.44	38 731	0.60	0.47
2007	88 443	0.44	39 298	0.60	0.62
2008	104 659	0.58	60 907	0.60	0.63
2009	53 450	0.47	24 945	0.60	0.50
2010	75 340	0.47	35 161	0.60	0.53
2011	68 256	0.49	33 457	0.60	0.52
2012	91 636	0.38	34 550	0.60	0.51
2013	68 344	0.47	31 896	0.60	0.53
2014	83 312	0.47	38 881	0.60	0.51
2015	65 287	0.47	30 469	0.60	0.55
2016	72 814	0.47	33 982	0.60	0.57
2017	52 880	0.47	24 679	0.55	0.61
2018	42 021	0.47	19 611	0.40	0.49

The spawning target attainment was 68 % in 2018 and the probability for meeting the spawning target was 2 %. The management target was not reached, as the last 4 years' (2015-2018) overall probability of reaching the spawning target was 1 % with an overall attainment of 57 % (Figure 16).

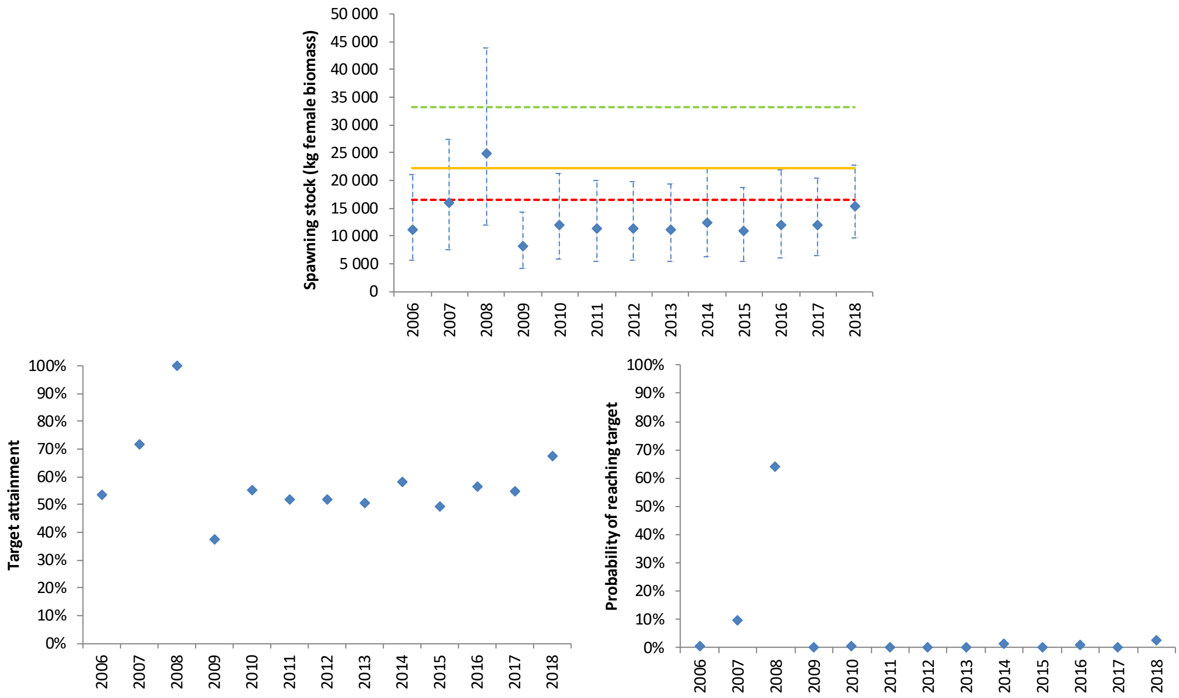


Figure 16. The estimated spawning stock (top row), percent truncated spawning target attainment (bottom row, left) and probability of reaching the spawning target (bottom row, right) in the period 2006-2018 for the Tana MS stock.

3.1.2 Exploitation

The estimated total exploitation rate (based on weight) of Tana MS salmon was 63 % in the years 2015-2018 (Figure 17), with 19 % of the pre-fishery abundance caught in coastal fisheries and 44 % in main stem fisheries. The average estimated total pre-fishery abundance for Tana MS salmon was 61 678 kg and the average total catch was 38 717 kg in the period 2015-2018.

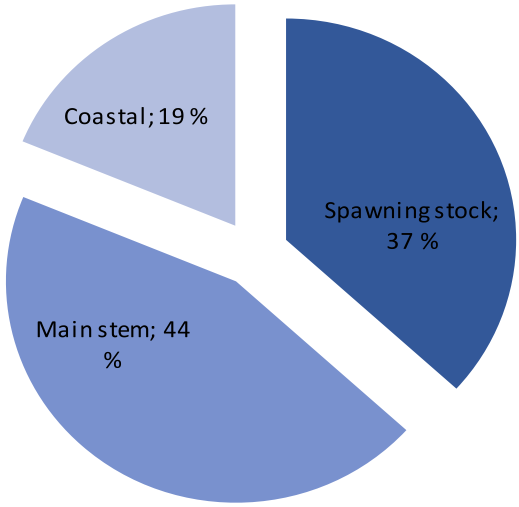


Figure 17. The total amount of salmon belonging to Tana MS in 2015-2018, distributed into surviving spawning stock and salmon caught in fisheries in either coastal or main stem fisheries. The percentages in the figure represent the proportion of the pre-fishery abundance that survives to spawning or are caught in coastal or main stem fisheries.

Estimated relative exploitation efficiencies (based on weight) in areas in various periods are given in Table 3.

Table 3. Relative exploitation rates of Tana MS salmon in different areas (based on weight) in three periods. First column is the years 2015-2018, corresponding to the management target-period. Second column is the years 2006-2016, corresponding to the years with available data before the new agreement. The third column is 2018, the most recent year and the first year with good monitoring data after the new agreement.

	2015-2018	2006-2016	2018
Coastal	19 %	18 %	20 %
Main stem	54 %	61 %	38 %

The relative exploitation efficiencies represent the proportion of surviving salmon that are caught in an area. So, for instance, the main stem efficiency estimate is the estimated main stem catch of Tana MS salmon divided by the estimated amount of salmon that have survived the coastal fisheries.

In the years 2015-2018, overexploitation varied between 31 % (2018) and 51 % (2015). The average overexploitation was estimated at 44 %. This means that exploitation on average was responsible for reducing the spawning stock size by an amount of 44 % below the spawning target. Maximum sustainable exploitation varied between 29 % (2018) and 43 % (2016). The average maximum sustainable total exploitation rate in the period was 34 %, significantly lower than the estimated average total exploitation of 63 %.

3.1.3 Stock recovery

In the previous report (Anon. 2018), we advised a 19 % reduction in the total river exploitation rate of Tana MS salmon from the 2006-2016 level in order to achieve stock recovery over two generations. The current evaluation shows that exploitation has been reduced from 61 to 38 %, which corresponds to a 38 % reduction in exploitation. The stock recovery model indicates that this level of reduction is sufficiently high to allow for stock recovery after one generation.

3.2 Máskejohka

Máskejohka is the lowermost major tributary in the Tana River system, entering the Tana approximately 28 km upstream from the Tana estuary. It is a middle-sized river with a total of 55 km available for salmon of which 30 km constitutes the main Máskejohka. The lowermost 10 km of the main river is slow-flowing and meandering with very little production area available for salmon, but there are extensive areas available both for spawning and juvenile production further upstream. The rest of the Máskejohka-system consists of the tributaries Geasis (7 km), Uvjalátnjá (7 km) and Ciikojohka (11 km). In these smaller tributaries, salmon distribution is limited upwards by waterfalls. The Máskejohka salmon stock has a mixture of sea-age groups, mostly 1-3SW and a few 4SW.

3.2.1 Status assessment

The spawning target for Máskejohka is 3 155 148 eggs (2 281 583-4 149 588 eggs). The female biomass needed to obtain this egg deposition is 1 521 kg (1 100-2 000 kg) when using a stock-specific fecundity of 2 075 eggs kg^{-1}.

The following basic formula estimates the annual spawning stock size for Máskejohka:

*Spawning stock size = ((Catch / Exploitation rate) - Catch) * Female proportion*

The data input for the variables in this formula are summarized in Table 4. Female proportions in Table 4 in the years 2006-2008 and 2011-2012 are based on Tana main stem stock-identified samples from the Genmix project, while female proportions in the other years are based on the size composition of the catch and the 5-year Genmix average female proportion of different size groups.

Ascending salmon have not been counted so far in Máskejohka, so the exploitation estimates must be based on other sources of information. In a comprehensive analysis of 214 historical estimates of exploitation rates from 40 river systems, a pattern was revealed of different exploitation rates among salmon weight classes and among rivers of various size and a table of standardized exploitation estimates were established (Forseth et al. 2013). Máskejohka is a medium-sized river, and historically there have been a relatively high number of fishermen and few restrictions in the river. Based on the exploitation rate table in Forseth et al. (2013) summarizing national Norwegian exploitation rate patterns, we selected 50 %, 40 % and 30 % as exploitation estimates for the three size-groups of salmon in the first years of the assessment (Table 4). Decreasing numbers of fishermen lead us to subtract 5 % from the exploitation estimates in 2013 and a further 5 % in 2015. We reduced the exploitation rates by 10 % in 2017 and 2018 due to the new fishing regulations that were put in place in 2017 (Table 4).

To account for uncertainty, the exploitation rate and female proportion estimates in Table 4 were treated as modal values, with a 20 % uncertainty used to estimate minimum and maximum values of exploitation and 10 % uncertainty used for female proportions. The modal, minimum and maximum values were then used to construct a triangular probability distribution for exploitation and female proportion, and these distributions in combination with catches result in triangular probability distributions for the spawning stock estimates. A similar triangular probability distribution was constructed for the spawning target, using 1 521 kg as the mode, 1 100 kg as the minimum and 2 000 kg as the maximum value.

Table 4. Summary of stock data used to estimate annual spawning stock sizes in Máskejohka.

Year	Catch (<3 kg)	Catch (3-7 kg)	Catch (>7 kg)	Expl. rate (<3 kg)	Expl. rate (3-7 kg)	Expl. rate (>7 kg)	Female prop. (<3 kg)	Female prop. (3-7 kg)	Female prop. (>7 kg)
2006	1 097	714	102	0.50	0.40	0.30	0.14	0.73	0.39
2007	427	672	192	0.50	0.40	0.30	0.34	0.74	0.46
2008	740	889	691	0.50	0.40	0.30	0.06	0.59	0.87
2009	731	449	307	0.50	0.40	0.30	0.15	0.74	0.56
2010	620	1 020	330	0.50	0.40	0.30	0.15	0.74	0.56
2011	429	608	405	0.50	0.40	0.30	0.04	0.77	0.66
2012	726	783	260	0.50	0.40	0.30	0.11	0.86	0.60
2013	388	478	113	0.45	0.35	0.25	0.15	0.74	0.56
2014	534	754	208	0.45	0.35	0.25	0.15	0.74	0.56
2015	663	488	167	0.40	0.30	0.20	0.15	0.74	0.56
2016	485	801	252	0.40	0.30	0.20	0.15	0.74	0.56
2017	202	705	244	0.36	0.27	0.18	0.15	0.74	0.56
2018	346	371	139	0.36	0.27	0.18	0.15	0.74	0.56

A Monte Carlo simulation with 10 000 iterations was then used to compare the spawning stock distribution with the spawning target distribution. For each iteration, one number is randomly drawn from the spawning stock distribution and one number drawn from the spawning target distribution. The average extent that the spawning stock distribution exceeds the spawning target distribution becomes the spawning target attainment. The proportion of the iterations where the random spawning stock size exceeds the random spawning target becomes the probability that the stock had enough spawners.

The spawning target attainment was 79 % in 2018 and the probability of meeting the spawning target was 7 %. The management target was not reached, as the last 4 years' (2015-2018) overall probability of reaching the spawning target was 71 % with an overall attainment of 112 % (Figure 18).

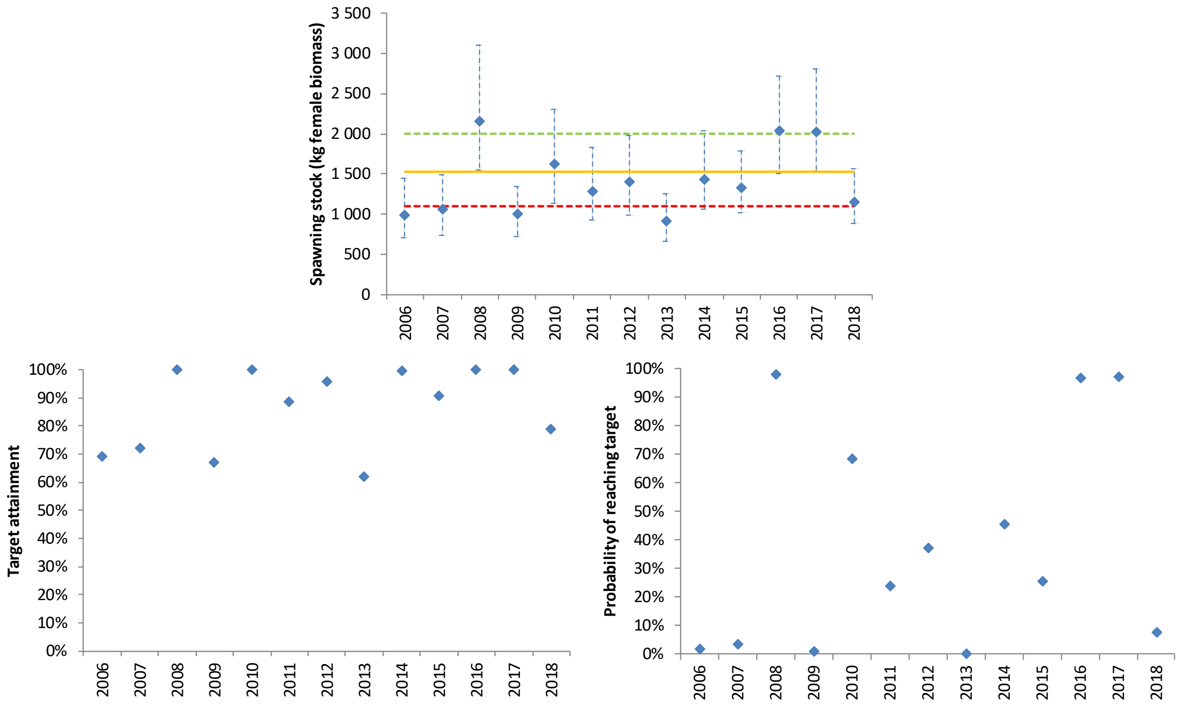


Figure 18. The estimated spawning stock (top row), percent truncated spawning target attainment (bottom row, left) and probability of reaching the spawning target (bottom row, right) in the period 2006-2018 in the Norwegian tributary Máskejohka.

3.2.2 Exploitation

The estimated total exploitation rate (based on weight) of Máskejohka salmon was 50 % in the years 2015-2018 (Figure 19), with 15 % of the pre-fishery abundance caught in coastal fisheries, 15 % in main stem fisheries and 19 % in Máskejohka. The average estimated total pre-fishery abundance for Máskejohka salmon was 6 380 kg and the average total catch was 3 159 kg in the period 2015-2018.

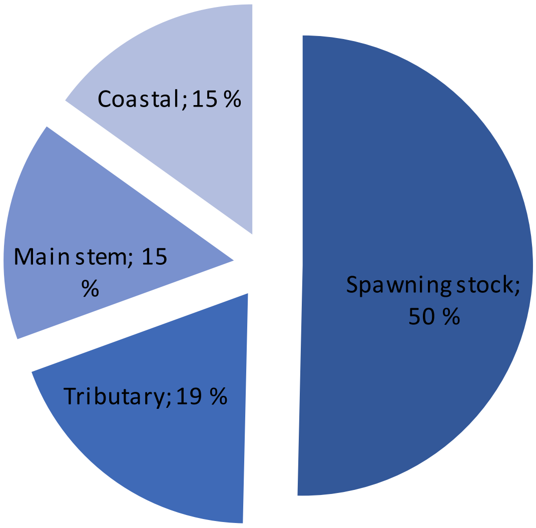


Figure 19. The total amount of salmon belonging to Máskejohka in 2015-2018, distributed into surviving spawning stock and salmon caught in fisheries in either coastal, main stem or Máskejohka fisheries. The percentages in the figure represent the proportion of the pre-fishery abundance that survives to spawning or are caught in coastal, main stem or tributary fisheries.

Estimated relative exploitation efficiencies (based on weight) in areas in various periods are given in Table 5.

Table 5. Relative exploitation rates of Máskejohka salmon in different areas (based on weight) in three periods. First column is the years 2015-2018, corresponding to the management target-period. Second column is the years 2006-2016, corresponding to the years with available data before the new agreement. The third column is 2018, the most recent year and the first year with good monitoring data after the new agreement.

	2015-2018	**2006-2016**	**2018**
Coastal	15 %	14 %	17 %
Main stem	18 %	23 %	18 %
Tributary	27 %	36 %	25 %

The relative exploitation efficiencies represent the proportion of surviving salmon that are caught in an area. So, for instance, the main stem efficiency estimate is the estimated main stem catch of Máskejohka salmon divided by the estimated amount of salmon that have survived the coastal fisheries.

In the years 2015-2018, overexploitation varied between 0 % (2016, 2017) and 24 % (2018). The average overexploitation was estimated at 9 %. This means that exploitation on average was responsible for reducing the spawning stock size by an amount of 9 % below the spawning target. Maximum sustainable exploitation varied between 19 % (2018) and 54 % (2016, 2017). The average maximum sustainable total exploitation rate in the period was 38 %, lower than the estimated average total exploitation of 50 %.

3.2.3 Stock recovery

Management target attainment of the Maskejohka stock is at 71 %, well above the threshold of 40 % that indicates the need for a recovery plan.

The estimates of maximum sustainable exploitation and the total exploitation of Máskejohka-salmon indicate that over the last four years, the total exploitation has been slightly higher than the estimated maximum sustainable exploitation. The exploitation of Máskejohka-salmon must therefore be monitored closely to ensure that exploitation rates are kept at a reasonable level compared to the maximum sustainable exploitation rate.

3.3 Buolbmátjohka/Pulmankijoki

Buolbmátjohka/Pulmankijoki is a small-sized tributary located approximately 55 km upstream of the Tana estuary. A large lake (Buolbmátjávri/Pulmankijärvi) is situated close to 10 km upstream in this tributary. The border between Norway and Finland runs through the lake, leaving the northernmost quarter of the lake and the outlet river as Norwegian and the rest of the system as Finnish. There are two inlet rivers on the Finnish side of the lake: the upper Pulmankijoki entering the lake from the south and Kalddasjoki flowing from the west.

The lowermost 10 km (below the lake) are still-flowing and meandering with substratum consisting mainly of clay and silt. No spawning areas are present in this part. The main spawning areas are found in Kalddasjoki and the upper Pulmankijoki. The salmon stock is dominated by 1SW and small 2SW salmon.

3.3.1 Status assessment

The Buolbmátjohka/Pulmankijoki spawning target is 1 329 133 eggs (996 849-1 993 698 eggs). The female biomass needed to obtain this egg deposition is 511 kg (383-767 kg) when using a stock-specific fecundity of 2 600 eggs kg^{-1}.

Very little fishing occurs in the outlet river of Pulmankijärvi. There is a gillnet salmon fishery with accurate catch statistics operating in the lake, while fishing is prohibited in the upper Pulmankijoki and partly in Kalddasjoki.

The following basic formula estimates the annual spawning stock size for Buolbmátjohka/Pulmankijoki:

*Spawning stock size = ((Catch / Exploitation rate) - Catch) * Female proportion*

The data input for the variables in this formula are summarized in Table 6. Female proportions in Table 6 are based on the sex distribution of scale samples from Pulmankijärvi.

So far, there have not been any fish counts of ascending salmon in Buolbmátjohka/Pulmankijoki. There has, however, been snorkeling counts of the spawning stock in a 4 km stretch of upper Pulmankijoki since 2003. The monitored area covers approximately 20 % of the salmon-producing river length of Pulmankijoki and covers the best spawning areas of Pulmankijoki. These counts can be used to estimate the exploitation rate of the Buolbmátjohka/Pulmankijoki fisheries after the following formulas:

*Spawning count = Snorkeling count / (Snorkeling efficiency * Area covered)*

Exploitation rate = Catch / (Spawning count + Catch)

Table 6. Summary of stock data used to estimate annual spawning stock sizes in Buolbmátjohka/Pulmankijoki.

Year	Catch (kg)	Snorkeling count	Snorkeling efficiency	Area covered	Exploitation rate	Female proportion
2003	860	66	0.60	0.2	0.49	0.55
2004	300	34	0.80	0.2	0.48	0.47
2005	600	87	0.80	0.2	0.45	0.51
2006	1 010	143	0.80	0.2	0.45	0.50
2007	805	59	0.80	0.2	0.56	0.52
2008	650	67	0.80	0.2	0.50	0.54
2009	745	76	0.70	0.2	0.53	0.49
2010	590	75	0.80	0.2	0.42	0.52
2011	610	99	0.80	0.2	0.43	0.45
2012	935	196	0.70	0.2	0.30	0.51
2013	890	151	0.80	0.2	0.42	0.49
2014	1 090	215	0.80	0.2	0.32	0.58
2015	630	154	0.80	0.2	0.35	0.51
2016	665	108	0.70	0.2	0.37	0.50
2017	348	96	0.70	0.2	0.26	0.50
2018	856	131	0.70	0.2	0.40	0.52

To account for uncertainty, the exploitation rate and female proportion estimates in Table 6 were treated as modal values, with a 20 % uncertainty used to estimate minimum and maximum values of exploitation and 10 % uncertainty used for female proportions. The modal, minimum and maximum values were then used to construct a triangular probability distribution for exploitation and female proportion, and these distributions in combination with catches result in triangular probability distributions for the spawning stock estimates. A similar triangular probability distribution was constructed for the spawning target, using 511 kg as the mode, 383 kg as the minimum and 767 kg as the maximum value.

A Monte Carlo simulation with 10 000 iterations was then used to compare the spawning stock distribution with the spawning target distribution. For each iteration, one number is randomly drawn from the spawning stock distribution and one number drawn from the spawning target distribution. The average extent that the spawning stock distribution exceeds the spawning target distribution becomes the spawning target attainment. The proportion of the iterations where the random spawning stock size exceeds the random spawning target becomes the probability that the stock had enough spawners.

The spawning target attainment was 126 % in 2018 and the probability of meeting the spawning target was 81 %. The management target was not reached, as the last 4 years' (2015-2018) overall probability of reaching the spawning target was 65 % with an overall attainment of 112 % (Figure 20).

