Tana Monitoring and Research Group

Status of the Tana/Teno River salmon populations in 2017

Report from the Tana Monitoring and Research Group 1/2018

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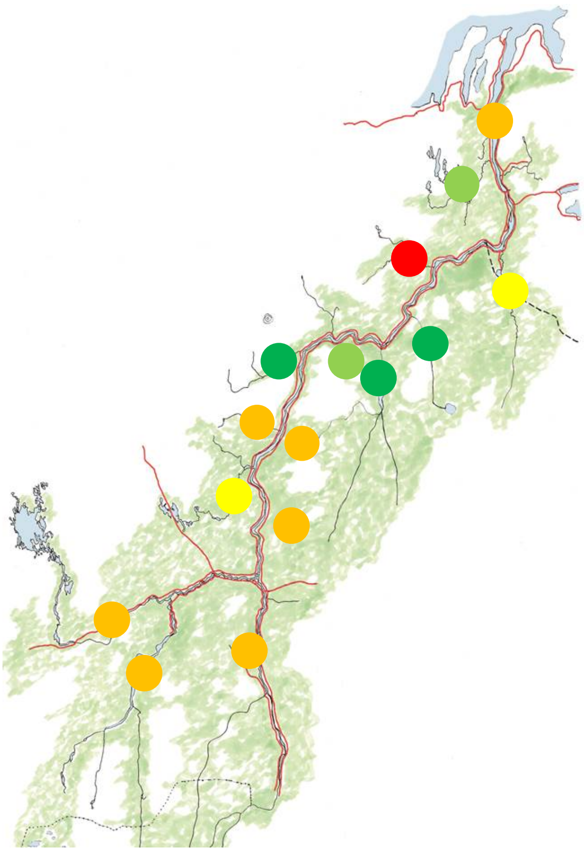
Summary

Anon. 2018. Status of the Tana/Teno River salmon populations in 2017. Report from the Tana Monitoring and Research Group nr 1/2018.

This report is the first 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, 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 evaluation.

The map below summarizes the 2014-2017 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 colour 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 (2014-2017) was poor in 8 of the 15 stocks that we evaluated. The best status was found in Máskejohka, Veahčajohka/Vetsijoki, Ohcejohka/Utsjoki, Goahppelašjohka/Kuoppilasjoki, and Leavvajohka. Most of these are low-exploitation tributaries,

either partly (Veahčajohka/Vetsijoki, Utsjoki) or fully (Goahppelašjohka/Kuoppilasjoki, Leavvajohka). While exploitation within Máskejohka is likely substantial, it is also the lowermost tributary of the Tana/Teno and thus experiences low main stem exploitation.

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 have lacked a total of 32 000 kg female spawners to reach their management targets.

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

The table below summarizes the stock-specific management targets and status numbers from 2017. A late spring and consistently high-water levels made the monitoring challenging in 2017 and have likely affected the fisheries as well. This makes it necessary to approach the 2017-numbers with a certain level of caution. However, the management target evaluation is relatively robust from the effects of a single year and the problems in 2017 therefore have had minimal effects on the management target evaluation.

	Management target probability	**4-year target attainment**	**2017 probability**	**2017 target attainment**
Tana/Teno MS	0 %	54 %	0 %	50 %
Máskejohka	80 %	118 %	97 %	139 %
Buolbmátjohka/Pulmankijoki	66 %	113 %	39 %	96 %
Lákšjohka	0 %	56 %	0 %	44 %
Veahčajohka/Vetsijoki	100 %	197 %	19 %	85 %
Ohcejohka/Utsjoki (+tributaries)	99 %	152 %	3 %	70 %
Goahppelašjohka/Kuoppilasjoki	85 %	131 %	80 %	125 %
Leavvajohka	100 %	444 %	100 %	417 %
Báišjohka	31 %	91 %	21 %	85 %
Njiljohka/Nilijoki	28 %	91 %	6 %	75 %
Váljohka	73 %	121 %	61 %	111 %
Áhkojohka/Akujoki	0 %	64 %	0 %	29 %
Kárášjohka (+tributaries)	0 %	35 %	0 %	38 %
Iešjohka	0 %	37 %	0 %	49 %
Anárjohka/Inarijoki (+tributaries)	0 %	38 %	0 %	38 %