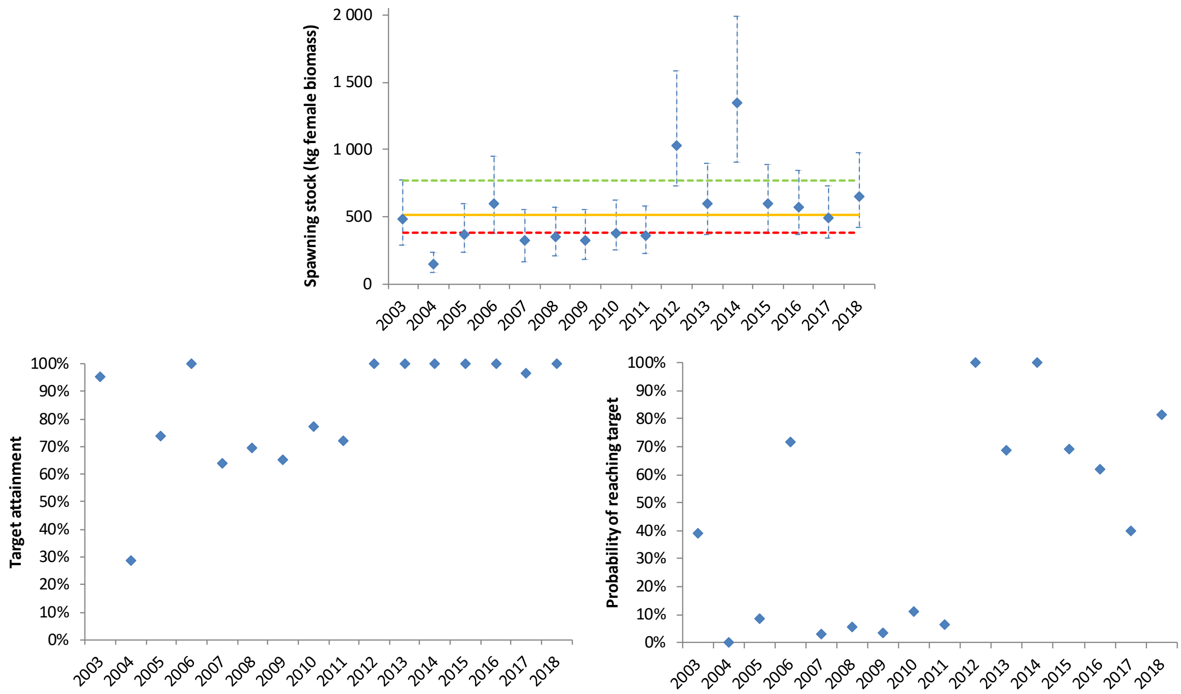


Figure 20. The estimated spawning stock (top row), percent truncated spawning target attainment (bottom row, left) and probability of reaching the spawning target (bottom row, right) in the period 2003-2018 in the Norwegian/Finnish tributary Buolbmátjohka/Pulmankijoki.

3.3.2 Exploitation

The estimated total exploitation rate (based on weight) of Buolbmátjohka/Pulmankijoki salmon was 52 % in the years 2015-2018 (Figure 21), with 12 % of the pre-fishery abundance caught in coastal fisheries, 12 % in main stem fisheries and 27 % in Buolbmátjohka/Pulmankijoki (=Lake Pulmankijärvi). The average estimated total pre-fishery abundance for Buolbmátjohka/Pulmankijoki salmon was 2 329 kg and the average total catch was 1 183 kg in the period 2015-2018.

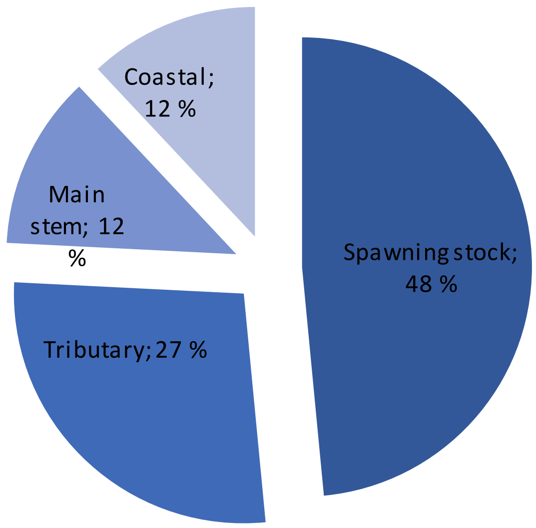


Figure 21. The total amount of salmon belonging to Buolbmátjohka/Pulmankijoki in 2015-2018, distributed into surviving spawning stock and salmon caught in fisheries in either coastal, main stem or Buolbmátjohka/Pulmankijoki fisheries. The percentages in the figure represent the proportion of the pre-fishery abundance that survives to spawning or are caught in coastal, main stem or tributary fisheries.

Estimated relative exploitation efficiencies (based on weight) in areas in various periods are given in Table 7.

Table 7. Relative exploitation rates of Buolbmátjohka/Pulmankijoki salmon in different areas (based on weight) in three periods. First column is the years 2015-2018, corresponding to the management target-period. Second column is the years 2006-2016, corresponding to the years with available data before the new agreement. The third column is 2018, the most recent year and the first year with good monitoring data after the new agreement.

	2015-2018	**2006-2016**	**2018**
Coastal	12 %	10 %	12 %
Main stem	14 %	16 %	9 %
Tributary	35 %	41 %	40 %

The relative exploitation efficiencies represent the proportion of surviving salmon that are caught in an area. So, for instance, the main stem efficiency estimate is the estimated main stem catch of Buolbmátjohka/Pulmankijoki salmon divided by the estimated amount of salmon that have survived the coastal fisheries.

In the years 2015-2018, overexploitation varied between 0 % (2015-2016, 2018) and 4 % (2017). The average overexploitation was estimated at 1 %. This means that exploitation on average was responsible for reducing the spawning stock size by an amount of 1 % below the spawning target. Maximum sustainable exploitation varied between 33 % (2017) and 44 % (2018). The average maximum sustainable total exploitation rate in the period was 40 %, lower than the estimated average total exploitation of 52 %.

3.3.3 Stock recovery

Management target attainment of the Buolbmátjohka/Pulmankijoki stock is at 65 %, well above the threshold of 40 % that indicates the need for a recovery plan.

3.4 Lákšjohka

Lákšjohka is a small- to medium-sized tributary that enters the Tana 77 km upstream from the Tana river mouth. There is a 3-m high vertical waterfall with a fish ladder approximately 9 km from the Lákšjohka river mouth. There are few spawning grounds available for salmon below the waterfall, while the river habitat above the waterfall is well-suited both for spawning and juvenile production. Problems with the ladder will therefore directly limit salmon production in Lákšjohka.

Total river length used by salmon in the Lákšjohka system is estimated to be at least 41 km. There are no further waterfalls limiting salmon distribution above the fish ladder. The main Lákšjohka is close to 14 km long. Further up the salmon can use two small tributaries, over 17 km in Deavkkehanjohka and 11 km in Gurtejohka.

The salmon in Lákšjohka are relatively small-sized, with 1SW fish weighing around 1 kg and 2SW fish 2-3 kg. Fish larger than 7 kg are rarely caught.

3.4.1 Status assessment

The Lákšjohka spawning target is 2 969 946 eggs (2 203 525-4 454 919 eggs). The female biomass needed to obtain this egg deposition is 1 165 kg (864-1 747 kg) when using a stock-specific fecundity of 2 550 eggs kg^{-1}.

The following basic formula estimates the annual spawning stock size for Lákšjohka:

*Spawning stock size = ((Catch / Exploitation rate) - Catch) * Female proportion*

The data input for the variables in this formula are summarized in Table 8. Female proportions in Table 8 in the years 2006-2008 and 2011-2012 are based on Tana main stem stock-identified samples from the Genmix project, while female proportions in the other years are the 5-year average from Genmix.

A video camera setup has counted ascending salmon in Lákšjohka since 2009, allowing us to accurately estimate the annual exploitation rate in Lákšjohka. The exploitation rate was around 30 % in 2009-2011 and around 20 % in 2012-2013. We used a total exploitation of around 30 % also for the years preceding 2009. Beginning in 2014, the proportions of released salmon increased significantly in Lákšjohka. This led to decreased exploitation rates, and the combined exploitation rate of all size classes in 2014-2018 have been in the range 6-14 %. There were problems with the video monitoring in 2017, so the video counts were treated as a minimum estimate of the number of ascending salmon, 50 % was added as the most likely estimate of ascending salmon and 100 % as an estimate of the maximum number. In 2018 conditions for video monitoring were good and the counting results indicate an exploitation of 6 % (Table 8).

To account for uncertainty, the exploitation rate and female proportion estimates in Table 8 were treated as modal values, with a 10 % uncertainty used to estimate minimum and maximum values of exploitation and 10 % uncertainty used for female proportions. Due to water level conditions in 2017, the monitoring numbers had a higher uncertainty than usual. Because of this, a 20 % uncertainty was used on the lower side of the exploitation rate and 35 % on the upper side. The modal, minimum and maximum values were then used to construct a triangular probability distribution for exploitation and female proportion, and these distributions in combination with catches result in triangular probability distributions for the spawning stock estimates. A similar triangular probability distribution was constructed for the spawning target, using 1 165 kg as the mode, 864 kg as the minimum and 1 747 kg as the maximum value.

Table 8. Summary of stock data used to estimate annual spawning stock sizes in Lákšjohka.

Year	Catch (<3 kg)	Catch (3-7 kg)	Catch (>7 kg)	Expl. rate (<3 kg)	Expl. rate (3-7 kg)	Expl. rate (>7 kg)	Female prop. (<3 kg)	Female prop. (3-7 kg)	Female prop. (>7 kg)
2006	609	91	0	0.30	0.30	0.20	0.72	0.39	0.50
2007	357	63	20	0.30	0.30	0.20	0.78	0.58	0.50
2008	385	51	22	0.30	0.30	0.20	0.57	0.82	0.50
2009	266	70	0	0.35	0.37	0.37	0.71	0.61	0.50
2010	208	29	0	0.29	0.29	0.29	0.71	0.61	0.50
2011	173	31	14	0.36	0.42	0.42	0.64	0.75	0.50
2012	185	44	0	0.17	0.15	0.15	0.55	0.64	0.50
2013	155	28	0	0.28	0.13	0.13	0.71	0.61	0.50
2014	84	15	0	0.08	0.06	0.06	0.71	0.61	0.50
2015	118	16	0	0.18	0.06	0.06	0.71	0.61	0.50
2016	99	56	0	0.17	0.06	0.06	0.71	0.61	0.50
2017	42	19	0	0.08	0.05	0.05	0.71	0.61	0.50
2018	39	26	0	0.06	0.06	0.06	0.71	0.61	0.50

A Monte Carlo simulation with 10 000 iterations was then used to compare the spawning stock distribution with the spawning target distribution. For each iteration, one number is randomly drawn from the spawning stock distribution and one number drawn from the spawning target distribution. The average extent that the spawning stock distribution exceeds the spawning target distribution becomes the spawning target attainment. The proportion of the iterations where the random spawning stock size exceeds the random spawning target becomes the probability that the stock had enough spawners.

The spawning target attainment was 55 % in 2018 and the probability of meeting the spawning target was 0 %. The management target was not reached, as the last 4 years' (2015-2018) overall probability of reaching the spawning target was 0 % with an overall attainment of 53 % (Figure 22).

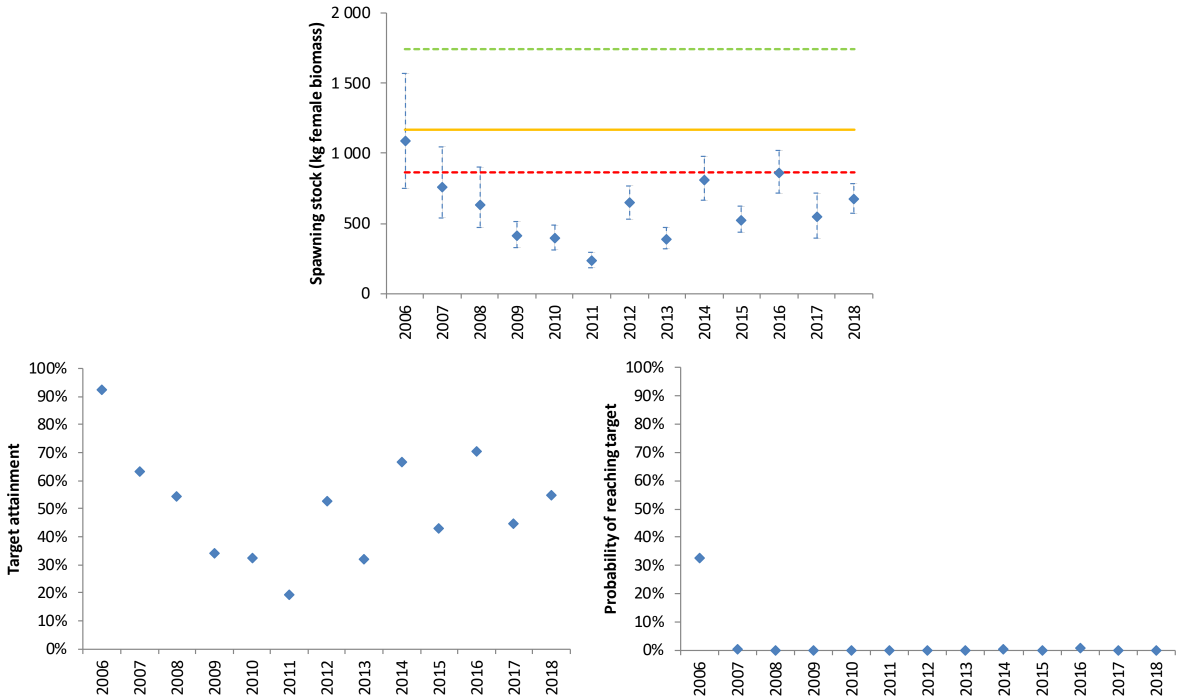


Figure 22. The estimated spawning stock (top row), percent truncated spawning target attainment (bottom row, left) and probability of reaching the spawning target (bottom row, right) in the period 2006-2018 in the Norwegian tributary Lákšjohka.

3.4.2 Exploitation

The estimated total exploitation rate (based on weight) of Lákšjohka salmon was 48 % in the years 2015-2018 (Figure 23), with 17 % of the pre-fishery abundance caught in coastal fisheries, 25 % in main stem fisheries and 6 % in Lákšjohka. The average estimated total pre-fishery abundance for Lákšjohka salmon was 1 810 kg and the average total catch was 851 kg in the period 2015-2018.

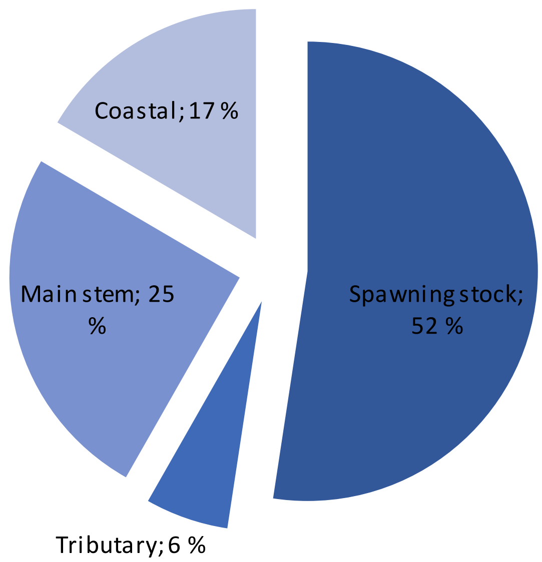


Figure 23. The total amount of salmon belonging to Lákšjohka in 2015-2018, distributed into surviving spawning stock and salmon caught in fisheries in either coastal, main stem or Lákšjohka fisheries. The percentages in the figure represent the proportion of the pre-fishery abundance that survives to spawning or are caught in coastal, main stem or tributary fisheries.

Estimated relative exploitation efficiencies (based on weight) in areas in various periods are given in Table 9.

Table 9. Relative exploitation rates of Lákšjohka salmon in different areas (based on weight) in three periods. First column is the years 2015-2018, corresponding to the management target-period. Second column is the years 2006-2016, corresponding to the years with available data before the new agreement. The third column is 2018, the most recent year and the first year with good monitoring data after the new agreement.

	2015-2018	**2006-2016**	**2018**
Coastal	17 %	15 %	18 %
Main stem	30 %	33 %	23 %
Tributary	10 %	24 %	5 %

The relative exploitation efficiencies represent the proportion of surviving salmon that are caught in an area. So, for instance, the main stem efficiency estimate is the estimated main stem catch of Lákšjohka salmon divided by the estimated amount of salmon that have survived the coastal fisheries.

In the years 2015-2018, overexploitation varied between 26 % (2016) and 49 % (2015). The average overexploitation was estimated at 40 %. This means that exploitation on average was responsible for reducing the spawning stock size by an amount of 40 % below the spawning target. Maximum sustainable exploitation varied between 0 % (2015, 2017, 2018) and 23 % (2016). A maximum exploitation of 0 % indicates no exploitable surplus. The average maximum sustainable total exploitation rate in the period was 6 %, significantly lower than the estimated average total exploitation of 48 %.

3.4.3 Stock recovery

In the previous report (Anon. 2018), we advised a 23 % reduction in the total river exploitation rate of Lákšjohka salmon from the 2006-2016 level in order to achieve stock recovery over two generations. The current evaluation shows that exploitation has been reduced from 49 to 27 %, which corresponds to a 45 % reduction in exploitation. The stock recovery model indicate that this level of reduction is sufficiently high to allow for stock recovery after one generation.

3.5 Veahčajohka/Vetsijoki

Veahčajohka/Vetsijoki is a middle-sized river flowing into the Tana main stem approximately 95 km from the Tana estuary. It is one of the most important salmon tributaries flowing to the Tana from the Finnish side, with a sizeable proportion of MSW salmon. Vetsijoki itself has a salmon-producing length of around 42 km. In addition, approximately 6 km is available in the small tributary Vaisjoki.

3.5.1 Status assessment

The revised Vetsijoki spawning target is 2 505 400 eggs (1 754 240-3 758 130 eggs). The female biomass needed to obtain this egg deposition is 1 101 kg (771-1 652 kg) when using a stock-specific fecundity of 2 275 eggs kg^{-1}.

The following basic formula estimates the annual spawning stock size for Veahčajohka/Vetsijoki:

*Spawning stock size = ((Catch / Exploitation rate) - Catch) * Female proportion*

The data input for the variables in this formula are summarized in Table 10. Female proportions in Table 10 in the years 2006-2008 and 2011-2012 are based on Tana main stem stock-identified samples from the Genmix project, while female proportions in the other years are the 5-year average from Genmix.

Ascending salmon was counted in Vetsijoki with an acoustic counting system (ARIS) in 2016. The results indicate an exploitation of under 15 % in Vetsijoki and 15 % was selected as the exploitation rate in 2016. As we have only one year of counting, we have no information about how exploitation varies from year to year. Due to this, a slightly higher exploitation rate (20 %) was selected for 2006-2015 and 2017-2018 (Table 10).

To account for uncertainty, the exploitation rate and female proportion estimates in Table 10 were treated as modal values, with a 20 % uncertainty used to estimate minimum and maximum values of exploitation for all years except 2016 when a 10 % uncertainty was used due to the fish counting. In all years, 10 % uncertainty was used for female proportions. The modal, minimum and maximum values were then used to construct a triangular probability distribution for exploitation and female proportion, and these distributions in combination with catches result in triangular probability distributions for the spawning stock estimates. A similar triangular probability distribution was constructed for the spawning target, using 1 165 kg as the mode, 864 kg as the minimum and 1 747 kg as the maximum value.

A Monte Carlo simulation with 10 000 iterations was then used to compare the spawning stock distribution with the spawning target distribution. For each iteration, one number is randomly drawn from the spawning stock distribution and one number drawn from the spawning target distribution. The average extent that the spawning stock distribution exceeds the spawning target distribution becomes the spawning target attainment. The proportion of the iterations where the random spawning stock size exceeds the random spawning target becomes the probability that the stock had enough spawners.

Table 10. Summary of stock data used to estimate annual spawning stock sizes in Veahčajohka/Vetsijoki.

Year	Catch (kg)	Exploitation rate	Female proportion
2006	860	0.20	0.63
2007	560	0.20	0.71
2008	415	0.20	0.56
2009	630	0.20	0.59
2010	930	0.20	0.59
2011	485	0.20	0.57
2012	755	0.20	0.51
2013	375	0.20	0.59
2014	1 020	0.20	0.59
2015	885	0.20	0.59
2016	755	0.15	0.59
2017	401	0.20	0.59
2018	484	0.20	0.59

The spawning target attainment was 103 % in 2018 and the probability of meeting the spawning target was 51 %. The management target was reached, as the last 4 years' (2015-2018) overall probability of reaching the spawning target was 97 % with an overall attainment of 148 % (Figure 24).

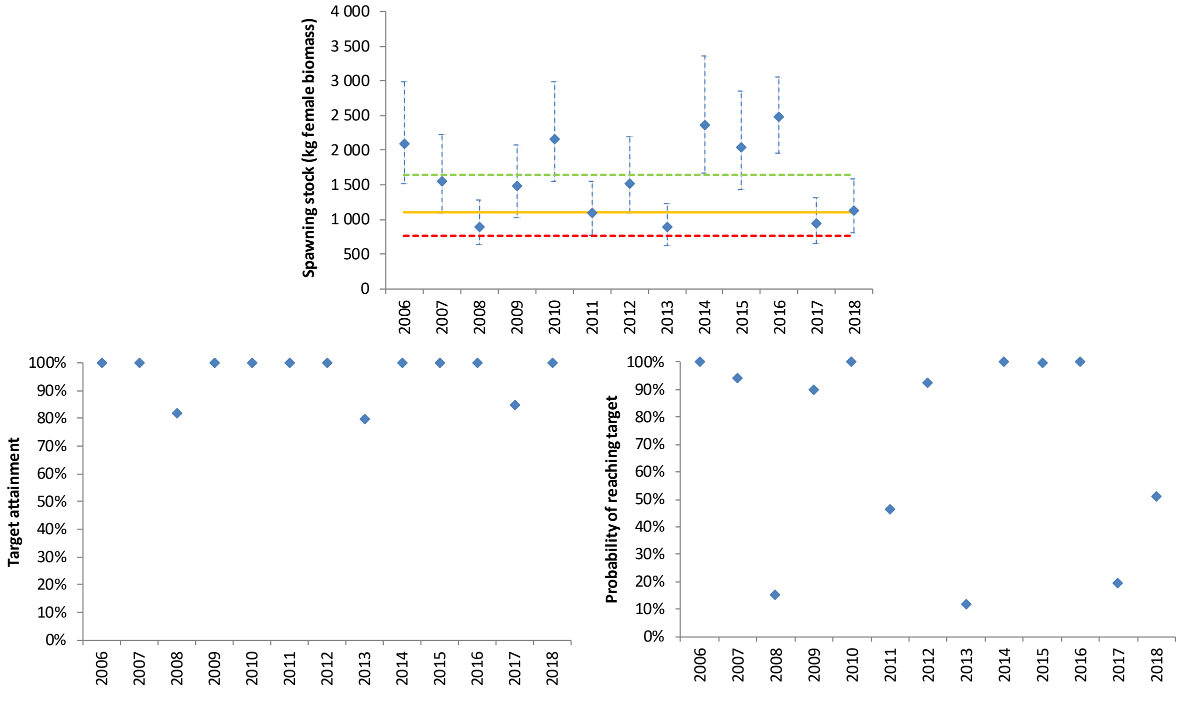


Figure 24. The estimated spawning stock (top row), percent truncated spawning target attainment (bottom row, left) and probability of reaching the spawning target (bottom row, right) in the period 2006-2018 in the Finnish tributary Veahčajohka/Vetsijoki.