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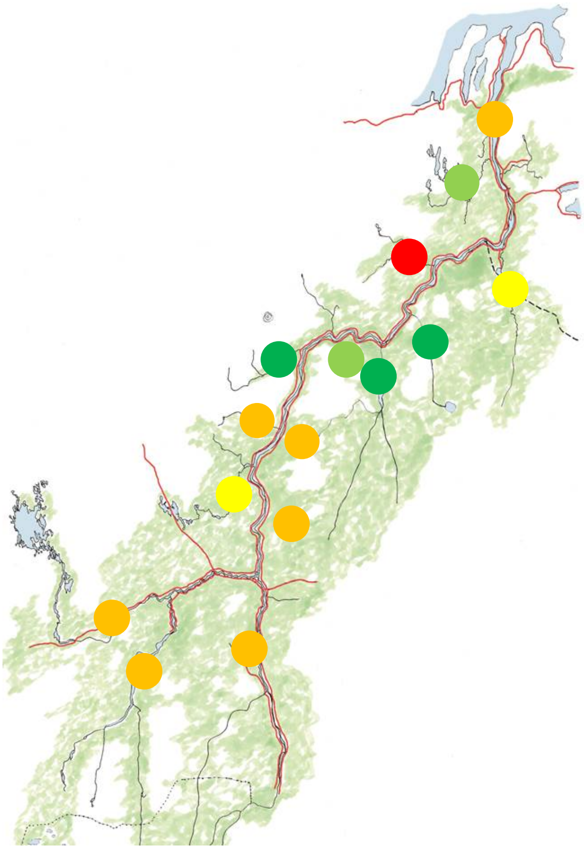
Sammendrag

Anon. 2018. Status for laksebestandene i Tanavassdraget i 2017. Rapport fra overvåkings- og forskergruppen for Tana nr 1/2018.

Denne rapporten er den første 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 2014-2017 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 (2014-2017) var dårlig i 8 av de 15 evaluerte bestandene. Best status ble funnet i Máskejohka, Veahčajohka/Vetsijoki, Ohcejohka/Utsjoki, Goahppelašjohka/Kuoppilasjoki og Leavvajohka. De fleste av disse er sideelver med lav beskatning,

enten delvis (Veahčajohka/Vetsijoki, Utsjoki) eller helt (Goahppelašjohka/Kuoppilasjoki. Leavvajohka). Mens beskatningstrykket i Máskejohka sannsynligvis er betydelig, er dette den nederste sideelva i vassdraget og bestanden her opplever derfor lav beskatning i hovedelva.

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 32 000 kg hunnlaks med tanke på å nå forvaltningsmålet.

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

Tabellen nedenfor oppsummerer de bestandsspesifikke forvaltningsmålene og statustallene fra 2017. Sen vår og vedvarende høy vannstand gjennom sommeren gjorde det utfordrende å overvåke lakseoppgangen i 2017 og forholdene har sannsynligvis også påvirket laksefisket. Dette gjør det nødvendig å vurdere de enkelte tallene fra 2017 med en viss grad av varsomhet. Samtidig er evalueringen av forvaltningsmål relativt robust fra effekten av et enkelt år, og problemene i 2017 har derfor sannsynligvis minimal effekt på de ulike forvaltningsmålene.

	Forvaltningsmål sannsynlighet	**4-års måloppnåelse**	**2017 sannsynlighet**	**2017 måloppnåelse**
Tanaelva	0 %	54 %	0 %	50 %
Máskejohka	80 %	118 %	97 %	139 %
Buolbmátjohka/Pulmankijoki	66 %	113 %	39 %	96 %
Lákšjohka	0 %	56 %	0 %	44 %
Veahčajohka/Vetsijoki	100 %	197 %	19 %	85 %
Ohcejohka/Utsjoki (+sideelver)	99 %	152 %	3 %	70 %
Goahppelašjohka/Kuoppilasjoki	85 %	131 %	80 %	125 %
Leavvajohka	100 %	444 %	100 %	417 %
Báišjohka	31 %	91 %	21 %	85 %
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Áhkojohka/Akujoki	0 %	64 %	0 %	29 %
Kárášjohka (+sideelver)	0 %	35 %	0 %	38 %
Iešjohka	0 %	37 %	0 %	49 %
Anárjohka/Inarijoki (+sideelver)	0 %	38 %	0 %	38 %

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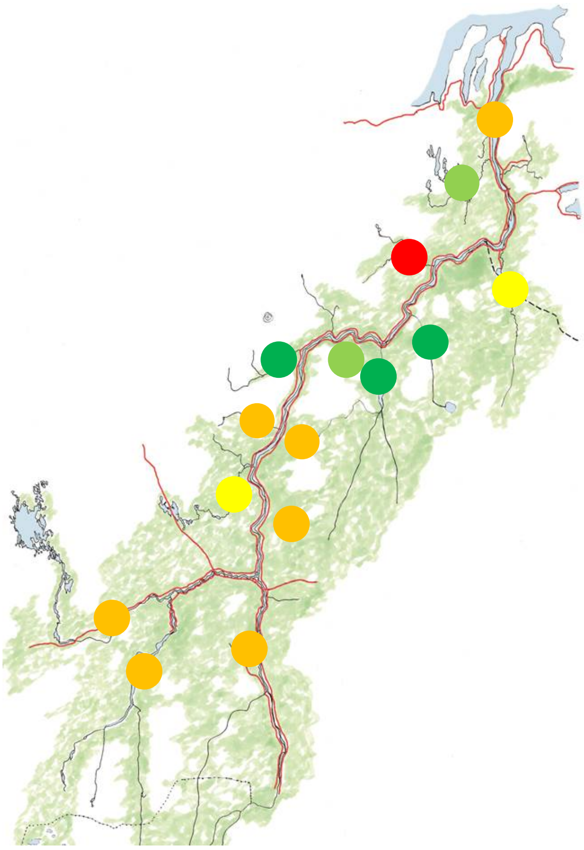
Yhteenveto

Anon. 2018. Tenojoen lohikantojen tila 2017. Tenon seuranta- ja tutkimusryhmän raportti nr 1/2018.