3.5.2 Exploitation

The estimated total exploitation rate (based on weight) of Veahčajohka/Vetsijoki salmon was 54 % in the years 2015-2018 (Figure 25), with 16 % of the pre-fishery abundance caught in coastal fisheries, 28 % in main stem fisheries and 10 % in Veahčajohka/Vetsijoki. The average estimated total pre-fishery abundance for Veahčajohka/Vetsijoki salmon was 6 101 kg and the average total catch was 3 307 kg in the period 2015-2018.

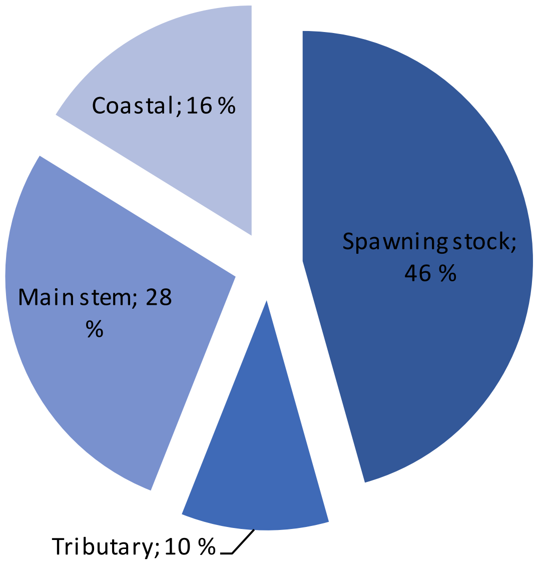


Figure 25. The total amount of salmon belonging to Veahčajohka/Vetsijoki in 2015-2018, distributed into surviving spawning stock and salmon caught in fisheries in either coastal, main stem or Veahčajohka/Vetsijoki fisheries. The percentages in the figure represent the proportion of the pre-fishery abundance that survives to spawning or are caught in coastal, main stem or tributary fisheries.

Estimated relative exploitation efficiencies (based on weight) in areas in various periods are given in Table 11.

Table 11. Relative exploitation rates of Veahčajohka/Vetsijoki salmon in different areas (based on weight) in three periods. First column is the years 2015-2018, corresponding to the management target-period. Second column is the years 2006-2016, corresponding to the years with available data before the new agreement. The third column is 2018, the most recent year and the first year with good monitoring data after the new agreement.

	2015-2018	2006-2016	2018
Coastal	16 %	15 %	18 %
Main stem	33 %	39 %	34 %
Tributary	18 %	20 %	20 %

The relative exploitation efficiencies represent the proportion of surviving salmon that are caught in an area. So, for instance, the main stem efficiency estimate is the estimated main stem catch of Veahčajohka/Vetsijoki salmon divided by the estimated amount of salmon that have survived the coastal fisheries.

In the years 2015-2018, overexploitation was 0 % for 2015, 2016, 2018 and 14 % in 2017. The average overexploitation was estimated at 4 %. This means that exploitation on average was responsible for reducing the spawning stock size by an amount of 4 % below the spawning target. Maximum sustainable exploitation varied between 52 % (2018) and 76 % (2016). The average maximum sustainable total exploitation rate in the period was 63 %, higher than the estimated average total exploitation of 54 %.

3.5.3 Stock recovery

Management target attainment of the Veahčajohka/Vetsijoki stock is at 97 %, well above the threshold of 40 % that indicates the need for a recovery plan.

3.6 Ohcejohka/Utsjoki + tributaries

Ohcejohka/Utsjoki is one of the largest tributaries of the River Tana with a catchment area of 1 665 km^2. The river flows 66 km in a mountain valley before connecting to the Tana main stem 108 km upstream from the sea. The main stem of Utsjoki comprises several deep lakes with connecting river stretches. Two major tributaries, the rivers Kevojoki and Tsarsjoki, drain to the middle part of Utsjoki. The salmon stock of Utsjoki consist of several distinct sub-stocks with grilse (1SW) populations dominating the two major tributaries while larger salmon form a considerable portion of the spawning stock in the Utsjoki main stem.

3.6.1 Status assessment

The Utsjoki (+tributaries) spawning target is 4 979 107 eggs (3 599 272-7 211 017 eggs). The female biomass needed to obtain this egg deposition is 2 059 kg (1 486-2 972 kg) when using stock-specific fecundities for the stocks in the Utsjoki main stem, Kevojoki and Tsarsjoki.

The following basic formula estimates the annual spawning stock size for Ohcejohka/Utsjoki:

*Spawning stock size = ((Catch / Exploitation rate) - Catch) * Female proportion*

The data input for the variables in this formula are summarized in Table 12. Female proportions in Table 12 in the years 2006-2008 and 2011-2012 are based on Tana main stem stock-identified samples from the Genmix project, while female proportions in the other years are the 5-year average from Genmix.

A video camera setup has counted the number of ascending salmon in Utsjoki since 2002. Annual exploitation rates can therefore be estimated from the video counts and used in the status evaluation. There were problems with water level during 2017 which might have caused many salmon to pass without being counted. The video counts are therefore treated as a minimum estimate and we have added 30 % as an estimate of the most likely number of ascending salmon and 60 % as an estimate of the maximum number. Conditions for monitoring in 2018 were very good.

To account for uncertainty, the exploitation rate and female proportion estimates in Table 12 were treated as modal values, with a 10 % uncertainty used to estimate minimum and maximum values of exploitation for all years. In all years, 10 % uncertainty was used for female proportions. The modal, minimum and maximum values were then used to construct a triangular probability distribution for exploitation and female proportion, and these distributions in combination with catches result in triangular probability distributions for the spawning stock estimates. A similar triangular probability distribution was constructed for the spawning target, using 2 059 kg as the mode, 1 486 kg as the minimum and 2 972 kg as the maximum value.

A Monte Carlo simulation with 10 000 iterations was then used to compare the spawning stock distribution with the spawning target distribution. For each iteration, one number is randomly drawn from the spawning stock distribution and one number drawn from the spawning target distribution. The average extent that the spawning stock distribution exceeds the spawning target distribution becomes the spawning target attainment. The proportion of the iterations where the random spawning stock size exceeds the random spawning target becomes the probability that the stock had enough spawners.

Table 12. Summary of stock data used to estimate annual spawning stock sizes in Ohcejohka/Utsjoki. In 2018 data the sea-age groups are combined.

Year	Catch (kg)	Video count (1SW)	Video count (MSW)	Avg. size (1SW)	Avg. size (MSW)	Exploitation rate	Female proportion (1SW)	Female proportion (MSW)
2002	1 965	2 744	345	1.59	3.59	0.35	0.53	0.74
2003	1 305	2 308	274	1.59	3.59	0.28	0.53	0.74
2004	800	1 202	95	1.59	3.59	0.36	0.53	0.74
2005	1 400	2 699	47	1.59	3.59	0.31	0.53	0.74
2006	2 375	6 555	109	1.61	3.61	0.22	0.43	0.8
2007	1 945	3 251	167	1.39	3.29	0.38	0.73	0.59
2008	2 605	2 061	307	1.32	3.58	0.68	0.64	0.72
2009	2 095	3 712	124	1.59	3.59	0.33	0.53	0.74
2010	1 305	1 932	377	1.59	3.59	0.30	0.53	0.74
2011	1 625	3 349	534	1.59	3.86	0.22	0.34	0.84
2012	2 605	5 029	868	1.75	4.16	0.21	0.45	0.81
2013	1 695	4 765	367	1.59	3.59	0.19	0.53	0.74
2014	2 955	3 659	1 319	1.59	3.59	0.28	0.53	0.74
2015	2 149	3 346	602	1.59	3.59	0.29	0.53	0.74
2016	2 090	2 934	836	1.59	3.59	0.27	0.53	0.74
2017	1 853	856	509	1.59	3.59	0.45	0.53	0.74
2018	1 926	4 743		2.67		0.15	0.63	

The spawning target attainment was 317 % in 2018 and the probability of meeting the spawning target was 100 %. The management target was reached, as the last 4 years' (2015-2018) overall probability of reaching the spawning target was 100 % with an overall attainment of 221 % (Figure 26).

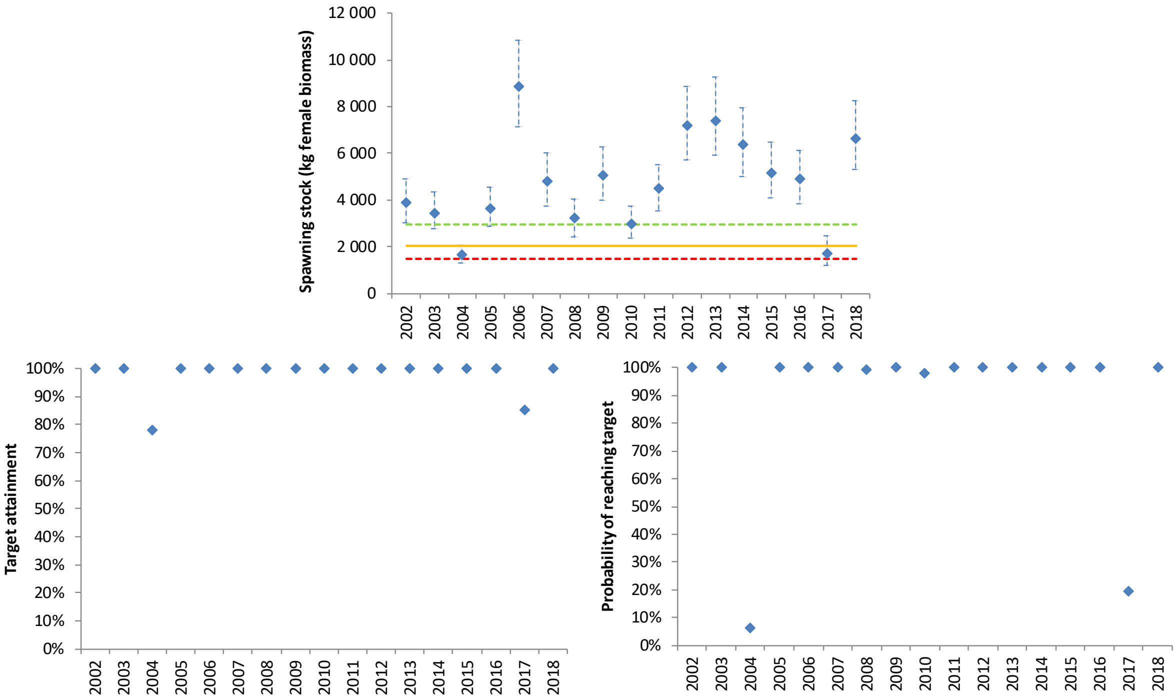


Figure 26. The estimated spawning stock (top row), percent truncated spawning target attainment (bottom row, left) and probability of reaching the spawning target (bottom row, right) in the period 2002-2018 in the Finnish tributary Ohcejohka/Utsjoki.

3.6.2 Exploitation

The estimated total exploitation rate (based on weight) of Ohcejohka/Utsjoki salmon was 46 % in the years 2015-2018 (Figure 27), with 15 % of the pre-fishery abundance caught in coastal fisheries, 16 % in main stem fisheries and 15 % in Ohcejohka/Utsjoki. The average estimated total pre-fishery abundance for Ohcejohka/Utsjoki salmon was 13 615 kg and the average total catch was 6 273 kg in the period 2015-2018.

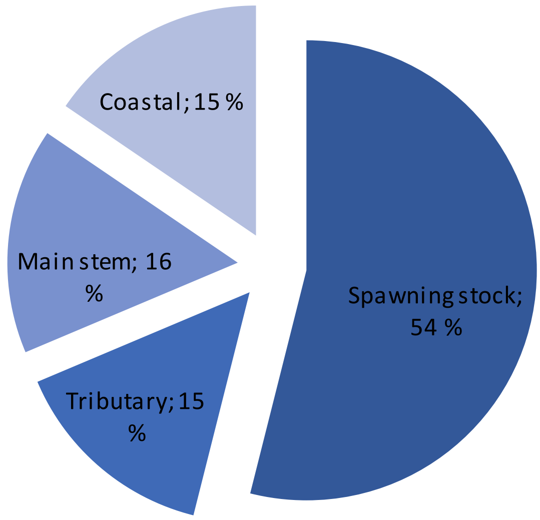


Figure 27. The total amount of salmon belonging to Ohcejohka/Utsjoki in 2015-2018, distributed into surviving spawning stock and salmon caught in fisheries in either coastal, main stem or Ohcejohka/Utsjoki fisheries. The percentages in the figure represent the proportion of the pre-fishery abundance that survives to spawning or are caught in coastal, main stem or tributary fisheries.

Estimated relative exploitation efficiencies (based on weight) in areas in various periods are given in Table 13.

Table 13. Relative exploitation rates of Ohcejohka/Utsjoki salmon in different areas (based on weight) in three periods. First column is the years 2015-2018, corresponding to the management target-period. Second column is the years 2006-2016, corresponding to the years with available data before the new agreement. The third column is 2018, the most recent year and the first year with good monitoring data after the new agreement.

	2015-2018	**2006-2016**	**2018**
Coastal	15 %	14 %	18 %
Main stem	19 %	28 %	11 %
Tributary	21 %	28 %	15 %

The relative exploitation efficiencies represent the proportion of surviving salmon that are caught in an area. So, for instance, the main stem efficiency estimate is the estimated main stem catch of Ohcejohka/Utsjoki salmon divided by the estimated amount of salmon that have survived the coastal fisheries.

In the years 2015-2018, overexploitation was 0 % for 2015, 2016, 2018 and 16 % in 2017. The average overexploitation was estimated at 4 %. This means that exploitation on average was responsible for reducing the spawning stock size by an amount of 4 % below the spawning target. Maximum sustainable exploitation varied between 45 % (2017) and 78 % (2018). The average maximum sustainable total exploitation rate in the period was 68 %, higher than the estimated average total exploitation of 46 %.

3.6.3 Stock recovery

Management target attainment of the Ohcejohka/Utsjoki stock is at 100 %, well above the threshold of 40 % that indicates the need for a recovery plan.

3.7 Goahppelašjohka/Kuoppilasjoki

Goahppelašjohka/Kuoppilasjoki is a small river entering the Tana main stem from the south c. 125 km upstream from the Tana estuary. The river has a catchment area of 102 km^2. There are no evident migration barriers in this river system, so salmon can migrate relatively far upstream. Starting from the lake Kuoppilasjärvi, a 13-km river stretch is available for salmon. A tributary river Birkejohka/Pirkejoki enters Kuoppilasjoki from the southwest direction, and this river also has a small tributary (Goaskinjohka) which is likely supporting annual salmon spawning and juvenile production. An additional 12 km is available in Pirkejoki and Goaskinjohka.

The salmon stock is small-sized, dominated by 1SW and some small 2SW salmon.

3.7.1 Status assessment

The Goahppelašjohka/Kuoppilasjoki spawning target is 695 950 eggs (518 426-1 045 925 eggs). The female biomass needed to obtain this egg deposition is 273 kg (203-409 kg) when using a stock-specific fecundity of 2 550 eggs kg^{-1}.

The following basic formula estimates the annual spawning stock size for Goahppelašjohka/Kuoppilasjoki:

*Spawning stock size = ((Catch / Exploitation rate) - Catch) * Female proportion*

The data input for the variables in this formula are summarized in Table 14. Female proportions in Table 14 in the years 2006-2008 and 2011-2012 are based on Tana main stem stock-identified samples from the Genmix project, while female proportions in the other years are the 5-year average from Genmix.

Historically, there has been no catch statistics from Goahppelašjohka/Kuoppilasjoki and no monitoring or fish counting either. The license selling was changed in 2017 and an estimated catch of 20 kg were caught both in 2017 and 2018. There has been fishing and catches in Goahppelašjohka/Kuoppilasjoki also earlier, but the extent of this is largely unknown. The status therefore must be evaluated by alternative means. One feasible approach is to use the proportion of salmon belonging to Goahppelašjohka/Kuoppilasjoki that are found in the main stem fisheries and an estimate of the main stem exploitation rate. We have direct estimates of the main stem proportion of Goahppelašjohka/Kuoppilasjoki salmon in 2006-2008 and 2011-2012 and can use the average from these five years to cover the remaining years in the period 2006-2018. The main stem exploitation is estimated at 40 % based on the location along the Tana main stem and the main stem exploitation of other stocks. The main stem exploitation rate estimate in 2017 was reduced by 10 % from previous years in 2017 due to the implementation of new fishing rules in Tana. The exploitation estimate was reduced by 30 % in 2018 as indicated by the combined main stem and tributary fish counting (Table 14).

To account for uncertainty, the exploitation rate and female proportion estimates in Table 14 were treated as modal values, with a 20 % uncertainty used to estimate minimum and maximum values of exploitation for all years. In all years, 10 % uncertainty was used for female proportions. The modal, minimum and maximum values were then used to construct a triangular probability distribution for exploitation and female proportion, and these distributions in combination with catches result in triangular probability distributions for the spawning stock estimates. A similar triangular probability distribution was constructed for the spawning target, using 273 kg as the mode, 203 kg as the minimum and 409 kg as the maximum value.

Table 14. Summary of stock data used to estimate annual spawning stock sizes in Goahppelašjohka/Kuoppilasjoki.

Year	Estimated main stem catch (kg)	Main stem proportion	Main stem exploitation rate	Female proportion
2006	901	0.0101	0.40	0.35
2007	877	0.0099	0.40	0.54
2008	792	0.0076	0.40	0.55
2009	443	0.0083	0.40	0.43
2010	624	0.0083	0.40	0.43
2011	343	0.0050	0.40	0.40
2012	764	0.0083	0.40	0.33
2013	566	0.0083	0.40	0.43
2014	690	0.0083	0.40	0.43
2015	541	0.0083	0.40	0.43
2016	603	0.0083	0.40	0.43
2017	438	0.0083	0.36	0.43
2018	368	0.0083	0.28	0.43

A Monte Carlo simulation with 10 000 iterations was then used to compare the spawning stock distribution with the spawning target distribution. For each iteration, one number is randomly drawn from the spawning stock distribution and one number drawn from the spawning target distribution. The average extent that the spawning stock distribution exceeds the spawning target distribution becomes the spawning target attainment. The proportion of the iterations where the random spawning stock size exceeds the random spawning target becomes the probability that the stock had enough spawners.

The spawning target attainment was 146 % in 2018 and the probability of meeting the spawning target was 95 %. The management target was reached, as the last 4 years' (2015-2018) overall probability of reaching the spawning target was 87 % with an overall attainment of 132 % (Figure 28).

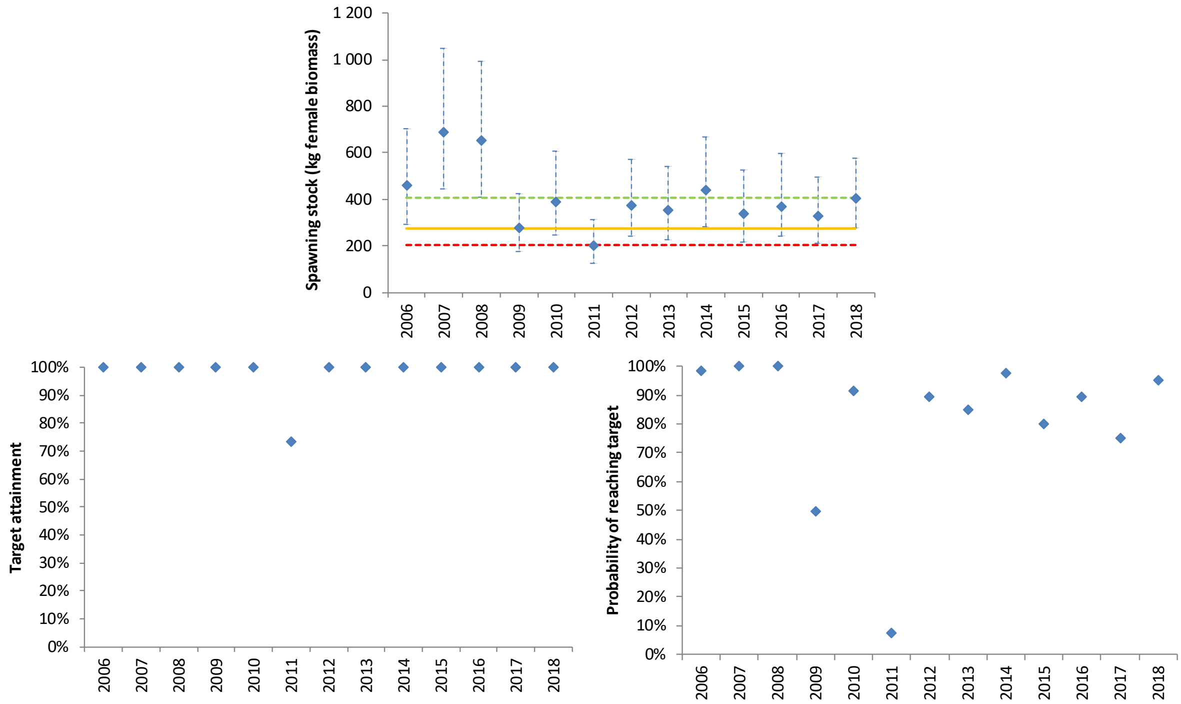


Figure 28. The estimated spawning stock (top row), percent truncated spawning target attainment (bottom row, left) and probability of reaching the spawning target (bottom row, right) in the period 2006-2018 in the Finnish tributary Goahppelašjohka/Kuoppilasjoki.