Tämä raportti on uudelleen asetetun Tenojoen seuranta- ja tutkimusryhmän ensimmäinen 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 kantojen tilan vuosina 2014-2017 Tenon vesistön erin osissa. Merkkien väri kuvastaa kannan tilaa neljän edellisen vuoden aikana seuraavasti:

1) Hoitotavoitteen saavuttamisen todennäköisyys yli 75 % ja kutukantatavoite ylitetty yli 140 % (tumman vihreä symboli oheisessa kartassa)
2) Hoitotavoitteen saavuttamisen todennäköisyys yli 75 % ja kutukantatavoite ylitetty alle 140 % (vaalean vihreä)
3) Hoitotavoitteen saavuttamisen todennäköisyys 40-75 % (keltainen))
4) Hoitotavoitteen saavuttamisen todennäköisyys alle 40 %, lohikannassa hyödynnettävää ylijäämää (oranssi)
5) Hoitotavoitteen saavuttamisen todennäköisyys alle 40 %, lohikannassa ei hyödynnettävää ylijäämää (punainen)



Kantojen tila viimeisen neljän vuoden aikana (2014-2017) oli huono kahdeksassa 15:stä arvioidusta lohikannasta. Paras kantojen tila oli Máskejohkassa, Veahčajohka/Vetsijoessa, Ohcejohka/Utsjoessa, Goahppelašjohka/Kuoppilasjoessa ja Leavvajohkassa. Useimmissa näissä sivujoissa kalastus on vähäistä tai olematonta. Vaikka kalastus Máskejohkassa on melko voimakasta, se on Tenon alimmainen sivujoki ja sen lohikantaan kohdistuu vain vähän pääuoman kalastusta.

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 32 000 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 and 2017 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.

Oheinen taulukko esittää kantakohtaisesti hoitotavoitteen ja kutukantatavoitteen saavuttamisen vuonna 2017 ja edellisenä neljänä vuotena. Myöhäinen kevät ja pitkään vallinnut korkea vedenkorkeus kesällä 2017 vaikeuttivat useita lohikantojen seurantoja ja vaikuttivat myös lohenkalastukseen. Siksi vuoden 2017 arvioihin on suhtauduttava varauksella. Yksittäisen vuoden tilanne ei kuitenkaan vaikuta ratkaisevasti hoitotavoitteen saavuttamisen arviointiin, joten vuoden 2017 tietojen laatu ei oleellisesti vaikuta kokonaiskuvaan.

	Hoitotavoitteen saavuttamisen todennäköisyys	**4 vuoden kutukantatavoitteen saavuttaminen**	**2017 hoitotavoitteen saavuttaminen**	**2017 kutukantatavoitteen saavuttaminen**
Teno pääuoma	0 %	54 %	0 %	50 %
Máskejohka	80 %	118 %	97 %	139 %
Buolbmátjohka/Pulmankijoki	66 %	113 %	39 %	96 %
Lákšjohka	0 %	56 %	0 %	44 %
Veahčajohka/Vetsijoki	100 %	197 %	19 %	85 %
Ohcejohka/Utsjoki (+sivujoet)	99 %	152 %	3 %	70 %
Goahppelašjohka/Kuoppilasjoki	85 %	131 %	80 %	125 %
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Báišjohka	31 %	91 %	21 %	85 %
Njiljohka/Nilijoki	28 %	91 %	6 %	75 %
Váljohka	73 %	121 %	61 %	111 %
Áhkojohka/Akujoki	0 %	64 %	0 %	29 %
Kárášjohka (+sivujoet)	0 %	35 %	0 %	38 %
Iešjohka	0 %	37 %	0 %	49 %
Anárjohka/Inarijoki (+sivujoet)	0 %	38 %	0 %	38 %

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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 in light of 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 River Tana started back in the 1970s and is based on long-term investigations 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 River Utsjoki (since 2002) and Lákšjohka (since 2009)
- Spawning adult salmon by snorkelling in three tributaries (Akujoki, Ylä-Pulmankijoki, since 2003 and Nilijoki, since 2009)
- Ascending adult salmon by a sonar in River Kárášjohka (experiments in 2010, 2012, 2017).

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) and Vetsijoki (sonar+video, 2016), and 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.

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 2017 resulted in a small number of samples (1 556) compared to most of the earlier years (Figure 1). Reasons behind this include the apparently low abundance of 1SW fish, which means clearly less individuals in catches than usual. Unfavourable fishing conditions for the early and mid-part of the season might have also contributed to the low catches and thus small number of samples. Finally, the new Tana agreement, which came into force for the 2017 fishing season, might have induced reactions among fishers with some potentially having less motivation to collect samples than in earlier years.