3.7.2 Exploitation

The estimated total exploitation rate (based on weight) of Goahppelašjohka/Kuoppilasjoki salmon was 47 % in the years 2015-2018 (Figure 29), with 16 % of the pre-fishery abundance caught in coastal fisheries, 31 % in main stem fisheries and 0 % in Goahppelašjohka/Kuoppilasjoki. The average estimated total pre-fishery abundance for Goahppelašjohka/Kuoppilasjoki salmon was 1 571 kg and the average total catch was 732 kg in the period 2015-2018.

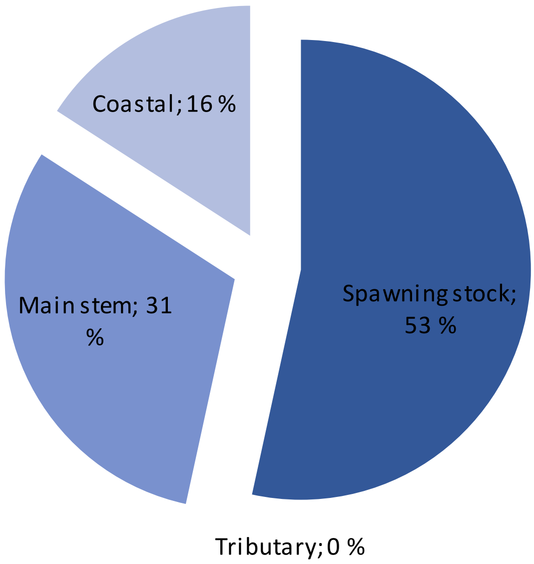


Figure 29. The total amount of salmon belonging to Goahppelašjohka/Kuoppilasjoki in 2015-2018, distributed into surviving spawning stock and salmon caught in fisheries in either coastal, main stem or Goahppelašjohka/Kuoppilasjoki fisheries. The percentages in the figure represent the proportion of the pre-fishery abundance that survives to spawning or are caught in coastal, main stem or tributary fisheries.

Estimated relative exploitation efficiencies (based on weight) in areas in various periods are given in Table 15.

Table 15. Relative exploitation rates of Goahppelašjohka/Kuoppilasjoki salmon in different areas (based on weight) in three periods. First column is the years 2015-2018, corresponding to the management target-period. Second column is the years 2006-2016, corresponding to the years with available data before the new agreement. The third column is 2018, the most recent year and the first year with good monitoring data after the new agreement.

	2015-2018	2006-2016	2018
Coastal	16 %	15 %	17 %
Main stem	37 %	41 %	27 %
Tributary	0 %	0 %	0 %

The relative exploitation efficiencies represent the proportion of surviving salmon that are caught in an area. So, for instance, the main stem efficiency estimate is the estimated main stem catch of Goahppelašjohka/Kuoppilasjoki salmon divided by the estimated amount of salmon that have survived the coastal fisheries.

In the years 2015-2018, overexploitation was 0 % for all years and the average overexploitation was therefore also estimated at 0 %. Maximum sustainable exploitation varied between 57 % (2017) and 64 % (2016). The average maximum sustainable total exploitation rate in the period was 59 %, significantly higher than the estimated average total exploitation of 47 %.

3.7.3 Stock recovery

Management target attainment of the Goahppelašjohka/Kuoppilasjoki stock is at 87 %, well above the threshold of 40 % that indicates the need for a recovery plan.

3.8 Leavvajohka

Leavvajohka is a middle-sized tributary (catchment area 313 km^2) running into the Tana main stem almost 140 km from the Tana estuary. It is a relatively long and fast-running river with no tributaries and relatively few pools. For this reason, Leavvajohka is not considered an attractive fishing place for anglers, and there are only a few fishermen visiting each year. The salmon stock is small-sized, dominated by 1SW and some small 2SW salmon.

3.8.1 Status assessment

The Leavvajohka spawning target is 499 203 eggs (249 602-748 805 eggs). The female biomass needed to obtain this egg deposition is 208 kg (104-312 kg) when using a stock-specific fecundity of 2 400 eggs kg^{-1}. Since this spawning target was established (Falkegård et al. 2014), it has been documented that the upper limit of salmon distribution used for the spawning target calculation was set too far down in the river. The present spawning target is therefore set significantly too low and this target needs to be revised.

The following basic formula estimates the annual spawning stock size for Leavvajohka:

*Spawning stock size = ((Catch / Exploitation rate) - Catch) * Female proportion*

The data input for the variables in this formula are summarized in Table 16. Female proportions in Table 16 in the years 2006-2008 and 2011-2012 are based on Tana main stem stock-identified samples from the Genmix project, while female proportions in the other years are the 5-year average from Genmix.

There is no catch statistics from Leavvajohka and no monitoring or fish counting either. The status therefore must be evaluated by alternative means. One feasible approach is to use the proportion of salmon belonging to Leavvajohka that are found in the main stem fisheries and an estimate of the main stem exploitation rate. We have direct estimates of the main stem proportion of Leavvajohka salmon in 2006-2008 and 2011-2012 and can use the average from these five years to cover the remaining years in the period 2006-2018. The main stem exploitation is estimated at 40 % based on the location along the Tana main stem and the main stem exploitation of other stocks. The main stem exploitation rate estimate in 2017 was reduced by 10 % from previous years in 2017 due to the implementation of new fishing rules in Tana. The exploitation estimate was reduced by 30 % in 2018 as indicated by the combined main stem and tributary fish counting (Table 16).

To account for uncertainty, the exploitation rate and female proportion estimates in Table 16 were treated as modal values, with a 20 % uncertainty used to estimate minimum and maximum values of exploitation for all years. In all years, 10 % uncertainty was used for female proportions. The modal, minimum and maximum values were then used to construct a triangular probability distribution for exploitation and female proportion, and these distributions in combination with catches result in triangular probability distributions for the spawning stock estimates. A similar triangular probability distribution was constructed for the spawning target, using 273 kg as the mode, 203 kg as the minimum and 409 kg as the maximum value.

A Monte Carlo simulation with 10 000 iterations was then used to compare the spawning stock distribution with the spawning target distribution. For each iteration, one number is randomly drawn from the spawning stock distribution and one number drawn from the spawning target distribution. The average extent that the spawning stock distribution exceeds the spawning target distribution becomes the spawning target attainment. The proportion of the iterations where the random spawning stock size exceeds the random spawning target becomes the probability that the stock had enough spawners.

Table 16. Summary of stock data used to estimate annual spawning stock sizes in Leavvajohka.

Year	Estimated main stem catch (kg)	Main stem proportion	Main stem exploitation rate	Female proportion
2006	1 167	0.0131	0.40	0.50
2007	1 863	0.0211	0.40	0.80
2008	1 364	0.0130	0.40	0.62
2009	696	0.0130	0.40	0.56
2010	981	0.0130	0.40	0.56
2011	415	0.0061	0.40	0.59
2012	1 037	0.0113	0.40	0.48
2013	890	0.0130	0.40	0.56
2014	1 085	0.0130	0.40	0.56
2015	850	0.0130	0.40	0.56
2016	948	0.0130	0.40	0.56
2017	689	0.0130	0.36	0.56
2018	547	0.0130	0.28	0.56

The spawning target attainment was 406 % in 2018 and the probability of meeting the spawning target was 100 %. The management target was reached, as the last 4 years' (2015-2018) overall probability of reaching the spawning target was 100 % with an overall attainment of 387 % (Figure 30).

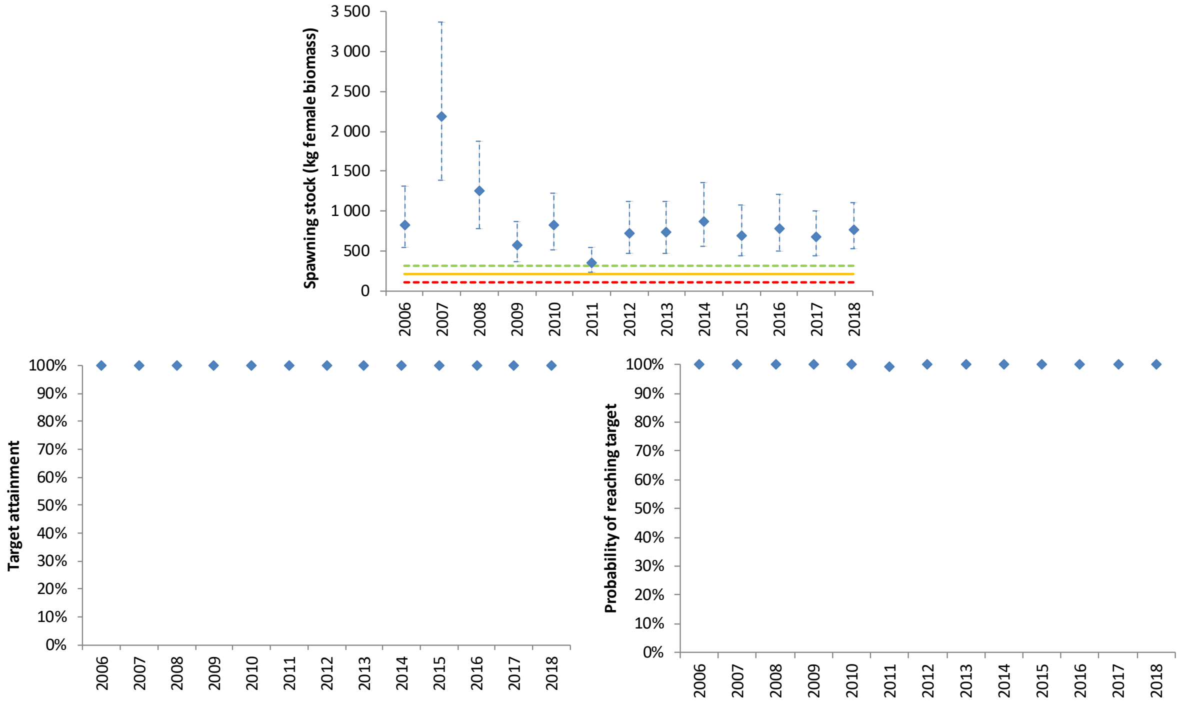


Figure 30. The estimated spawning stock (top row), percent truncated spawning target attainment (bottom row, left) and probability of reaching the spawning target (bottom row, right) in the period 2006-2018 in the Norwegian tributary Leavvajohka.

3.8.2 Exploitation

The estimated total exploitation rate (based on weight) of Leavvajohka salmon was 48 % in the years 2015-2018 (Figure 31), with 17 % of the pre-fishery abundance caught in coastal fisheries, 30 % in main stem fisheries and 0 % in Leavvajohka. The average estimated total pre-fishery abundance for Leavvajohka salmon was 2 494 kg and the average total catch was 1 191 kg in the period 2015-2018.

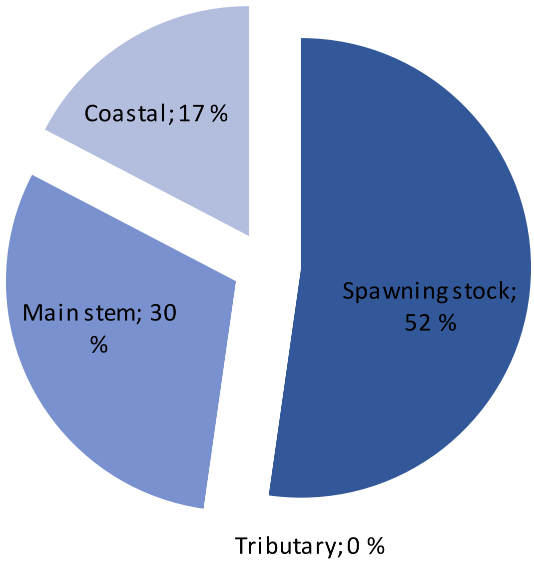


Figure 31. The total amount of salmon belonging to Leavvajohka in 2015-2018, distributed into surviving spawning stock and salmon caught in fisheries in either coastal, main stem or Leavvajohka fisheries. The percentages in the figure represent the proportion of the pre-fishery abundance that survives to spawning or are caught in coastal, main stem or tributary fisheries.

Estimated relative exploitation efficiencies (based on weight) in areas in various periods are given in Table 17.

Table 17. Relative exploitation rates of Leavvajohka salmon in different areas (based on weight) in three periods. First column is the years 2015-2018, corresponding to the management target-period. Second column is the years 2006-2016, corresponding to the years with available data before the new agreement. The third column is 2018, the most recent year and the first year with good monitoring data after the new agreement.

	2015-2018	2006-2016	2018
Coastal	17 %	17 %	19 %
Main stem	37 %	41 %	28 %
Tributary	0 %	0 %	0 %

The relative exploitation efficiencies represent the proportion of surviving salmon that are caught in an area. So, for instance, the main stem efficiency estimate is the estimated main stem catch of Leavvajohka salmon divided by the estimated amount of salmon that have survived the coastal fisheries.

In the years 2015-2018, overexploitation was 0 % for all years and the average overexploitation was therefore also estimated at 0 %. Maximum sustainable exploitation varied between 84 % (2015, 2017, 2018) and 87 % (2016). The average maximum sustainable total exploitation rate in the period was 85 %, significantly higher than the estimated average total exploitation of 48 %.

3.8.3 Stock recovery

Management target attainment of the Leavvajohka stock is at 100 %, well above the threshold of 40 % that indicates the need for a recovery plan.

3.9 Báišjohka

Báišjohka is a small-sized tributary entering the Tana main stem from the west approximately 160 km from the estuary. We have few catch records from Báišjohka, and there are few anglers visiting the river each summer. Báišjohka flows very broadly and shallow at places in its lowermost part, so salmon migration into the river is likely water-level dependent.

3.9.1 Status assessment

The Báišjohka spawning target is 946 688 eggs (711 516-1 423 032 eggs). The female biomass needed to obtain this egg deposition is 395 kg (296-593 kg) when using a stock-specific fecundity of 2 400 eggs kg^{-1}.

The following basic formula estimates the annual spawning stock size for Báišjohka:

*Spawning stock size = ((Catch / Exploitation rate) - Catch) * Female proportion*

The data input for the variables in this formula are summarized in Table 18. Female proportions in Table 18 in the years 2006-2008 and 2011-2012 are based on Tana main stem stock-identified samples from the Genmix project, while female proportions in the other years are the 5-year average from Genmix.

There is no catch statistics from Báišjohka and no monitoring or fish counting either. The status therefore must be evaluated by alternative means. One feasible approach is to use the proportion of salmon belonging to Báišjohka that are found in the main stem fisheries and an estimate of the main stem exploitation rate. We have direct estimates of the main stem proportion of Báišjohka salmon in 2006-2008 and 2011-2012 and can use the average from these five years to cover the remaining years in the period 2006-2018. The main stem exploitation is estimated at 45 % based on the location along the Tana main stem and the main stem exploitation of other stocks. The main stem exploitation rate estimate in 2017 was reduced by 10 % from previous years in 2017 due to the implementation of new fishing rules in Tana. The exploitation estimate was reduced by 30 % in 2018 as indicated by the combined main stem and tributary fish counting (Table 18).

To account for uncertainty, the exploitation rate and female proportion estimates in Table 18 were treated as modal values, with a 20 % uncertainty used to estimate minimum and maximum values of exploitation for all years. In all years, 10 % uncertainty was used for female proportions. The modal, minimum and maximum values were then used to construct a triangular probability distribution for exploitation and female proportion, and these distributions in combination with catches result in triangular probability distributions for the spawning stock estimates. A similar triangular probability distribution was constructed for the spawning target, using 779 kg as the mode, 508 kg as the minimum and 1 168 kg as the maximum value.

A Monte Carlo simulation with 10 000 iterations was then used to compare the spawning stock distribution with the spawning target distribution. For each iteration, one number is randomly drawn from the spawning stock distribution and one number drawn from the spawning target distribution. The average extent that the spawning stock distribution exceeds the spawning target distribution becomes the spawning target attainment. The proportion of the iterations where the random spawning stock size exceeds the random spawning target becomes the probability that the stock had enough spawners.

Table 18. Summary of stock data used to estimate annual spawning stock sizes in Báišjohka.

Year	Estimated main stem catch (kg)	Main stem proportion	Main stem exploitation rate	Female proportion
2006	473	0.0053	0.45	0.49
2007	1 026	0.0116	0.45	0.77
2008	813	0.0078	0.45	0.75
2009	381	0.0071	0.45	0.61
2010	536	0.0071	0.45	0.61
2011	207	0.0030	0.45	0.44
2012	701	0.0077	0.45	0.57
2013	487	0.0071	0.45	0.61
2014	593	0.0071	0.45	0.61
2015	465	0.0071	0.45	0.61
2016	518	0.0071	0.45	0.61
2017	377	0.0071	0.40	0.61
2018	299	0.0071	0.32	0.61

The spawning target attainment was 95 % in 2018 and the probability for meeting the spawning target was 37 %. The management target was not reached, as the last 4 years' (2015-2018) overall probability of reaching the spawning target was 29 % with an overall attainment of 90 % (Figure 32).

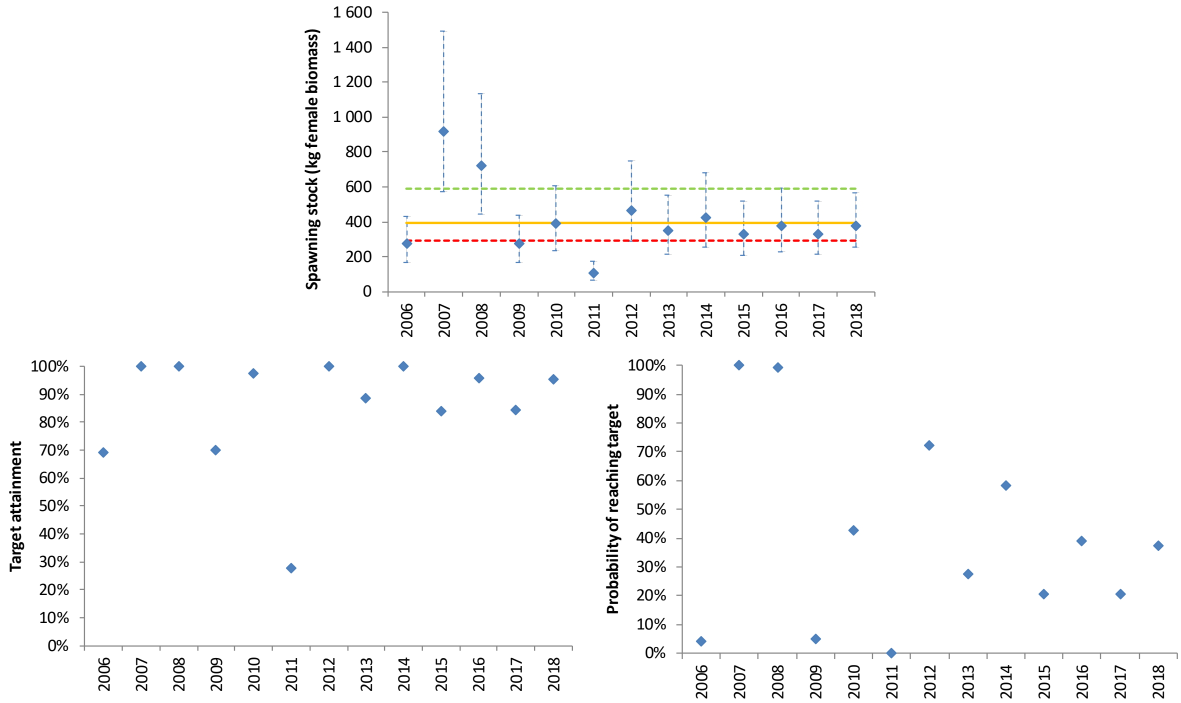


Figure 32. The estimated spawning stock (top row), percent truncated spawning target attainment (bottom row, left) and probability of reaching the spawning target (bottom row, right) in the period 2006-2018 in the Norwegian tributary Báišjohka.

3.9.2 Exploitation

The estimated total exploitation rate (based on weight) of Báišjohka salmon was 52 % in the years 2015-2018 (Figure 33), with 17 % of the pre-fishery abundance caught in coastal fisheries, 35 % in main stem fisheries and 0 % in Báišjohka. The average estimated total pre-fishery abundance for Báišjohka salmon was 1 196 kg and the average total catch was 614 kg in the period 2015-2018.

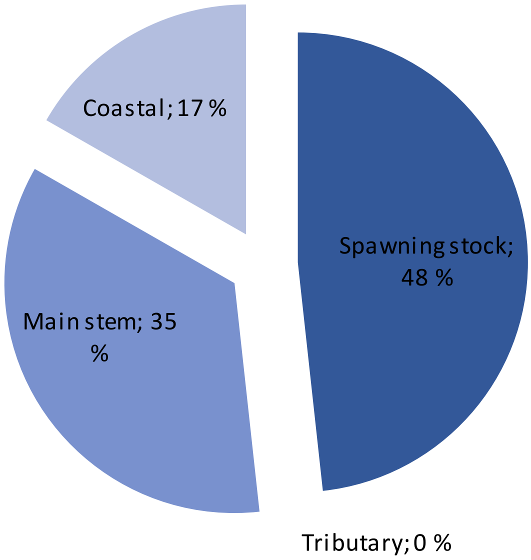


Figure 33. The total amount of salmon belonging to Báišjohka in 2015-2018, distributed into surviving spawning stock and salmon caught in fisheries in either coastal, main stem or Báišjohka fisheries. The percentages in the figure represent the proportion of the pre-fishery abundance that survives to spawning or are caught in coastal, main stem or tributary fisheries.

Estimated relative exploitation efficiencies (based on weight) in areas in various periods are given in Table 19.

Table 19. Relative exploitation rates of Báišjohka salmon in different areas (based on weight) in three periods. First column is the years 2015-2018, corresponding to the management target-period. Second column is the years 2006-2016, corresponding to the years with available data before the new agreement. The third column is 2018, the most recent year and the first year with good monitoring data after the new agreement.

	2015-2018	2006-2016	2018
Coastal	17 %	16 %	18 %
Main stem	42 %	46 %	33 %
Tributary	0 %	0 %	0 %

The relative exploitation efficiencies represent the proportion of surviving salmon that are caught in an area. So, for instance, the main stem efficiency estimate is the estimated main stem catch of Báišjohka salmon divided by the estimated amount of salmon that have survived the coastal fisheries.

In the years 2015-2018, overexploitation varied between 4 % (2018) and 17 % (2015) and the average overexploitation was estimated at 10 %. Maximum sustainable exploitation varied between 42 %

(2018) and 53 % (2016). The average maximum sustainable total exploitation rate in the period was 45 %, lower than the estimated average total exploitation of 52 %.

3.9.3 Stock recovery

In the previous report (Anon. 2018), we advised an 8 % reduction in the total river exploitation rate of Báišjohka salmon from the 2006-2016 level in order to achieve stock recovery over two generations. The current evaluation shows that river exploitation has been reduced from 49 to 27 %, which corresponds to a 45 % reduction in exploitation. The stock recovery model indicate that this level of reduction is sufficiently high to allow for stock recovery after one generation.

3.10 Njiljohka/Nilijoki

Njiljohka/Nilijoki is a small river (catchment area 137 km^2) entering the Tana main stem from the east approximately 160 km from the Tana estuary opposite to the River Baisjohka. The salmon-producing river length in Njiljohka/Nilijoki is c. 13 km, after which a “stone field” with extremely shallow water prevents further migration of adult salmon.

3.10.1 Status assessment

The Njiljohka/Nilijoki spawning target is 519 520 eggs (355 130-776 280 eggs). The female biomass needed to obtain this egg deposition is 221 kg (151-330 kg) when using a stock-specific fecundity of 2 350 eggs kg^{-1}.

Spawning salmon have been counted almost annually in Njiljohka/Nilijoki in the autumn with snorkeling in the years 2006-2018, with the exceptions of 2007, 2008 and 2013. The snorkeling counts can be used directly as a basis for the target assessment of Njiljohka/Nilijoki and the following basic formula estimates the annual spawning stock size in the snorkeling years:

*Spawning stock size = Snorkeling count * Average size * Detection rate * Area covered * Female prop.*

The data input for the variables in this formula are summarized in Table 20. Female proportions in Table 20 are based on snorkeling detections of males and females each year. Fishing pressure in Njiljohka/Nilijoki is low and no catch statistics is available. Average sizes in Table 20 are based on a combination of main stem Genmix samples from 2006-2008 and 2011-2012.

Table 20. Summary of snorkeling data used to estimate annual spawning stock sizes in Njiljohka/Nilijoki.

Year	Snorkeling count (1SW)	Snorkeling count (MSW)	Average size (1SW)	Average size (MSW)	Detection rate	Area covered	Female prop. (1SW)	Female prop. (MSW)
2006	210	6	1.3	3.6	0.80	1	0.41	0.83
2007								
2008								
2009	127	14	1.3	3.6	0.75	1	0.37	0.64
2010	65	24	1.3	3.6	0.80	1	0.42	0.70
2011	131	16	1.3	3.6	0.80	1	0.40	0.75
2012	151	14	1.3	3.6	0.75	1	0.51	0.43
2013								
2014	154	34	1.3	3.6	0.80	0.7	0.52	0.65
2015	75	15	1.3	3.6	0.80	0.7	0.36	0.80
2016	70	29	1.3	3.6	0.75	0.7	0.40	0.93
2017	65	27	1.3	3.6	0.75	0.7	0.36	0.63
2018	205	11	1.3	3.6	0.75	0.7	0.43	0.50

In the years without snorkeling (2007, 2008, 2013), an alternative approach can be taken based on the proportion of Njiljohka/Nilijoki salmon found in the main stem fisheries and an estimate of the main stem exploitation rate (Table 21). We have direct estimates of the main stem proportion of Njiljohka/Nilijoki salmon in 2007-2008 and can use the five-year Genmix average in 2013. The main stem exploitation is estimated at 45 % based on the location along the Tana main stem and the main stem exploitation of other stocks.

Table 21. Summary of stock data used to estimate annual spawning stock sizes in Njiljohka/Nilijoki in the years without snorkelling data.

Year	Estimated main stem catch (kg)	Main stem proportion	Main stem exploitation rate	Female proportion
2006				
2007	751	0.0085	0.45	0.78
2008	500	0.0048	0.45	0.63
2009				
2010				
2011				
2012				
2013	538	0.0079	0.45	0.58
2014				
2015				
2016				
2017				
2018				

To account for uncertainty, the exploitation rate and female proportion estimates in Table 20 and Table 21 were treated as modal values, with a 20 % uncertainty used to estimate minimum and maximum values of exploitation for all years. In all years, 10 % uncertainty was used for female proportions. The modal, minimum and maximum values were then used to construct a triangular probability distribution for exploitation and female proportion, and these distributions in combination with catches result in triangular probability distributions for the spawning stock estimates. A similar triangular probability distribution was constructed for the spawning target, using 221 kg as the mode, 151 kg as the minimum and 330 kg as the maximum value.

A Monte Carlo simulation with 10 000 iterations was then used to compare the spawning stock distribution with the spawning target distribution. For each iteration, one number is randomly drawn from the spawning stock distribution and one number drawn from the spawning target distribution. The average extent that the spawning stock distribution exceeds the spawning target distribution becomes the spawning target attainment. The proportion of the iterations where the random spawning stock size exceeds the random spawning target becomes the probability that the stock had enough spawners.

The spawning target attainment was 108 % in 2018 and the probability of meeting the spawning target was 62 %. The management target was not reached, as the last 4 years' (2015-2018) overall probability of reaching the spawning target was 22 % with an overall attainment of 88 % (Figure 34).

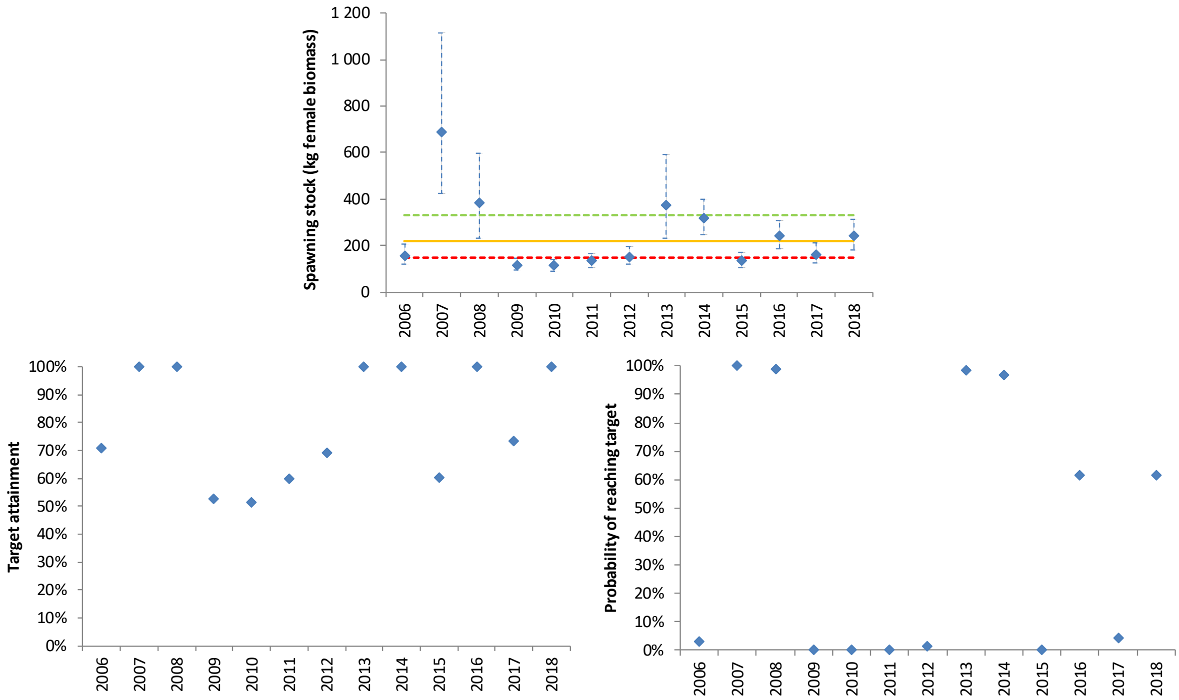


Figure 34. The estimated spawning stock (top row), percent truncated spawning target attainment (bottom row, left) and probability of reaching the spawning target (bottom row, right) in the period 2006-2018 in the Finnish tributary Njiljohka/Nilijoki.

3.10.2 Exploitation

The estimated total exploitation rate (based on weight) of Njiljohka/Nilijoki salmon was 61 % in the years 2015-2018 (Figure 35), with 17 % of the pre-fishery abundance caught in coastal fisheries, 43 % in main stem fisheries and 0 % in Njiljohka/Nilijoki. The average estimated total pre-fishery abundance for Njiljohka/Nilijoki salmon was 1 065 kg and the average total catch was 645 kg in the period 2015-2018.

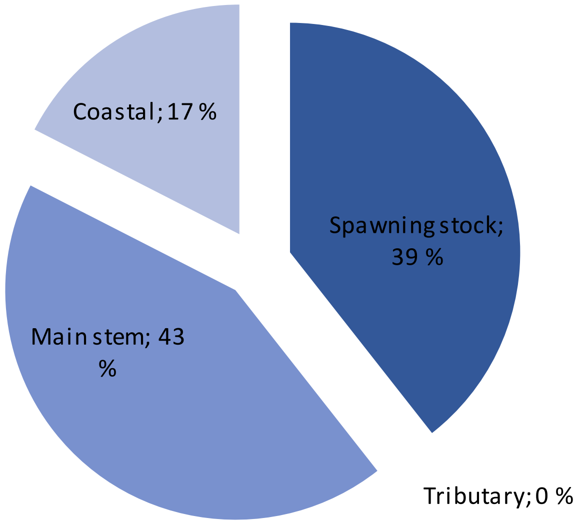


Figure 35. The total amount of salmon belonging to Njiljohka/Nilijoki in 2015-2018, distributed into surviving spawning stock and salmon caught in fisheries in either coastal, main stem or Njiljohka/Nilijoki fisheries. The percentages in the figure represent the proportion of the pre-fishery abundance that survives to spawning or are caught in coastal, main stem or tributary fisheries.

Estimated relative exploitation efficiencies (based on weight) in areas in various periods are given in Table 22.

Table 22. Relative exploitation rates of Njiljohka/Nilijoki salmon in different areas (based on weight) in three periods. First column is the years 2015-2018, corresponding to the management target-period. Second column is the years 2006-2016, corresponding to the years with available data before the new agreement. The third column is 2018, the most recent year and the first year with good monitoring data after the new agreement.

	2015-2018	**2006-2016**	**2018**
Coastal	17 %	17 %	19 %
Main stem	52 %	59 %	37 %
Tributary	0 %	0 %	0 %

The relative exploitation efficiencies represent the proportion of surviving salmon that are caught in an area. So, for instance, the main stem efficiency estimate is the estimated main stem catch of Njiljohka/Nilijoki salmon divided by the estimated amount of salmon that have survived the coastal fisheries.

In the years 2015-2018, overexploitation varied between 0 % (2016, 2018) and 39 % (2015). The average overexploitation was estimated at 16 %. Maximum sustainable exploitation varied between 46 % (2015) and 68 % (2016). The average maximum sustainable total exploitation rate in the period was 54 %, lower than the estimated average total exploitation of 61 %.

3.10.3 Stock recovery

In the previous report (Anon. 2018), we advised a 5 % reduction in the total river exploitation rate of Njiljohka/Nilijoki salmon from the 2006-2016 level in order to achieve stock recovery over two generations. The current evaluation shows that river exploitation has been reduced from 52 to 37 %, which corresponds to a 29 % reduction in exploitation. The stock recovery model indicates that this level of reduction is sufficiently high to allow for stock recovery after one generation.

3.11 Váljohka

Váljohka is a small-sized river flowing into the Tana main stem 175 km from the Tana river estuary. The lowermost part of Váljohka is relatively slow-flowing, but further upstream the water velocity picks up and more spawning and production areas become available. A total of 45 km is available for salmon in Váljohka itself. In addition, approximately 18 km is available in the small tributary Ástejohka.

3.11.1 Status assessment

The Váljohka spawning target is 1 907 595 eggs (1 245 502-2 861 393 eggs). The female biomass needed to obtain this egg deposition is 779 kg (508-1 168 kg) when using a stock-specific fecundity of 2 450 eggs kg^{-1}.

The following basic formula estimates the annual spawning stock size for Váljohka:

*Spawning stock size = ((Catch / Exploitation rate) - Catch) * Female proportion*

The data input for the variables in this formula are summarized in Table 23. Female proportions in Table 23 in the years 2006-2008 and 2011-2012 are based on Tana main stem stock-identified samples from the Genmix project, while female proportions in the other years are based on the size composition of the Váljohka catch and the 5-year Genmix average female proportion of different size groups.

Fishing pressure in Váljohka is low with only a few fishermen every year and a limited reported catch ranging from 37 kg (2018) to 321 kg (2012). We have one year of fish counting with a video camera setup in 2015 that have provided an exploitation estimate. In addition, there have been snorkeling counts of the lower part of Váljohka in 2014-2015 and in Ástejohka in 2015. The video counting found that a minimum number of 741 salmon (629 1SW, 112 MSW) ascended Váljohka in 2015. An additional 100 salmon were counted in the tributary Ástejohka (which were not covered by the video counting). In combination with the catch statistics in 2015, the estimated exploitation rate in 2015 becomes 7 %. A comparison between the snorkeling and video counts in 2015 show that due to the limited area covered by snorkeling, only 25 % of the salmon were accounted for during the snorkeling. A 25 % observation rate in the 2014 snorkeling points to an exploitation of only 4 % in this year.

The small number of licenses combined with low accessibility for fishermen in combination with the recent monitoring results indicates a low exploitation level throughout the status assessment period (2006-2018). This is a problem for the status assessment. The size of the spawning stock estimate is highly vulnerable to even minor changes in the exploitation estimate when we operate at exploitation estimates below 10-15 %. Consequently, the status assessment becomes highly sensitive when using only tributary-based numbers. We will therefore use a combined approach to assess status in Váljohka.

In addition to tributary catch statistics, we include main stem fisheries and the main stem genetic stock identification results so that we have two sources of information for the assessment: 1) estimated main stem catch, and 2) the Váljohka catch statistics. We have direct estimates of the main stem proportion of Váljohka salmon in 2006-2008 and 2011-2012 and can use the average size group female proportions from these five years to cover the remaining years in the period 2006-

2018. The reported Váljohka catch is added to the estimated main stem catch every year. The main stem exploitation is estimated at 40 % in 2006-2016 based on the location along the Tana main stem, the Váljohka salmon size composition and the estimated main stem exploitation of other stocks. If we then set the fisheries exploitation within Váljohka to 8 %, the combined exploitation rate estimate used for the status assessment in 2006-2016 becomes 45 %. The exploitation rate estimate in 2017 was reduced by 10 % from previous years in 2017 due to the implementation of new fishing rules in Tana. The exploitation estimate was reduced by 30 % in 2018 as indicated elsewhere in Tana through the combined results of the main stem and tributary fish countings (Table 23).

Table 23. Summary of stock data used to estimate annual spawning stock sizes in Váljohka.

Year	Estimated main stem and tributary catch (kg)	Main stem proportion	Main stem exploitation rate	Female proportion
2006	1 517	0.0101	0.45	0.58
2007	1 466	0.0099	0.45	0.80
2008	1 354	0.0076	0.45	0.68
2009	1 037	0.0083	0.45	0.42
2010	1 429	0.0083	0.45	0.50
2011	1 113	0.0050	0.45	0.59
2012	3 212	0.0083	0.45	0.42
2013	1 344	0.0083	0.45	0.47
2014	1 630	0.0083	0.45	0.44
2015	1 276	0.0083	0.45	0.55
2016	1 339	0.0083	0.45	0.56
2017	996	0.0083	0.40	0.57
2018	758	0.0083	0.31	0.45

To account for uncertainty, the exploitation rate and female proportion estimates in Table 23 were treated as modal values, with a 20 % uncertainty used to estimate minimum and maximum values of exploitation for all years. In all years, 10 % uncertainty was used for female proportions. The modal, minimum and maximum values were then used to construct a triangular probability distribution for exploitation and female proportion, and these distributions in combination with catches result in triangular probability distributions for the spawning stock estimates. A similar triangular probability distribution was constructed for the spawning target, using 779 kg as the mode, 508 kg as the minimum and 1 168 kg as the maximum value.

A Monte Carlo simulation with 10 000 iterations was then used to compare the spawning stock distribution with the spawning target distribution. For each iteration, one number is randomly drawn from the spawning stock distribution and one number drawn from the spawning target distribution. The average extent that the spawning stock distribution exceeds the spawning target distribution becomes the spawning target attainment. The proportion of the iterations where the random spawning stock size exceeds the random spawning target becomes the probability that the stock had enough spawners.

The spawning target attainment was 99 % in 2018 and the probability of meeting the spawning target was 53 %. The management target was not reached, as the last 4 years' (2015-2018) overall probability of reaching the spawning target was 60 % with an overall attainment of 110 % (Figure 36).

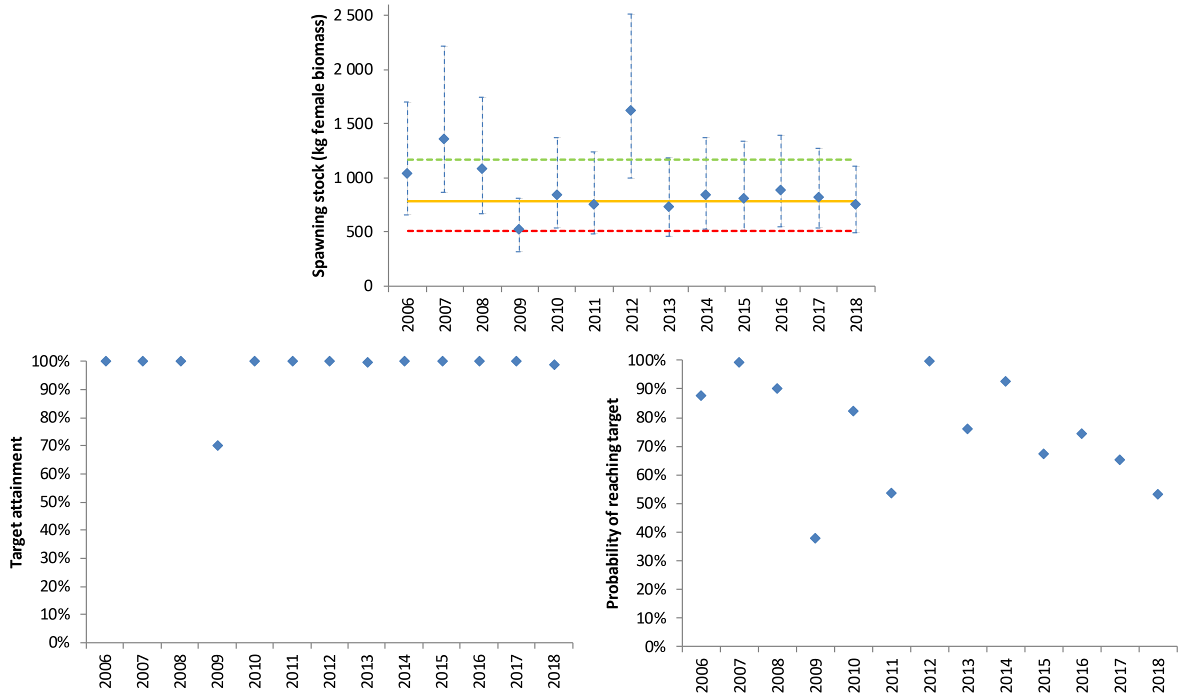


Figure 36. The estimated spawning stock (top row), percent truncated spawning target attainment (bottom row, left) and probability of reaching the spawning target (bottom row, right) in the period 2006-2018 in the Norwegian tributary Váljohka.

3.11.2 Exploitation

The estimated total exploitation rate (based on weight) of Váljohka salmon was 50 % in the years 2015-2018 (Figure 37), with 18 % of the pre-fishery abundance caught in coastal fisheries, 29 % in main stem fisheries and 3 % in Váljohka. The average estimated total pre-fishery abundance for Váljohka salmon was 3 098 kg and the average total catch was 1 554 kg in the period 2015-2018.

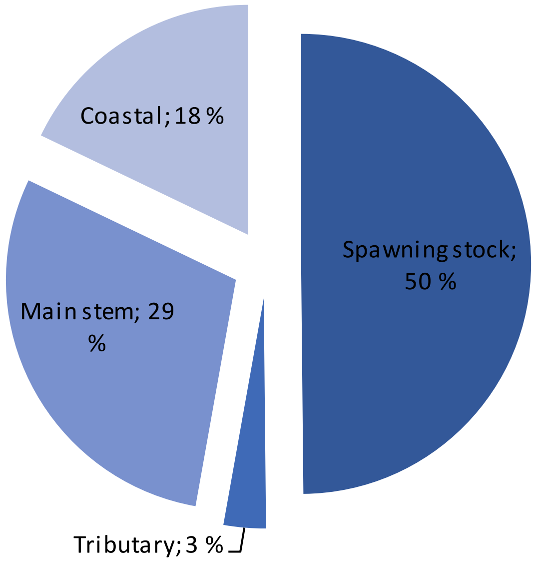


Figure 37. The total amount of salmon belonging to Váljohka in 2015-2018, distributed into surviving spawning stock and salmon caught in fisheries in either coastal, main stem or Váljohka fisheries. The percentages in the figure represent the proportion of the pre-fishery abundance that survives to spawning or are caught in coastal, main stem or tributary fisheries.

Estimated relative exploitation efficiencies (based on weight) in areas in various periods are given in Table 24.

Table 24. Relative exploitation rates of Váljohka salmon in different areas (based on weight) in three periods. First column is the years 2015-2018, corresponding to the management target-period. Second column is the years 2006-2016, corresponding to the years with available data before the new agreement. The third column is 2018, the most recent year and the first year with good monitoring data after the new agreement.

	2015-2018	2006-2016	2018
Coastal	19 %	16 %	20 %
Main stem	39 %	37 %	28 %
Tributary	6 %	9 %	2 %

The relative exploitation efficiencies represent the proportion of surviving salmon that are caught in an area. So, for instance, the main stem efficiency estimate is the estimated main stem catch of Váljohka salmon divided by the estimated amount of salmon that have survived the coastal fisheries.

In the years 2015-2018, overexploitation was 0 % in 2015-2017 and 3 % in 2018 and the average overexploitation was estimated at 1 %. Maximum sustainable exploitation varied between 42 % (2018) and 60 % (2016). The average maximum sustainable total exploitation rate in the period was 52 %, slightly higher than the estimated average total exploitation of 50 %.