The proportion of escaped farmed salmon among the samples have varied between 0 and 0.6 %, the long-term average (1985-2017) being 0.21 %. In 2017 the proportion was 0.15 %.

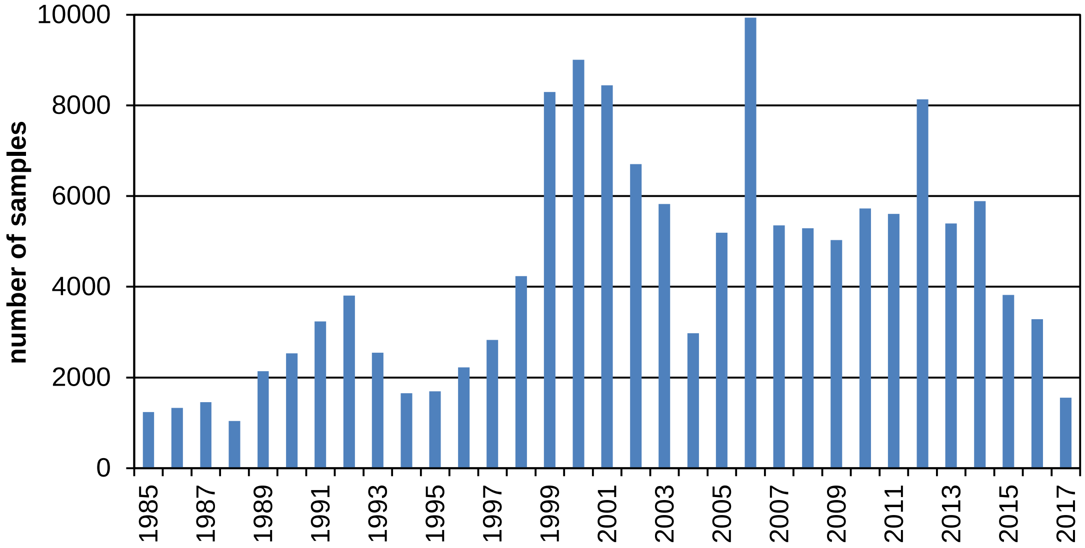

Figure 1. Number of salmon scale samples collected annually from the Tana system in 1985-2017.

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.

The estimated catch in 2017 was the lowest in the time series, 61 tons in total (c. 30 tons in both countries), which equals to c. 11 300 salmon (Figure 2 and Figure 3). The steepest decline from the previous year was evident in 1SW and 2SW salmon (Figure 3). There is a long-term decreasing trend in catches of large salmon, 3-5SW fish (Figure 3).

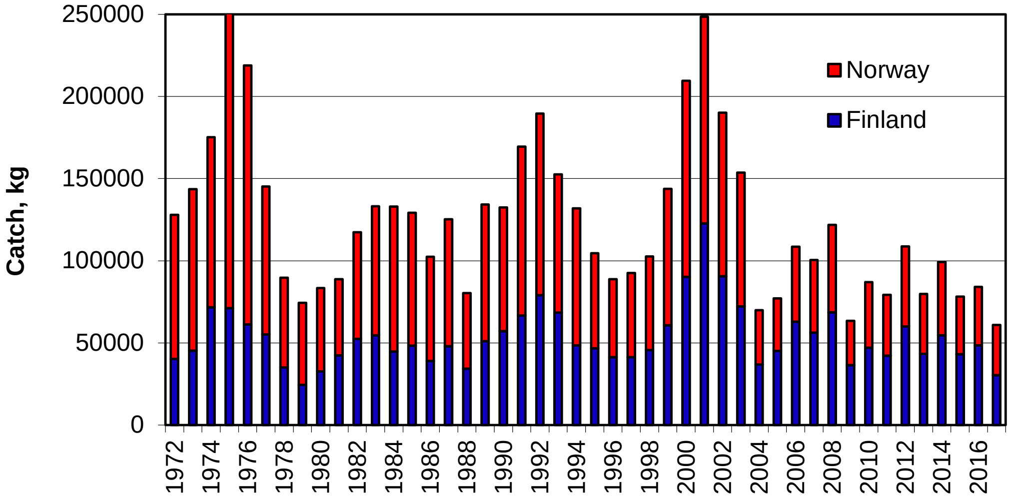

Figure 2. Estimated total salmon catch (kg) in the River Tana in Norway and Finland in 1972-2017.