3.11.3 Stock recovery

Management target attainment of the Váljohka stock is at 60 %, well above the threshold of 40 % that indicates the need for a recovery plan.

3.12 Áhkojohka/Akujoki

The river Áhkojohka/Akujoki is a small Finnish tributary (catchment area 193 km^2) flowing into the Tana mainstem from the east approximately 190 km upstream of the Tana estuary. Only the lower 6.2 km of the river is available for salmon production as an impassable waterfall prevents further upstream migration.

3.12.1 Status assessment

The Áhkojohka/Akujoki spawning target is 282 532 eggs (211 899-423 798 eggs). The female biomass needed to obtain this egg deposition is 126 kg (94-188 kg) when using a stock-specific fecundity of 2 250 eggs kg^{-1}.

Spawning salmon have been counted annually in Áhkojohka/Akujoki in the autumn with snorkeling in the years 2003-2017. These counts can be used directly as a basis for the target assessment of Áhkojohka/Akujoki and the following basic formula estimates the annual spawning stock size:

*Spawning stock size = Snorkeling count * Average size * Detection rate * Area covered * Female proportion*

The data input for the variables in this formula are summarized in Table 25. Female proportions in Table 25 are based on snorkeling detections of males and females each year.

Fishing pressure in Áhkojohka/Akujoki is low and there are no catch statistics. Average sizes in Table 25 are based on a combination of main stem Genmix samples from 2006-2008 and 2011-2012 and salmon samples from within Áhkojohka/Akujoki in 2007 and 2011. Area covered is 100 % of the salmon distribution area in Áhkojohka/Akujoki each year.

Table 25. Summary of stock data used to estimate annual spawning stock sizes in Áhkojohka/Akujoki.

Year	Snorkeling count (1SW)	Snorkeling count (MSW)	Average size (1SW)	Average size (MSW)	Detection rate	Area covered	Female prop. (1SW)	Female prop. (MSW)
2003	60	3	1.3	3.6	0.85	1	0.66	0.33
2004	42	6	1.3	3.6	0.85	1	0.45	0.83
2005	101	5	1.3	3.6	0.85	1	0.42	0.80
2006	162	9	1.3	3.6	0.85	1	0.26	0.89
2007	50	18	1.3	3.6	0.85	1	0.27	0.89
2008	35	18	1.3	3.6	0.85	1	0.34	0.61
2009	47	7	1.3	3.6	0.80	1	0.28	0.86
2010	45	14	1.3	3.6	0.85	1	0.56	0.64
2011	70	14	1.3	3.6	0.85	1	0.31	0.71
2012	116	18	1.3	3.6	0.80	1	0.53	0.78
2013	62	24	1.3	3.6	0.85	1	0.33	0.54
2014	90	23	1.3	3.6	0.85	1	0.44	0.61
2015	40	7	1.3	3.6	0.85	1	0.45	0.71
2016	53	26	1.3	3.6	0.80	1	0.32	0.81
2017	21	17	1.3	3.6	0.80	1	0.48	0.29
2018	65	3	1.3	3.6	0.80	1	0.51	0.33

To account for uncertainty, the exploitation rate and female proportion estimates in Table 25 were treated as modal values, with a 20 % uncertainty used to estimate minimum and maximum values of exploitation for all years. In all years, 10 % uncertainty was used for female proportions. The modal, minimum and maximum values were then used to construct a triangular probability distribution for exploitation and female proportion, and these distributions in combination with catches result in triangular probability distributions for the spawning stock estimates. A similar triangular probability distribution was constructed for the spawning target, using 126 kg as the mode, 94 kg as the minimum and 188 kg as the maximum value.

A Monte Carlo simulation with 10 000 iterations was then used to compare the spawning stock distribution with the spawning target distribution. For each iteration, one number is randomly drawn from the spawning stock distribution and one number drawn from the spawning target distribution. The average extent that the spawning stock distribution exceeds the spawning target distribution becomes the spawning target attainment. The proportion of the iterations where the random spawning stock size exceeds the random spawning target becomes the probability that the stock had enough spawners.

The spawning target attainment was 41 % in 2018 and the probability of meeting the spawning target was 0 %. The management target was not reached, as the last 4 years' (2015-2018) overall probability of reaching the spawning target was 0 % with an overall attainment of 49 % (Figure 38).

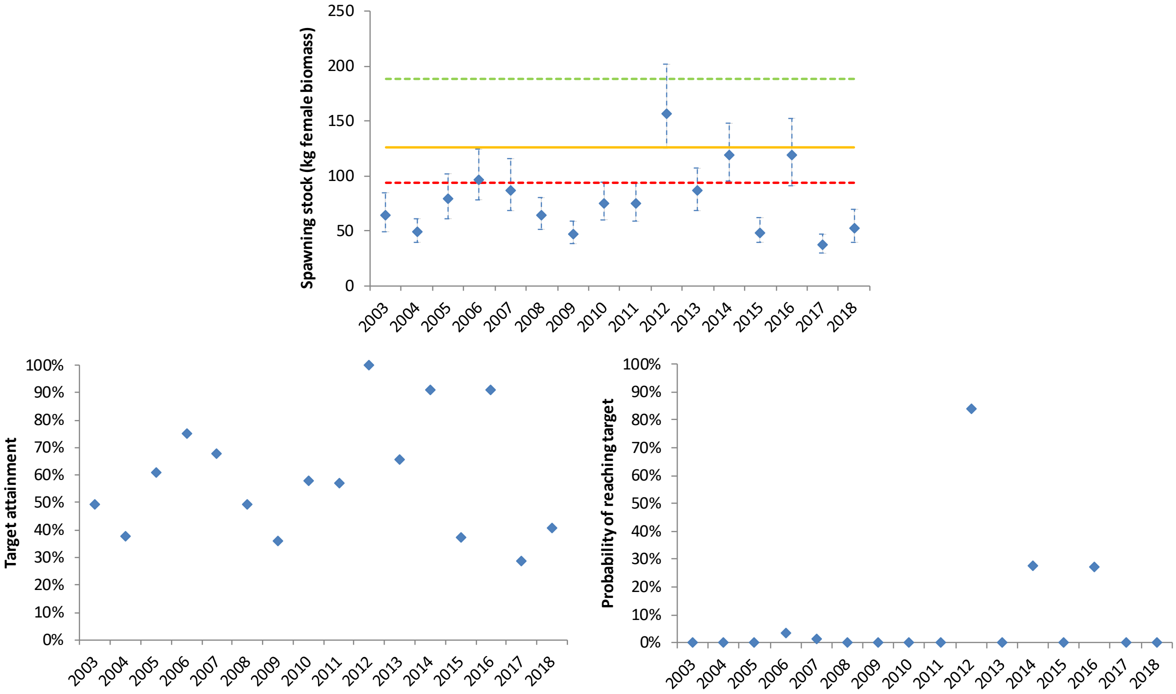


Figure 38. The estimated spawning stock (top row), percent truncated spawning target attainment (bottom row, left) and probability of reaching the spawning target (bottom row, right) in the period 2003-2018 in the Finnish tributary Áhkojohka/Akujoki.

3.12.2 Exploitation

The estimated total exploitation rate (based on weight) of Áhkojohka/Akujoki salmon was 81 % in the years 2015-2018 (Figure 39), with 17 % of the pre-fishery abundance caught in coastal fisheries, 63 % in main stem fisheries and 0 % in Áhkojohka/Akujoki. The average estimated total pre-fishery abundance for Áhkojohka/Akujoki salmon was 712 kg and the average total catch was 573 kg in the period 2015-2018.

The estimated exploitation distribution comes with one important cautionary note. The distribution is based on genetic stock identification of salmon catch samples from the Tana main stem and coastal areas. The small tributaries along the upper part of the Tana main stem are relatively similar in genetic structure and are therefore not easily separated in the genetic stock identification. Given that the distribution shown in Figure 39 deviates from the exploitation patterns of other tributaries in Tana, it seems likely that the procedure currently overestimates the coastal and main stem catch of Áhkojohka/Akujoki salmon.

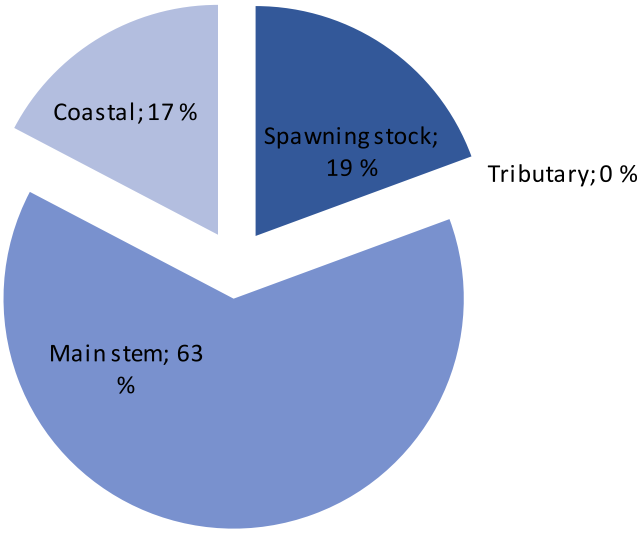


Figure 39. The total amount of salmon belonging to Áhkojohka/Akujoki in 2015-2018, distributed into surviving spawning stock and salmon caught in fisheries in either coastal, main stem or Áhkojohka/Akujoki fisheries. The percentages in the figure represent the proportion of the pre-fishery abundance that survives to spawning or are caught in coastal, main stem or tributary fisheries.

Estimated relative exploitation efficiencies (based on weight) in areas in various periods are given in Table 26.

Table 26. Relative exploitation rates of Áhkojohka/Akujoki salmon in different areas (based on weight) in three periods. First column is the years 2015-2018, corresponding to the management target-period. Second column is the years 2006-2016, corresponding to the years with available data before the new agreement. The third column is 2018, the most recent year and the first year with good monitoring data after the new agreement.

	2015-2018	2006-2016	2018
Coastal	17 %	16 %	19 %
Main stem	76 %	75 %	74 %
Tributary	0 %	0 %	0 %

The relative exploitation efficiencies represent the proportion of surviving salmon that are caught in an area. So, for instance, the main stem efficiency estimate is the estimated main stem catch of Áhkojohka/Akujoki salmon divided by the estimated amount of salmon that have survived the coastal fisheries.

In the years 2015-2018, overexploitation varied between 6 % (2016) and 70 % (2017). The average overexploitation was estimated at 49 %. Maximum sustainable exploitation varied between 49 % (2017) and 73 % (2016). The average maximum sustainable total exploitation rate in the period was 59 %, lower than the estimated average total exploitation of 81 %. Again, the above-mentioned caution must be heeded. The estimate of maximum sustainable exploitation depends on the distributed catch in the main stem and along the coast which might be overestimated. This would lead to an equally overestimated maximum sustainable exploitation estimate.

3.12.3 Stock recovery

In the previous report (Anon. 2018), we advised an 8 % reduction in the total river exploitation rate of Áhkojohka/Akujoki salmon from the 2006-2016 level in order to achieve stock recovery over two generations. The current evaluation shows that river exploitation has been reduced from 76 to 74 %, which corresponds to a 2 % reduction in exploitation. This level of reduction is not sufficiently high to allow for stock recovery after two generations. One note of caution here, however, the main stem exploitation estimate is based on genetic data that likely overestimates the exploitation rate of salmon from Áhkojohka/Akujoki. This will have to be addressed with more accurate genetic methods in the coming years.

3.13 Kárášjohka + tributaries

The confluence of Anárjohka (Inarijoki) and Kárášjohka forms the Tana main stem. Close to 40 km upstream, Kárášjohka meets Iešjohka at Skáidegeahči. The lowermost 40 km are relatively slow-flowing with sandy bottom, only a couple of places have higher water velocity and suitable conditions for salmon spawning. Above the confluence with Iešjohka, conditions in Kárášjohka become much better suited for salmon. There are several rapids and some waterfalls in Kárášjohka, with Šuorpmogorzi forming a partial obstacle. Electrofishing show, however, that salmon are able to pass and spawn above this waterfall. There is one major tributary, Bávttajohka, approximately 98 km upstream from Skáidegeahči. In this tributary, close to 40 km is available for salmon. Just downstream of the confluence between Kárášjohka and Iešjohka, there is another smaller tributary, Geaimmejohka, with 10 km available for salmon. The status assessment in this chapter is a combined evaluation of Kárášjohka and the tributaries Bávttajohka and Geaimmejohka.

3.13.1 Status assessment

The spawning target of Kárášjohka and its tributaries Bávttajohka and Geaimmejohka is 14 037 323 eggs (10 527 992-21 055 983 eggs). The female biomass needed to obtain this egg deposition is 7 290 kg (5 468-10 936 kg) when using stock-specific fecundities.

The following basic formula estimates the annual spawning stock size for Kárášjohka:

*Spawning stock size = ((Catch / Exploitation rate) - Catch) * Female proportion*

The data input for the variables in this formula are summarized in Table 27. Female proportions in Table 27 in the years 2006-2008 and 2011-2012 are based on Tana main stem stock-identified samples from the Genmix project, while female proportions in the other years are the 5-year average from Genmix.

There was acoustic fish counting in 2010, 2012 and 2017-2018 at Heastanjárga, below the upper bridge over Kárášjohka, approximately 5 km upstream from Skáidegeahči. These counts provided an estimate of the number of salmon of different size groups that migrated up into the upper part of Kárášjohka. The estimated exploitation rates in 2010 and 2012, in combination with the estimated catch of Kárášjohka-salmon downstream of the counting site, gave an estimated exploitation rate of

25 % for salmon <3 kg and 45 % for salmon >3 kg in the period 2006-2016. The estimate for 2017 was lower and 13 % was used for salmon <3 kg and 33 % for salmon >3 kg. Fish counting in 2018 indicated a further reduced exploitation, down to 10 % for salmon <7 kg and 20 % for salmon >7 kg (Table 27).

Table 27. Summary of stock data used to estimate annual spawning stock sizes in Kárášjohka.

Year	Catch (<3 kg)	Catch (3-7 kg)	Catch (>7 kg)	Expl. rate (<3 kg)	Expl. rate (3-7 kg)	Expl. rate (>7 kg)	Female prop. (<3 kg)	Female prop. (3-7 kg)	Female prop. (>7 kg)
2006	1 615	1 250	1 011	0.25	0.45	0.45	0.09	0.79	0.73
2007	252	1 254	687	0.25	0.45	0.45	0.23	0.70	0.82
2008	235	1 140	2 527	0.25	0.45	0.45	0.25	0.69	0.72
2009	439	287	572	0.25	0.45	0.45	0.09	0.71	0.73
2010	464	882	1 123	0.25	0.45	0.45	0.09	0.71	0.73
2011	472	898	1 098	0.25	0.45	0.45	0.06	0.73	0.73
2012	1 196	1 510	1 089	0.25	0.45	0.45	0.06	0.63	0.67
2013	541	1 314	1 084	0.25	0.45	0.45	0.09	0.71	0.73
2014	736	1 208	1 440	0.25	0.45	0.45	0.09	0.71	0.73
2015	412	1 665	1 535	0.25	0.45	0.45	0.09	0.71	0.73
2016	237	733	2 022	0.25	0.45	0.45	0.09	0.71	0.73
2017	115	517	1 395	0.13	0.33	0.33	0.09	0.71	0.73
2018	325	397	587	0.10	0.10	0.20	0.09	0.71	0.73

To account for uncertainty, the exploitation rate and female proportion estimates in Table 27 were treated as modal values, with a 10 % uncertainty used to estimate minimum and maximum values of exploitation and 10 % uncertainty used for female proportions. The modal, minimum and maximum values were then used to construct a triangular probability distribution for exploitation and female proportion, and these distributions in combination with catches result in triangular probability distributions for the spawning stock estimates. A similar triangular probability distribution was constructed for the spawning target, using 7 290 kg as the mode, 5 468 kg as the minimum and 10 936 kg as the maximum value.

A Monte Carlo simulation with 10 000 iterations was then used to compare the spawning stock distribution with the spawning target distribution. For each iteration, one number is randomly drawn from the spawning stock distribution and one number drawn from the spawning target distribution. The average extent that the spawning stock distribution exceeds the spawning target distribution becomes the spawning target attainment. The proportion of the iterations where the random spawning stock size exceeds the random spawning target becomes the probability that the stock had enough spawners.

The spawning target attainment was 59 % in 2018 and the probability for meeting the spawning target was 0 %. The management target was not reached, as the last 4 years' (2015-2018) overall probability of reaching the spawning target was 0 % with an overall attainment of 42 % (Figure 40).

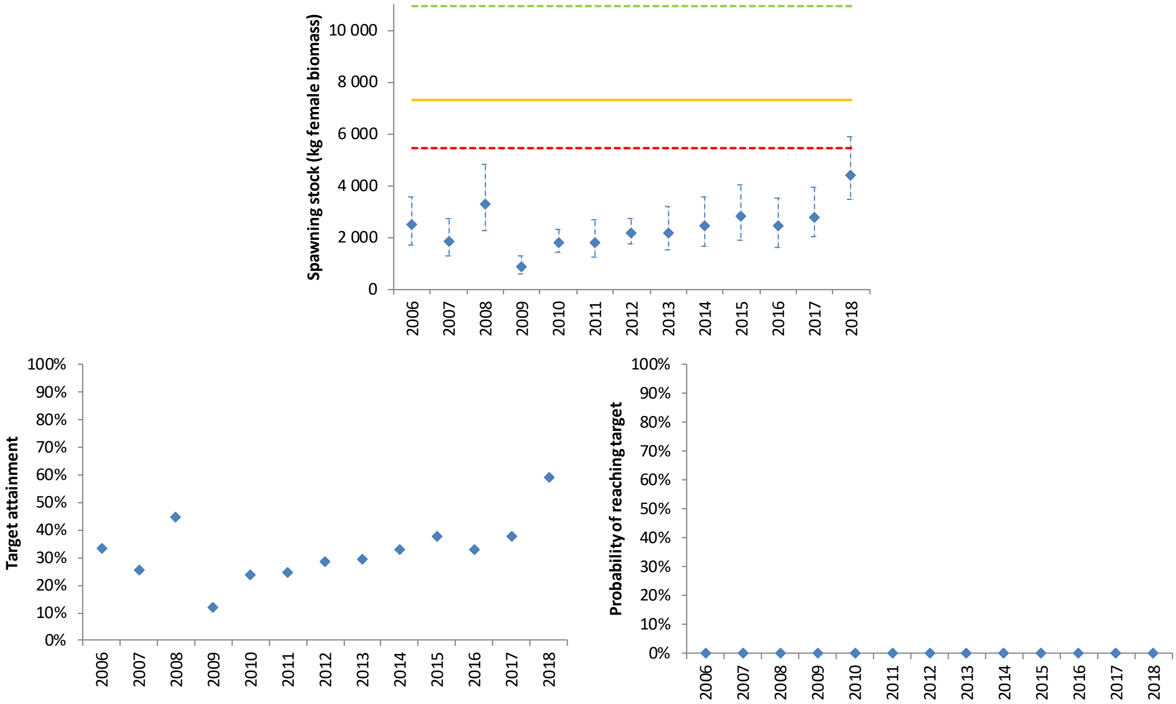


Figure 40. The estimated spawning stock (top row), percent truncated spawning target attainment (bottom row, left) and probability of reaching the spawning target (bottom row, right) in the period 2006-2018 in the Norwegian tributary Kárášjohka.

3.13.2 Exploitation

The estimated total exploitation rate (based on weight) of Kárášjohka salmon was 70 % in the years 2015-2018 (Figure 41), with 16 % of the pre-fishery abundance caught in coastal fisheries, 39 % in main stem fisheries and 15 % in Kárášjohka. The average estimated total pre-fishery abundance for Kárášjohka salmon was 16 440 kg and the average total catch was 11 487 kg in the period 2015-2018.

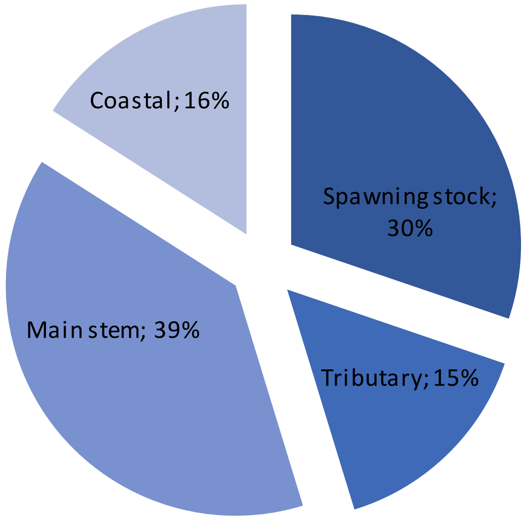


Figure 41. The total amount of salmon belonging to Kárášjohka in 2015-2018, distributed into surviving spawning stock and salmon caught in fisheries in either coastal, main stem or Kárášjohka fisheries. The percentages in the figure represent the proportion of the pre-fishery abundance that survives to spawning or are caught in coastal, main stem or tributary fisheries.

Estimated relative exploitation efficiencies (based on weight) in areas in various periods are given in Table 28.

Table 28. Relative exploitation rates of Kárášjohka salmon in different areas (based on weight) in three periods. First column is the years 2015-2018, corresponding to the management target-period. Second column is the years 2006-2016, corresponding to the years with available data before the new agreement. The third column is 2018, the most recent year and the first year with good monitoring data after the new agreement.

	2015-2018	**2006-2016**	**2018**
Coastal	16 %	14 %	19 %
Main stem	46 %	56 %	34 %
Tributary	33 %	45 %	14 %

The relative exploitation efficiencies represent the proportion of surviving salmon that are caught in an area. So, for instance, the main stem efficiency estimate is the estimated main stem catch of Kárášjohka salmon divided by the estimated amount of salmon that have survived the coastal fisheries.

In the years 2015-2018, overexploitation varied between 39 % (2018) and 67 % (2016). The average overexploitation was estimated at 57 %. This means that exploitation on average was responsible for reducing the spawning stock size by an amount of 57 % below the spawning target. Maximum sustainable exploitation varied between 15 % (2015, 2017) and 25 % (2016). The average maximum sustainable total exploitation rate in the period was 18 %, significantly lower than the estimated average total exploitation of 70 %.

3.13.3 Stock recovery

In the previous report (Anon. 2018), we advised a 23 % reduction in the total river exploitation rate of Kárášjohka salmon from the 2006-2016 level in order to achieve stock recovery over two generations. The current evaluation shows that river exploitation has been reduced from 76 to 43 %, which corresponds to a 43 % reduction in exploitation. This level of reduction is sufficiently high to allow for stock recovery after one generation.