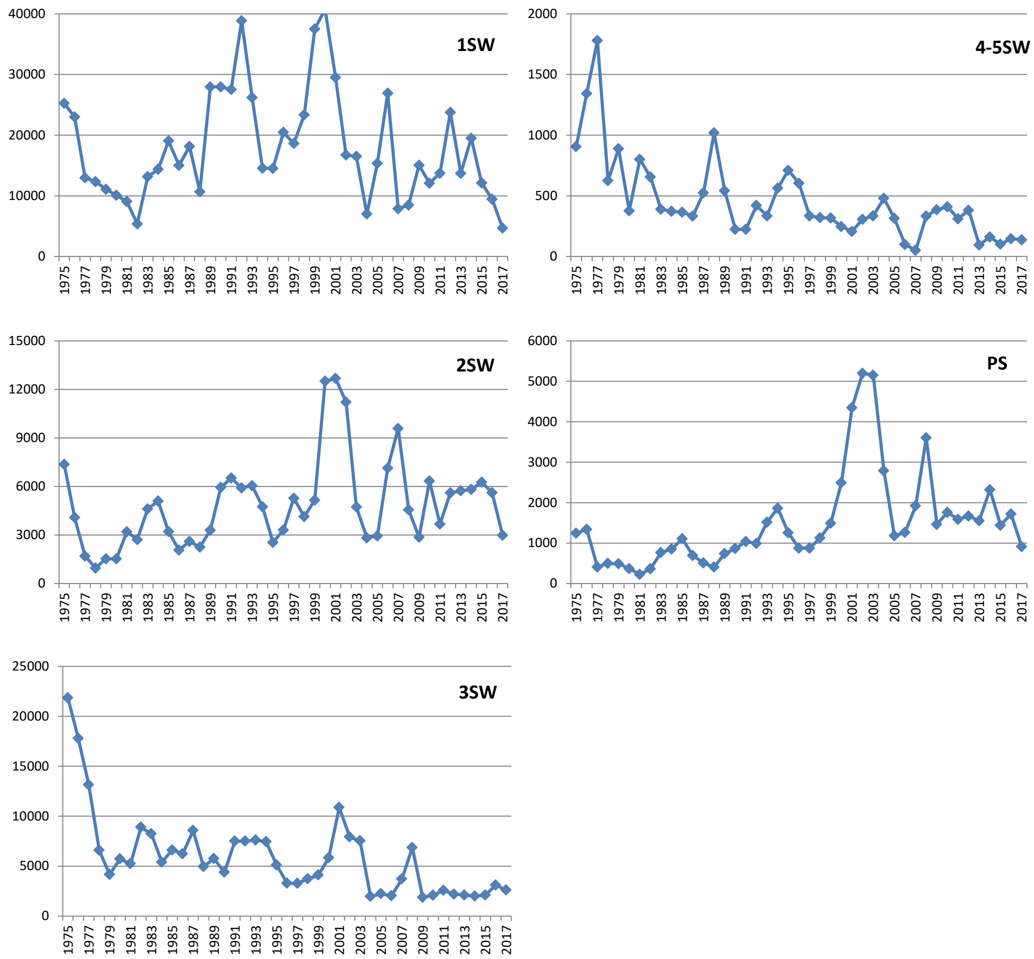

Figure 3. Estimated total salmon catch (n of fish) of different sea-age groups in the River Tana in the years 1975-2017. Note the different scales in vertical axes (PS=previous spawners).

In addition to catch statistics, yearly information on number of fishers and 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 regulation put into force in 2017, the numbers of tourist licences sold in Finland decreased dramatically from the earlier years, being 10 074 daily licences and 2 468 fishers (Figure 4). In Norway, a total of 4 796 fishing days were issued in 2017.

The number of local fishermen in Finland was 506 in 2017, being clearly less than the average figure over the previous five years (759). In Norway, a total of 1 356 local fishermen bought licences in 2017.

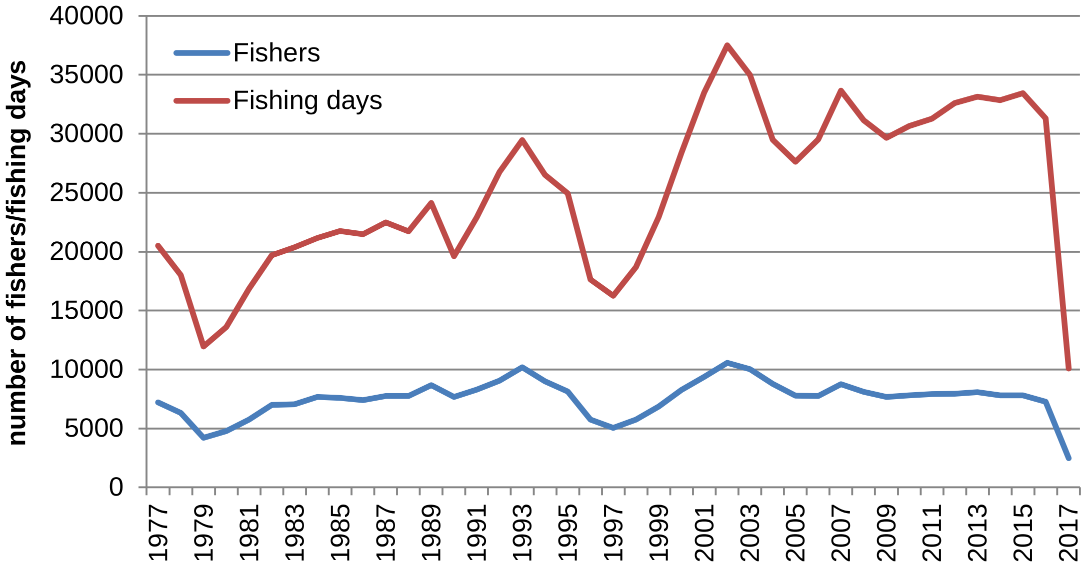

Figure 4. Number of tourist anglers (blue) and daily fishing licences (red) in the Tana on the Finnish side in 1977-2017.