3.14 Iešjohka

Iešjohka is one of the three large rivers that together form the Tana main stem. Iešjohka flows into the Kárášjohka at Skáidegeahči, and the Kárášjohka then flows close to 40 km before meeting Anárjohka, thereby forming the Tana main stem. The Iešjohka is a relatively fast-flowing river, with riffles and rapids of varying lengths spaced out by large slow flowing pools. The only major obstacle for salmon is a waterfall approximately 75 km upstream. Salmon can pass this waterfall, at least at low water levels.

3.14.1 Status assessment

The Iešjohka spawning target is 11 536 009 eggs (8 127 759-17 304 014 eggs). The female biomass needed to obtain this egg deposition is 6 072 kg (4 278-9 107 kg) when using a stock-specific fecundity of 1 900 eggs kg^{-1}.

The following basic formula estimates the annual spawning stock size for Iešjohka:

*Spawning stock size = ((Catch / Exploitation rate) - Catch) * Female proportion*

The data input for the variables in this formula are summarized in Table 29. Female proportions in Table 29 in the years 2006-2008 and 2011-2012 are based on Tana main stem stock-identified samples from the Genmix project, while female proportions in the other years are the 5-year average from Genmix.

There have so far been no attempts at counting salmon in Iešjohka. We do, however, have one year with fish counting in the neighbouring Kárášjohka and with corresponding genetic identification of Tana main stem samples. The run timing and size composition of salmon belonging to Kárášjohka and Iešjohka is very similar, and it is therefore reasonable to expect that salmon from both stocks are subject to the same exploitation in the Tana main stem. Given this assumption, the ratio of salmon entering Iešjohka and salmon entering upper Kárášjohka should equal the ratio of Iešjohka and Kárášjohka salmon in the main stem. The resulting exploitation rate of the Iešjohka fishery becomes 15 % for salmon <3 kg and 35 % for salmon >3 kg. Some salmon from Iešjohka is also exploited in the lower Kárášjohka, this catch increase the Iešjohka exploitation estimate with 5 % for all size groups, and we used 20 % for salmon <3 kg and 40 % for salmon >3 kg in the period 2006-2016.

In 2017, very few fishermen were active in Iešjohka and fishing conditions were severe in the first half of the fishing season. Comparing Iešjohka with the neighbouring Kárášjohka indicate a highly significantly lowered exploitation in Iešjohka in 2017. We reduced the exploitation estimate by 50 % in 2017. In 2018 results from the neighbouring Kárášjohka indicate continued low exploitation and the exploitation estimate in Iešjohka was set equal to Kárášjohka (Table 29).

To account for uncertainty, the exploitation rate and female proportion estimates in Table 29 were treated as modal values, with a 10 % uncertainty used to estimate minimum and maximum values of exploitation and 10 % uncertainty used for female proportions. The modal, minimum and maximum values were then used to construct a triangular probability distribution for exploitation and female proportion, and these distributions in combination with catches result in triangular probability distributions for the spawning stock estimates. A similar triangular probability distribution was constructed for the spawning target, using 6 072 kg as the mode, 4 278 kg as the minimum and 9 107 kg as the maximum value.

Table 29. Summary of stock data used to estimate annual spawning stock sizes in Iešjohka.

Year	Catch (<3 kg)	Catch (3-7 kg)	Catch (>7 kg)	Expl. rate (<3 kg)	Expl. rate (3-7 kg)	Expl. rate (>7 kg)	Female prop. (<3 kg)	Female prop. (3-7 kg)	Female prop. (>7 kg)
2006	1 690	1 137	1 672	0.20	0.40	0.40	0.09	0.69	0.64
2007	204	775	1 464	0.20	0.40	0.40	0.17	0.77	0.76
2008	237	953	3 132	0.20	0.40	0.40	0.18	0.50	0.73
2009	347	209	683	0.20	0.40	0.40	0.10	0.66	0.69
2010	269	416	869	0.20	0.40	0.40	0.10	0.66	0.69
2011	393	465	1 215	0.20	0.40	0.40	0.02	0.61	0.66
2012	569	708	1 209	0.20	0.40	0.40	0.12	0.65	0.64
2013	264	644	1 391	0.20	0.40	0.40	0.10	0.66	0.69
2014	400	721	1 711	0.20	0.40	0.40	0.10	0.66	0.69
2015	162	592	1 309	0.20	0.40	0.40	0.10	0.66	0.69
2016	121	290	1 559	0.20	0.40	0.40	0.10	0.66	0.69
2017	69	210	873	0.10	0.20	0.20	0.10	0.66	0.69
2018	314	227	445	0.10	0.10	0.20	0.10	0.66	0.69

A Monte Carlo simulation with 10 000 iterations was then used to compare the spawning stock distribution with the spawning target distribution. For each iteration, one number is randomly drawn from the spawning stock distribution and one number drawn from the spawning target distribution. The average extent that the spawning stock distribution exceeds the spawning target distribution becomes the spawning target attainment. The proportion of the iterations where the random spawning stock size exceeds the random spawning target becomes the probability that the stock had enough spawners.

The spawning target attainment was 46 % in 2018 and the probability of meeting the spawning target was 0 %. The management target was not reached, as the last 4 years' (2015-2018) overall probability of reaching the spawning target was 0 % with an overall attainment of 39 % (Figure 42).

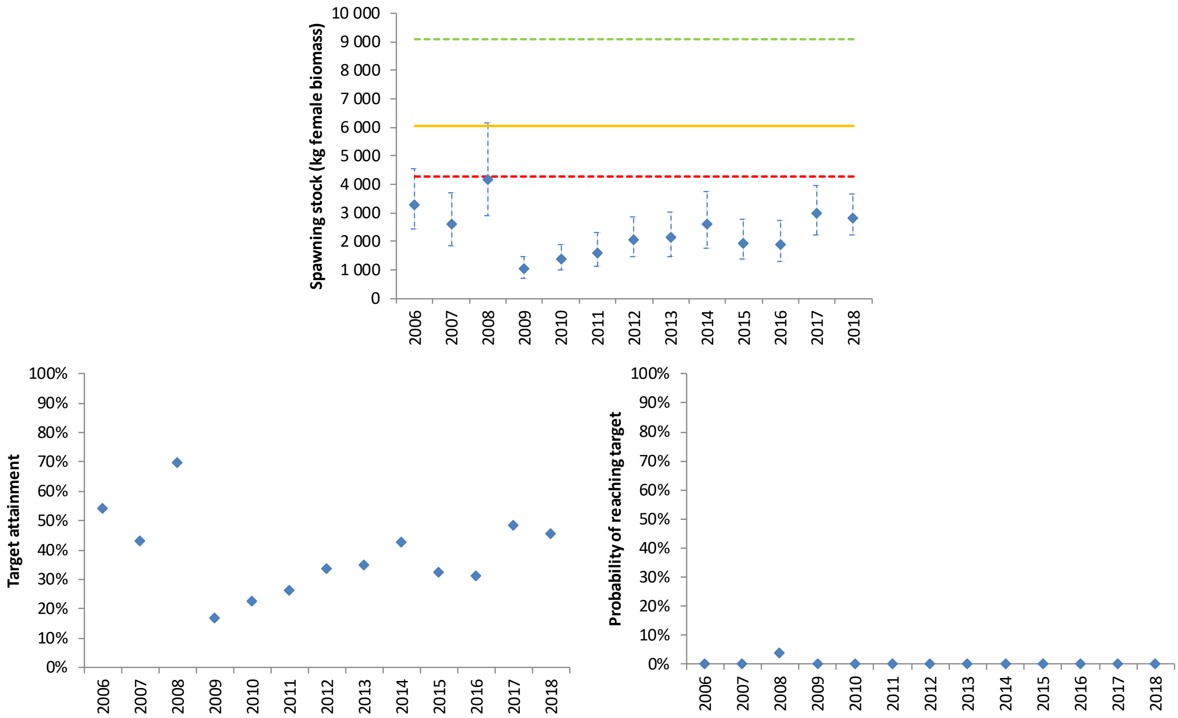


Figure 42. The estimated spawning stock (top row), percent truncated spawning target attainment (bottom row, left) and probability of reaching the spawning target (bottom row, right) in the period 2006-2018 in the Norwegian tributary Iešjohka.

3.14.2 Exploitation

The estimated total exploitation rate (based on weight) of Iešjohka salmon was 72 % in the years 2015-2018 (Figure 43), with 17 % of the pre-fishery abundance caught in coastal fisheries, 44 % in main stem fisheries and 11 % in Iešjohka. The average estimated total pre-fishery abundance for Iešjohka salmon was 14 369 kg and the average total catch was 10 294 kg in the period 2015-2018.

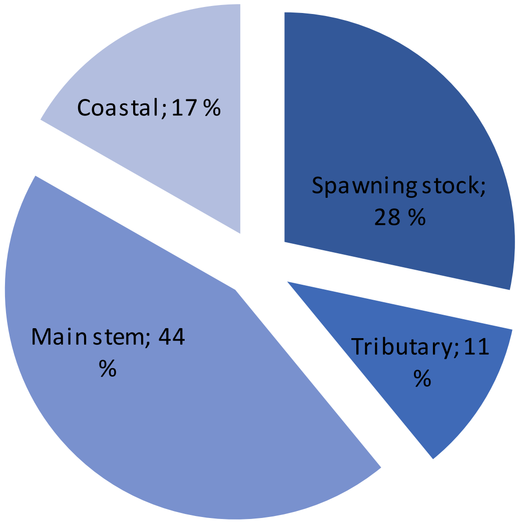


Figure 43. The total amount of salmon belonging to Iešjohka in 2015-2018, distributed into surviving spawning stock and salmon caught in fisheries in either coastal, main stem or Iešjohka fisheries. The percentages in the figure represent the proportion of the pre-fishery abundance that survives to spawning or are caught in coastal, main stem or tributary fisheries.

Estimated relative exploitation efficiencies (based on weight) in areas in various periods are given in Table 30.

Table 30. Relative exploitation rates of Iešjohka salmon in different areas (based on weight) in three periods. First column is the years 2015-2018, corresponding to the management target-period. Second column is the years 2006-2016, corresponding to the years with available data before the new agreement. The third column is 2018, the most recent year and the first year with good monitoring data after the new agreement.

	2015-2018	**2006-2016**	**2018**
Coastal	17 %	15 %	19 %
Main stem	53 %	57 %	41 %
Tributary	27 %	39 %	15 %

The relative exploitation efficiencies represent the proportion of surviving salmon that are caught in an area. So, for instance, the main stem efficiency estimate is the estimated main stem catch of Iešjohka salmon divided by the estimated amount of salmon that have survived the coastal fisheries.

In the years 2015-2018, overexploitation varied between 51 % (2017) and 69 % (2016). The average overexploitation was estimated at 60 %. This means that exploitation on average was responsible for reducing the spawning stock size by an amount of 60 % below the spawning target. Maximum sustainable exploitation varied between 5 % (2018) and 31 % (2016). The average maximum sustainable total exploitation rate in the period was 21 %, significantly lower than the estimated average total exploitation of 72 %.

3.14.3 Stock recovery

In the previous report (Anon. 2018), we advised a 22 % reduction in the total river exploitation rate of Iešjohka salmon from the 2006-2016 level in order to achieve stock recovery over two generations. The current evaluation shows that river exploitation has been reduced from 74 to 49 %, which corresponds to a 33 % reduction in exploitation. This level of reduction is sufficiently high to allow for stock recovery after one generation.

3.15 Anárjohka/Inarijoki + tributaries

Anárjohka/Inarijoki is one of the three large headwater rivers that together form the Tana main stem. The lower 83 km of Anárjohka/Inarijoki are border areas between Norway and Finland, while the remaining uppermost 10 km are Norwegian only. The salmon are efficiently stopped at the 12-15 m high Gumpegorži. There are several tributaries with salmon stocks on both sides of the river. The lowermost tributary is Gáregasjohka/Karigasjoki on the Finnish side with a production potential of 3 % of the total potential of the Anárjohka/Inarijoki river system. Further up we find the small Iškorasjohka (1 % of the production area), Goššjohka (29 %) and at the top Skiehččanjohka/Kietsimäjoki (2 %). There is one tributary on the Finnish side, Vuomajoki, that is missing a spawning target and therefore is not included in the evaluation. Recent observations, however, indicate salmon reproduction occurring also in Vuomajoki.

3.15.1 Status assessment

The Anárjohka/Inarijoki (+tributaries) spawning target is 17 699 952 eggs (13 221 714-26 549 928 eggs). The female biomass needed to obtain this egg deposition is 7 937 kg (5 928-11 906 kg) when using stock-specific fecundities.

The following basic formula estimates the annual spawning stock size for Anárjohka/Inarijoki:

*Spawning stock size = ((Catch / Exploitation rate) - Catch) * Female proportion*

The data input for the variables in this formula are summarized in Table 31. Female proportions in Table 31 in the years 2006-2008 and 2011-2012 are based on Tana main stem stock-identified samples from the Genmix project, while female proportions in the other years are based on the size composition of the catch and the 5-year Genmix average female proportion of different size groups.

There have been no attempts at counting salmon in Anárjohka/Inarijoki before 2018. By comparing the main stem catch proportion of Anárjohka/Inarijoki (+tributaries) salmon and the proportion of neighbouring Kárášjohka salmon in 2012, we get an estimated exploitation rate in Anárjohka/Inarijoki of approximately 25 %. We used this exploitation rate throughout the period 2006-2016. In 2017, a combination of difficult fishing conditions, few active fishermen and new regulatory measures aimed at decreasing exploitation likely led to significantly reduced exploitation. Sonar counting in Anárjohka/Inarijoki in 2018 indicate an exploitation rate of 0.125 and this estimate was used both for 2017 and 2018 (Table 31).

To account for uncertainty, the exploitation rate and female proportion estimates in Table 31 were treated as modal values, with a 20 % uncertainty used to estimate minimum and maximum values of exploitation and 10 % uncertainty used for female proportions. The modal, minimum and maximum values were then used to construct a triangular probability distribution for exploitation and female proportion, and these distributions in combination with catches result in triangular probability distributions for the spawning stock estimates. A similar triangular probability distribution was constructed for the spawning target, using 6 072 kg as the mode, 4 278 kg as the minimum and 9 107 kg as the maximum value.

Table 31. Summary of stock data used to estimate annual spawning stock sizes in Anárjohka/Inarijoki.

Year	Catch (kg)	Exploitation rate	Female proportion
2006	4 137	0.25	0.47
2007	2 266	0.25	0.74
2008	2 323	0.25	0.64
2009	2 005	0.25	0.45
2010	2 442	0.25	0.62
2011	1 908	0.25	0.45
2012	4 285	0.25	0.50
2013	1 986	0.25	0.62
2014	2 832	0.25	0.60
2015	1 881	0.25	0.65
2016	1 654	0.25	0.57
2017	639	0.125	0.64
2018	788	0.125	0.51

A Monte Carlo simulation with 10 000 iterations was then used to compare the spawning stock distribution with the spawning target distribution. For each iteration, one number is randomly drawn from the spawning stock distribution and one number drawn from the spawning target distribution. The average extent that the spawning stock distribution exceeds the spawning target distribution becomes the spawning target attainment. The proportion of the iterations where the random spawning stock size exceeds the random spawning target becomes the probability that the stock had enough spawners.

The spawning target attainment was 34 % in 2018 and the probability of meeting the spawning target was 0 %. The management target was not reached, as the last 4 years' (2015-2018) overall probability of reaching the spawning target was 0 % with an overall attainment of 39 % (Figure 44).

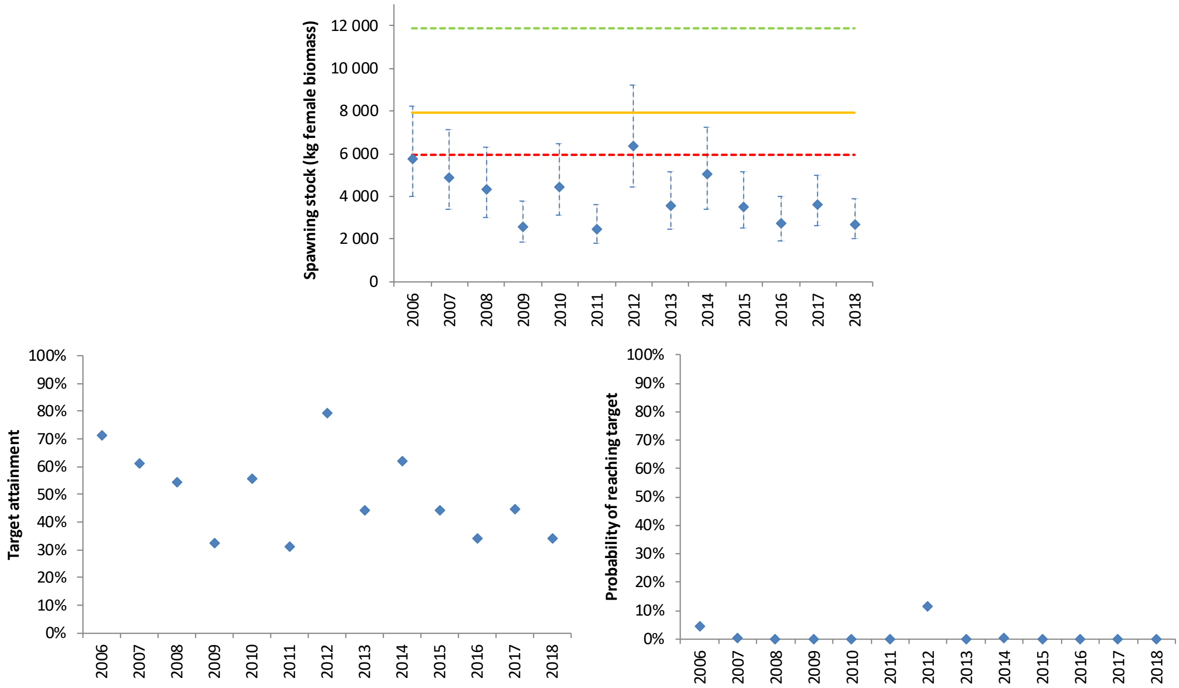


Figure 44. The estimated spawning stock (top row), percent truncated spawning target attainment (bottom row, left) and probability of reaching the spawning target (bottom row, right) in the period 2006-2018 in the tributary Anárjohka/Inarijoki.

3.15.2 Exploitation

The estimated total exploitation rate (based on weight) of Anárjohka/Inarijoki salmon was 71 % in the years 2015-2018 (Figure 45), with 17 % of the pre-fishery abundance caught in coastal fisheries, 48 % in main stem fisheries and 7 % in Anárjohka/Inarijoki. The average estimated total pre-fishery abundance for Anárjohka/Inarijoki salmon was 18 469 kg and the average total catch was 13 195 kg in the period 2015-2018.

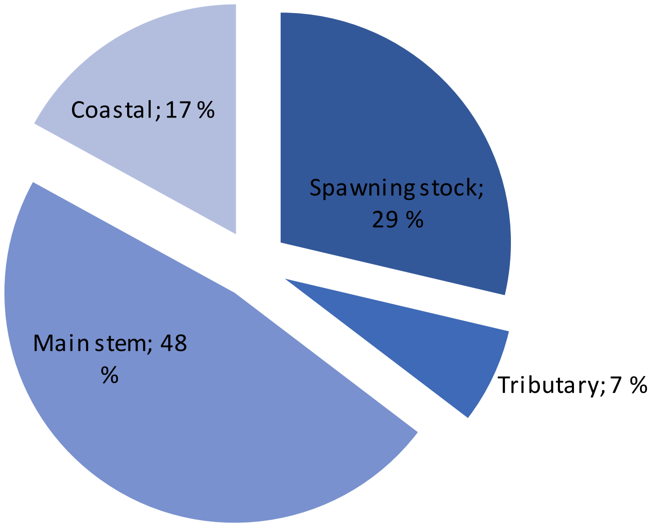


Figure 45. The total amount of salmon belonging to Anárjohka/Inarijoki in 2015-2018, distributed into surviving spawning stock and salmon caught in fisheries in either coastal, main stem or Anárjohka/Inarijoki fisheries. The percentages in the figure represent the proportion of the pre-fishery abundance that survives to spawning or are caught in coastal, main stem or tributary fisheries.

Estimated relative exploitation efficiencies (based on weight) in areas in various periods are given in Table 32.

Table 32. Relative exploitation rates of Anárjohka/Inarijoki salmon in different areas (based on weight) in three periods. First column is the years 2015-2018, corresponding to the management target-period. Second column is the years 2006-2016, corresponding to the years with available data before the new agreement. The third column is 2018, the most recent year and the first year with good monitoring data after the new agreement.

	2015-2018	2006-2016	2018
Coastal	17 %	15 %	19 %
Main stem	58 %	55 %	51 %
Tributary	19 %	26 %	13 %

The relative exploitation efficiencies represent the proportion of surviving salmon that are caught in an area. So, for instance, the main stem efficiency estimate is the estimated main stem catch of Anárjohka/Inarijoki salmon divided by the estimated amount of salmon that have survived the coastal fisheries.

In the years 2015-2018, overexploitation varied between 54 % (2017) and 66 % (2016). The average overexploitation was estimated at 60 %. This means that exploitation on average was responsible for reducing the spawning stock size by an amount of 60 % below the spawning target. Maximum sustainable exploitation varied between 0 % (2018) and 31 % (2015). A maximum exploitation of 0 % indicates no exploitable surplus. The average maximum sustainable total exploitation rate in the period was 22 %, significantly lower than the estimated average total exploitation of 71 %.

3.15.3 Stock recovery

In the previous report (Anon. 2018), we advised a 22 % reduction in the total river exploitation rate of Anárjohka/Inarijoki salmon from the 2006-2016 level in order to achieve stock recovery over two generations. The current evaluation shows that river exploitation has been reduced from 67 to 57 %, which corresponds to a 15 % reduction in exploitation. This level of reduction is not sufficiently high to allow for stock recovery after two generations.

3.16 Tana/Teno (total)

3.16.1 Status assessment

This chapter evaluates the Tana/Teno river system and its stock complex as if it was a single-stock system. This is accomplished by pooling all spawning targets into one total target for the entire river. The pooled target can then be evaluated by combining the annual total catch statistic with an estimate of the total exploitation rate in the river system.

The Tana/Teno total spawning target is 104 487 286 eggs (77 005 421-155 648 837 eggs). The female biomass needed to obtain this egg deposition is 51 846 kg (38 277-77 371 kg) when using stock-specific fecundities.