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 River Tana mainstem, 12 in the River Utsjoki and 10 in the River 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 underyearling salmon fry in Inarijoki and Utsjoki have been higher in recent years than before. Electrofishing was not conducted in the Tana main stem in 2017, in Utsjoki in 2016-2017 and only part of the sites in Inarijoki were electrofished in 2017 (Figure 5).

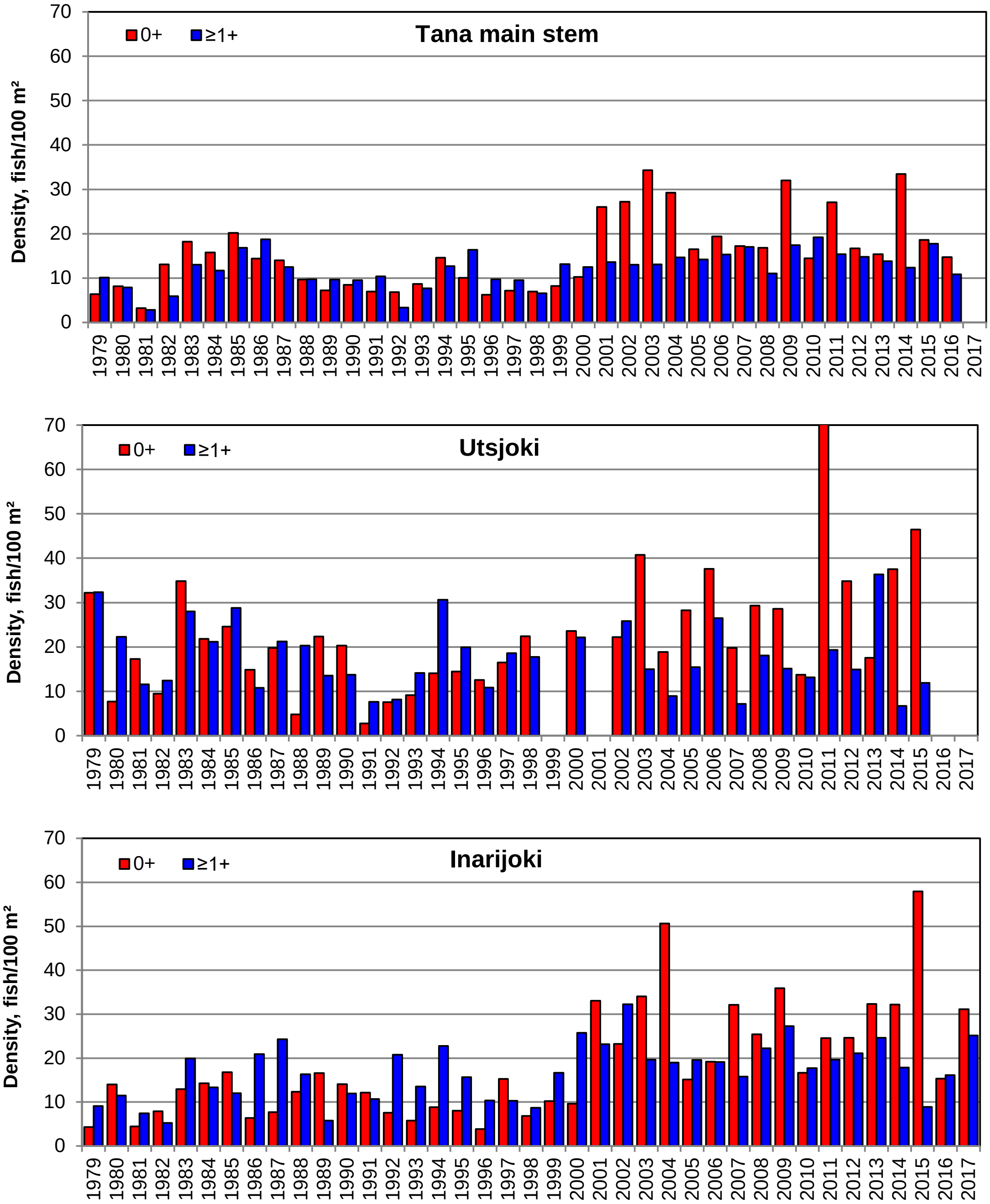

Figure 5. Juvenile salmon densities (fish/100m^2; one pass) at permanent electrofishing sites in the rivers Teno, Inarijoki and Utsjoki in the years 1979-2017.

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 using multiple methods.

2.4.1 Video monitoring

2.4.1.1 Utsjoki

Monitoring of ascending adult salmon and descending smolt has been conducted in 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, and the count in 2017 was one of the lowest in record, 1 369 individuals (Figure 6). Water levels and discharges in 2017 were unusually high throughout the summer that influenced the accuracy of the video data. Therefore, caution should be exercised in interpreting the 2017 figures, especially regarding the stock status evaluation in Utsjoki.