The following basic formula estimates the annual spawning stock size for Tana/Teno (total):

*Spawning stock size = ((Catch / Exploitation rate) - Catch) * Female proportion*

The data input for the variables in this formula are summarized in Table 33. Female proportions in Table 33 are based on long-term scale data. The exploitation rates are based on the combined catch distribution estimates of the stock-specific evaluations above.

To account for uncertainty, the exploitation rate and female proportion estimates in Table 33 were treated as modal values, with a 20 % uncertainty used to estimate minimum and maximum values of exploitation and 10 % uncertainty used for female proportions. The modal, minimum and maximum values were then used to construct a triangular probability distribution for exploitation and female proportion, and these distributions in combination with catches result in triangular probability distributions for the spawning stock estimates. A similar triangular probability distribution was constructed for the spawning target, using 51 846 kg as the mode, 38 277 kg as the minimum and 77 371 kg as the maximum value.

A Monte Carlo simulation with 10 000 iterations was then used to compare the spawning stock distribution with the spawning target distribution. For each iteration, one number is randomly drawn from the spawning stock distribution and one number drawn from the spawning target distribution. The average extent that the spawning stock distribution exceeds the spawning target distribution becomes the spawning target attainment. The proportion of the iterations where the random spawning stock size exceeds the random spawning target becomes the probability that the stock had enough spawners.

Table 33. Summary of stock data used to estimate annual spawning stock sizes of the Tana/Teno river system.

Year	Total catch (kg)	Exploitation rate	Female proportion
1993	152 635	0.6	0.49
1994	131 878	0.6	0.63
1995	104 631	0.6	0.49
1996	88 832	0.6	0.51
1997	92 506	0.6	0.43
1998	102 627	0.6	0.46
1999	143 821	0.6	0.44
2000	209 532	0.6	0.50
2001	248 585	0.6	0.55
2002	190 107	0.6	0.56
2003	153 738	0.6	0.58
2004	69 994	0.6	0.59
2005	77 190	0.6	0.52
2006	108 596	0.6	0.42
2007	100 542	0.6	0.67
2008	121 860	0.6	0.64
2009	63 499	0.6	0.50
2010	87 058	0.6	0.56
2011	79 342	0.6	0.54
2012	108 794	0.6	0.46
2013	79 883	0.6	0.56
2014	99 236	0.6	0.49
2015	78 124	0.6	0.60
2016	84 744	0.6	0.58
2017	60 610	0.55	0.62
2018	49 349	0.4	0.50

The spawning target attainment was 69 % in 2018 and the probability of meeting the spawning target was 4 %. The management target was not reached, as the last 4 years' (2015-2018) overall probability of reaching the spawning target was 2 % with an overall attainment of 63 % (Figure 46).

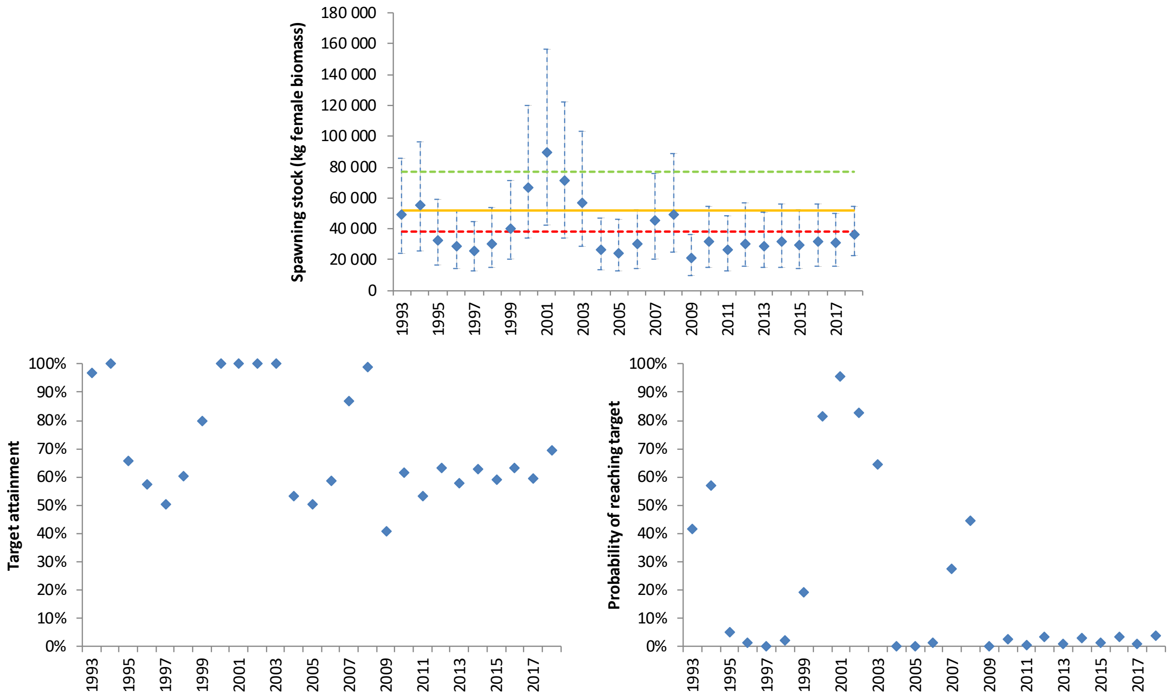


Figure 46. The estimated spawning stock (top row), percent truncated spawning target attainment (bottom row, left) and probability of reaching the spawning target (bottom row, right) in the period 1993-2018 for Tana/Teno (total).

3.16.2 Exploitation

The estimated total exploitation rate (based on weight) of Tana/Teno (total) salmon was 62 % in the years 2015-2018 (Figure 47), with 17 % of the pre-fishery abundance caught in coastal fisheries and 45 % in river fisheries. The average estimated total pre-fishery abundance for Tana/Teno salmon was 151 326 kg and the average total catch was 93 774 kg in the period 2015-2018.

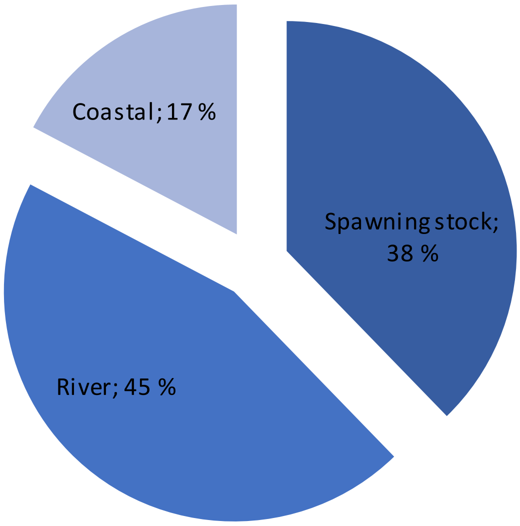


Figure 47. The total amount of salmon belonging to all Tana/Teno stocks in 2015-2018, distributed into surviving spawning stock and salmon caught in fisheries in either coastal or main stem fisheries. The percentages in the figure represent the proportion of the pre-fishery abundance that survives to spawning or are caught in coastal or main stem fisheries.

Estimated relative exploitation efficiencies (based on weight) in areas in various periods are given in Table 34.

Table 34. Relative exploitation rates of Tana/Teno salmon in different areas (based on weight) in three periods. First column is the years 2015-2018, corresponding to the management target-period. Second column is the years 2006-2016, corresponding to the years with available data before the new agreement. The third column is 2018, the most recent year and the first year with good monitoring data after the new agreement.

	2015-2018	**2006-2016**	**2018**
Coastal	17 %	16 %	19 %
Tana/Teno	54 %	62 %	40 %

The relative exploitation efficiencies represent the proportion of surviving salmon that are caught in an area. So, for instance, the main stem efficiency estimate is the estimated main stem catch of Tana MS salmon divided by the estimated amount of salmon that have survived the coastal fisheries.

4 Conclusions and further insights into the status assessment

Stock status over the last four years (2015-2018) was poor in 8 of the 15 stocks that we evaluated (Figure 48). The best status was found in Veahčajohka/Vetsijoki, Ohcejohka/Utsjoki, Goahppelašjohka/Kuoppilasjoki, and Leavvajohka. Stock status in Máskejohka decreased from the previous year, being now slightly below the management target (75% probability of attaining spawning target).

Of the stocks with poor status, the most important thing to note is the status of the upper main headwater areas of Kárášjohka, Iešjohka and Anárjohka/Inarijoki and of the Tana/Teno main stem. These areas had low target attainment and low exploitable surplus. These four areas constitute 84 % of the total Tana/Teno spawning target and over the last four years, these areas on average have lacked a total of over 30 000 kg female spawners to reach their management targets.

A lower than 40 % overall probability of reaching the spawning target over the last 4 years (corresponding to the orange colour in Figure 48) should, following NASCO guidelines, automatically trigger the formulation of a recovery plan for the affected stock. Eight of the 15 evaluated stocks are currently in this situation. In 2018, the assessment of stock status in some of the rivers was more precise than before since sonar counts were available from Tana/Teno main stem, Kárášjohka and Anárjohka/Inarijoki. However, few stocks with poor status still have little or no monitoring, like Báišjohka and Iešjohka. To minimize the risk of overestimating the spawning stock size, exploitation estimates for the non-monitored areas must be selected cautiously with broad uncertainty ranges. An implementation of a broad well-designed monitoring program would enable us to evaluate all areas with more precise knowledge-based estimates of exploitation.

The current stock status assessment makes no attempt to estimate any proportion of unreported catches in the different areas and the catch statistics of both countries are treated as an accurate representation of the actual catch in various parts of Tana. The MRG are looking at options of implementing such procedures as part of the assessment. The main consequence of including unreported catch in the assessment is that the target attainment will decrease.

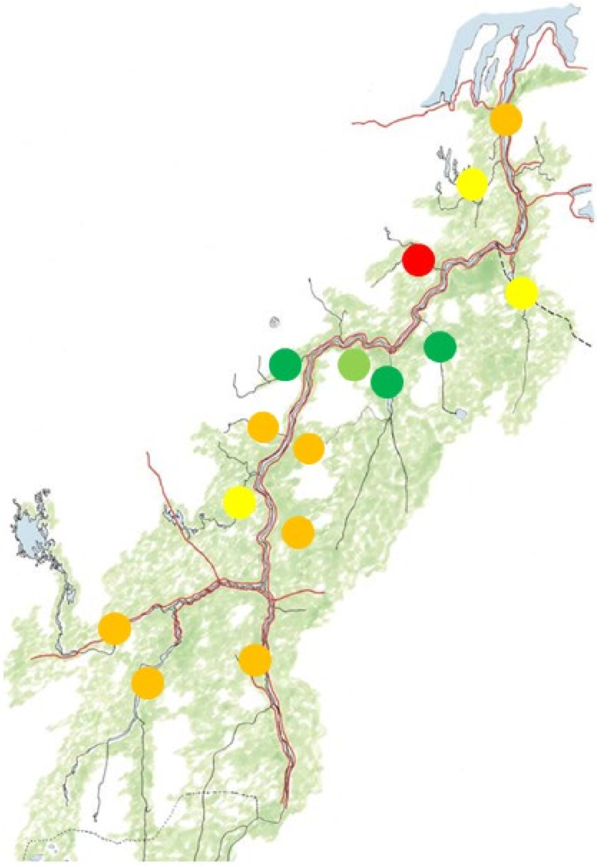


Figure 48. Map summary of the 2015-2018 stock status of the evaluated parts of the Tana/Teno river system. Symbol colour designates stock status over the last four years. Possible colours are: Dark green = overall probability of attaining spawning target higher than 75 %, overall target attainment over 140 %. Light green = overall probability of attaining spawning target higher than 75 %. Yellow = overall probability of attaining spawning target between 40 and 74 %, overall target attainment above 75 %. Orange = overall probability of attaining spawning target below 40 %, stock has had an exploitable surplus in at least 3 of the last 4 years. Red = stock had an exploitable surplus in less than 3 of the last 4 years.

Genetics were used to identify the home stock of main stem scale samples from the years 2006-2008 and 2011-2012. The scale samples from the lower Norwegian main stem can be used as an indication of how well the different stocks are doing in comparison to each other and their spawning target (Table 35). The lower main stem female catch proportions are an indication of the relative pre-fishery abundance of the different stocks, while the spawning target proportions are an indication of how large the different stocks are expected to be. Please note that this is not spawning target attainment proportions, but the relative percentages from the spawning targets for the respective areas (as they are detailed in Falkegård et al. 2014). So, if the catch proportion of a stock is higher than the spawning target proportion, that is an indication that the pre-fishery abundance of that stock is relatively high compared to other stocks. And a relatively high pre-fishery abundance would be the first indication that a stock is in relatively decent shape compared to the stocks that have a lower catch proportion.

Comparing Table 35 and Figure 48, we see that the stocks that do worst in the stock status assessment also are the stocks with a negative difference between lower main stem female catch proportion and spawning target proportion. Table 35 also indicates two other issues. First, that within the Ohcejohka/Utsjoki river system, the two tributaries Kevojoki and Tsarsjoki seem to do better than the Ohcejohka/Utsjoki main stem, while within the Anárjohka/Inarijoki system, the main source of the poor target attainment seem to be the Anárjohka/Inarijoki itself while the tributaries, particularly Goššjohka, seem to do better.

Table 35. Lower main stem female catch proportion (5-year average from the years 2006-2008, 2011-2012 that were genetically analysed from the scale samples in the Genmix-project) compared with spawning target proportions. A catch proportion smaller than the corresponding spawning target proportion indicates that a stock is doing worse than expected in comparison to other stocks, while a catch proportion higher than the corresponding spawning target proportion indicates a stock doing better than expected compared to other stocks. All percentages are rounded to nearest 0.5 %.

	Lower main stem female catch proportion	Spawning target proportion	Difference
Tana/Teno MS	40 %	43 %	-3 %
Máskejohka	5 %	3 %	2 %
Buolbmátjohka/Pulmankijoki	1 %	1 %	0 %
Lákšjohka	1.5 %	2 %	-0.5 %
Veahčajohka/Vetsijoki	5 %	2 %	3 %
Ohcejohka/Utsjoki (+tributaries)	6.5 %	4 %	2.5 %
Ohcejohka/Utsjoki main stem	1.5 %	2 %	-0.5 %
Kevojoki	3 %	1 %	2 %
Tsarsjoki	2 %	1 %	1 %
Goahppelašjohka/Kuoppilasjoki	1 %	0.5 %	0.5 %
Leavvajohka	1.5 %	0.5 %	1 %
Báišjohka	1 %	1 %	0 %
Njiljohka/Nilijoki	0.5 %	0.5 %	0 %
Váljohka	2 %	1.5 %	0.5 %
Áhkojohka/Akujoki	1 %	0 %	0 %
Kárášjohka (+tributaries)	10 %	14 %	-4 %
Iešjohka	10 %	12 %	-2 %
Anárjohka/Inarijoki (+tributaries)	13 %	15 %	-2 %
Anárjohka/Inarijoki	6.5 %	10 %	-3.5 %
Goššjohka	5.5 %	4.5 %	1 %
Other Anárjohka tributaries	1 %	1 %	0 %

As mentioned above, the main pattern summarized in Figure 48 is that the salmon stocks found in the three main headwater river systems, in addition to the Tana main stem (MS) stock, are doing worst in terms of stock status. This is an expected pattern, given that exploitation is the main impact factor affecting salmon stocks in Tana/Teno. The headwater stocks have the longest migration route and are affected by fisheries over the longest distances, and these stocks therefore experience the highest total exploitation rates in Tana/Teno. The Tana/Teno MS salmon is affected by the intensive main stem fisheries throughout the fishing season, while in comparison, tributary stocks escape the main stem fisheries as soon as they enter their respective home tributaries.

Estimates of overexploitation in the years 2015-2018 showed a significant effect on the salmon stocks in the upper headwater rivers and the main stem (Figure 49). When interpreting this result, it is highly important to remember the definition of overexploitation. It is defined as the reduction in spawning stock size below the spawning target that is caused by exploitation. The estimated pre-fishery abundance of different stocks tells us the amount of fish doing their spawning migration each year. Some of these fish are taken in coastal fisheries, some in main stem fisheries and some in their respective tributaries. For the overexploited stocks, the total catch exceeds the sustainable surplus.

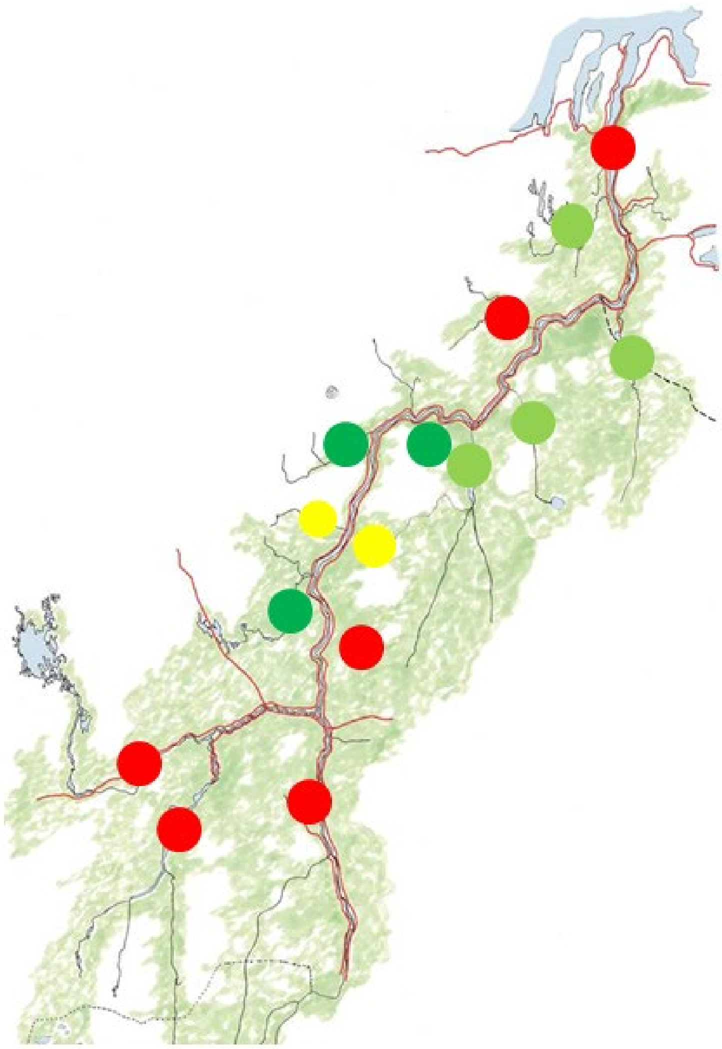


Figure 49. Map summary of the estimated overexploitation experienced in various parts of the Tana/Teno river system in the years 2015-2018. Symbol colour represents the extent of the overexploitation (in terms of percentages of the spawning target). Dark green = no effect (0 % of the spawning target), light green = small effect (<10 %), yellow = moderate effect (10-30 %), red = large effect (>30 %).

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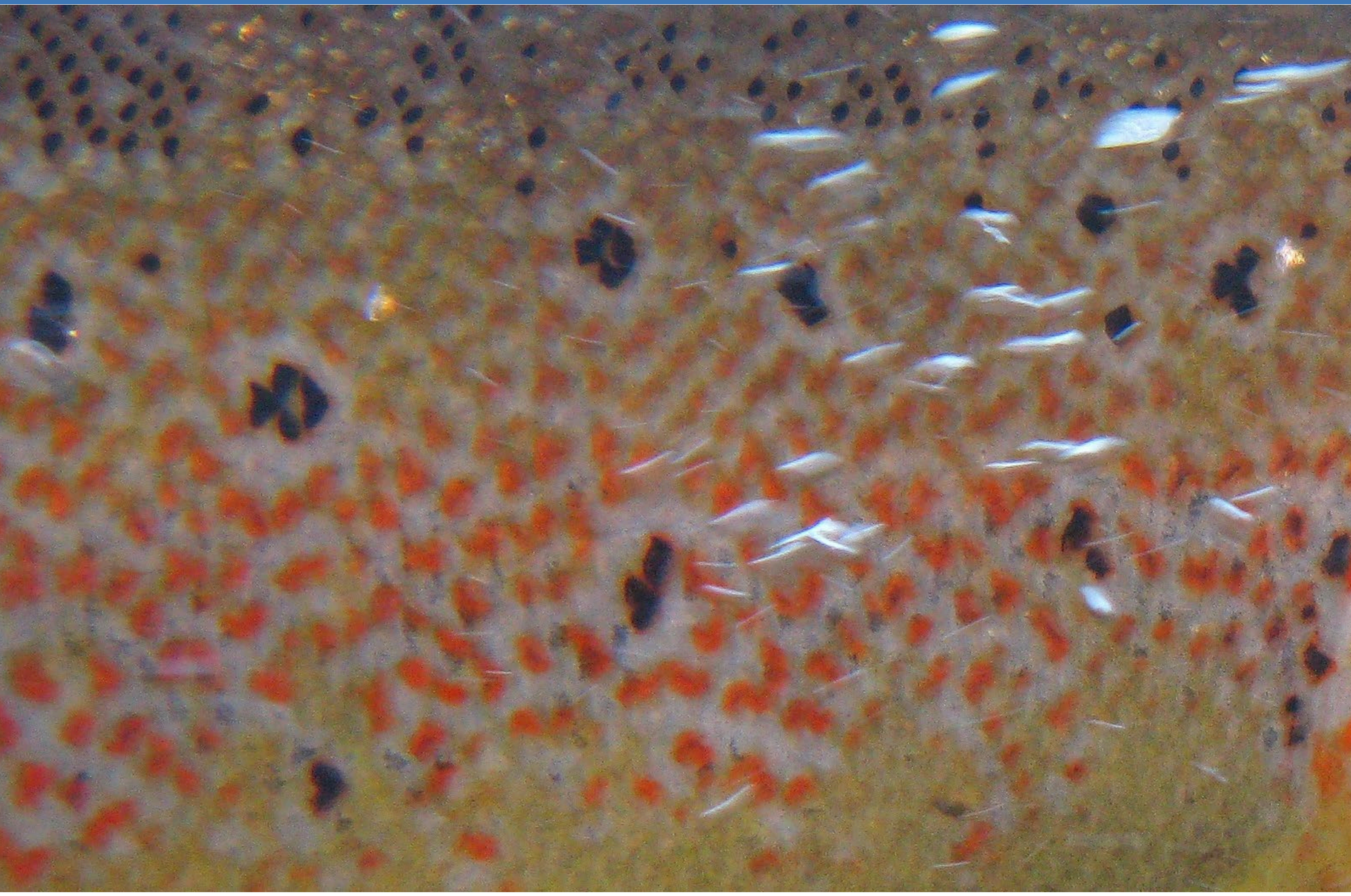

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