2.4.1.2 Lákšjohka

Monitoring of ascending adult salmon and descending smolt 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, and the count in 2017 was the lowest in record, 255 individuals (Figure 6). Water levels and discharges in 2017 were unusually high throughout the summer, which caused one camera break-up and prevented the use of guiding fences used in other years. These things had considerable effect on the accuracy of the video data in 2017 and the figures are not fully comparable to earlier years. Overall, caution should be exercised in interpreting the 2017 figures, especially regarding the stock status evaluation in Lákšjohka.

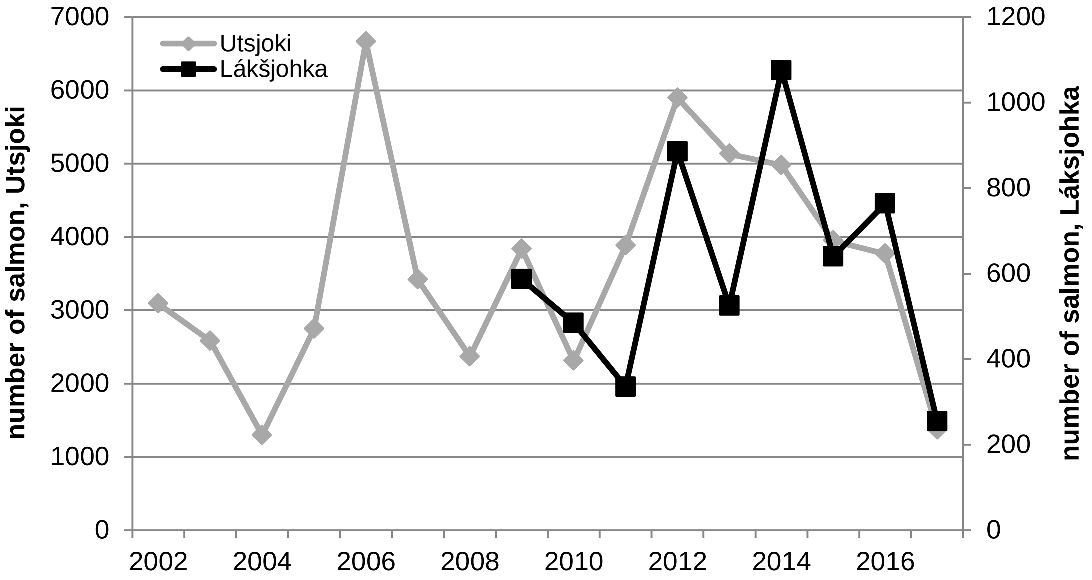

Figure 6. Video counts of ascending adult salmon at the video monitoring sites in the River Utsjoki and Lákšjohka. Sea age groups are combined.

2.4.2 Snorkelling counts

Salmon spawners have been counted by snorkelling on a yearly basis in rivers Akujoki and Ylä-Pulmankijoki since 2003. In 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 Ylä-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 Nilijoki, where a 5 km stretch on the upper reaches have been counted almost annually since 2009. The number of spawning salmon has varied between 38 and 171 in Akujoki, 34 and 215 in Ylä-

Pulmankijoki and 63 and 188 in Nilijoki. The 2017 figures were among the lowest in the time series in all rivers (Figure 7).

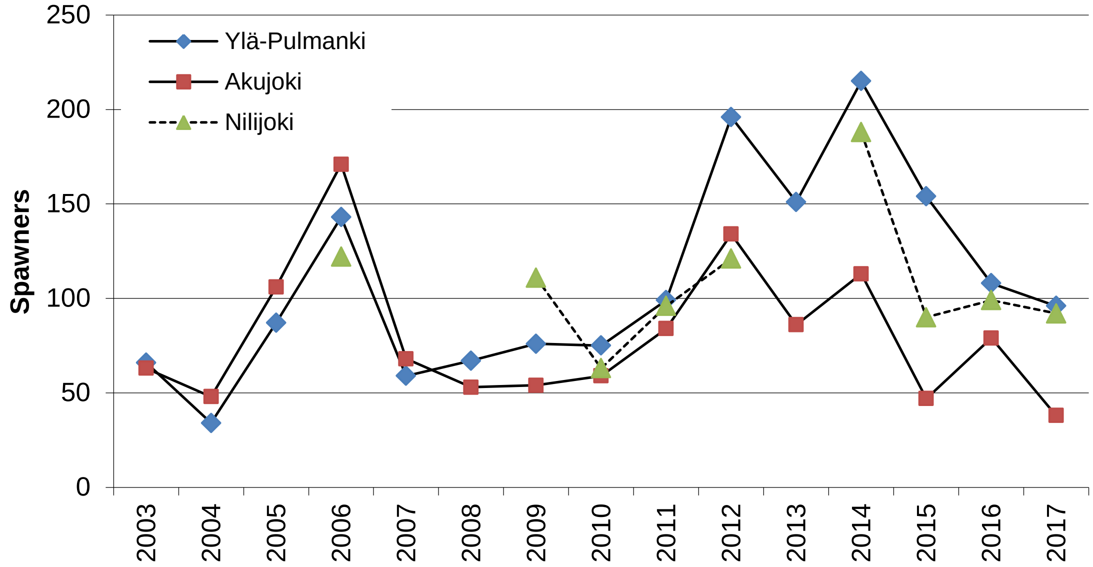

Figure 7. Snorkelling counts of spawning salmon in rivers Ylä-Pulmankijoki, Akujoki and Nilijoki in the years 2003-2017. Sea-age groups are combined.

2.4.3 Sonar and video counts

Echosounders or sonars have been used in counting the ascending salmon at some tributaries of the Tana in certain years, but time series have not been established for any river so far.

In the River Kárášjohka, sonar technology has been experimentally used in 2010 (DIDSON), 2012 (Simsonar) and 2017 (ARIS, Simsonar). The counting site is in Heastanjárga, close to the bridge (69 23’50’’N, 25 08’40’’E). Single year sonar counting (ARIS) was conducted in the River Vetsijoki in 2016 complemented with video monitoring. A video count was done in the River Váljohka in 2015.

Numbers of fish counted in Kárášjohka show relatively low levels of escapement (

Table 1) and these numbers of salmon show low compliance with the spawning target. In contrast, the number of fish ascended in Vetsijoki in 2016 revealed a good run size (c. 2 200 individuals, Figure 8), and combined with catch estimates, resulted in full attainment of the spawning target.

The Váljohka video count in 2015 indicated a spawning run of at least 800 salmon in the period of 10.6.-20.8. At the same time a considerable amount of salmon (100 fish) were also observed at the Váljohka tributary, the River Astejohka, by snorkelling. These fish were not observed in the video monitoring because Astejohka is running into Váljohka below the video counting site. Overall, the video and snorkelling counts indicated a salmon stock size of c. 1 000 fish in 2015, suggesting a full attainment of the spawning target.

Table 1. Sonar counts of ascending salmon in the River Kárášjohka in 2010, 2012 and 2017. (1SW: 50-67,5 cm; MSW: ≥67,5 cm).

Year	Time period	1SW	MSW	All	Note	Equipment
2010	9.6.-31.8.2010	1016	661	1677	Missing time estimated	Didson
2012	6.6.-27.8.2012	1038	1589	2627	Missing time not estimated	Simsonar
2017	7.6.-31.8.2017	371	492	863	Missing time not estimated	Aris/Simsonar

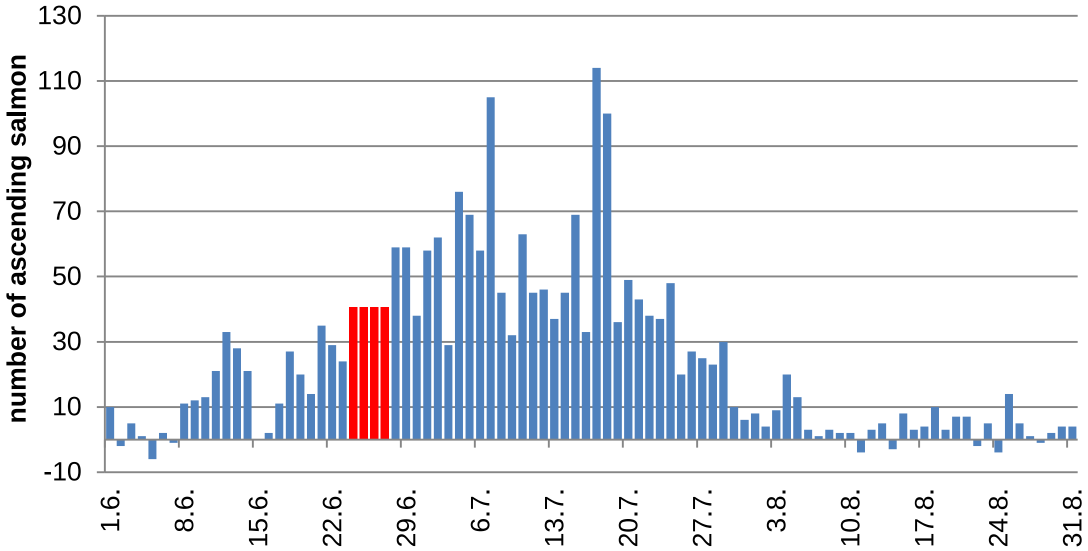

Figure 8. Numbers of ascending salmon in the River Vetsijoki in 1.6.-31.8.2016 based on sonar and video counting. The red bars indicate numbers that have been estimated based on days before and after the missing days. Sea age groups are combined.

Counting of salmon by sonar technology at the Tana main stem has been planned for 2018, and the resulting information – provided the challenging mission proves successful – is a useful addition to the tributary-specific data and will improve the understanding on the status, dynamics and exploitation of the different populations of the Tana system. Provisionally, the planned counting site is going to be at the Buolbmátsuolu at the Buolbmátjohka/Pulmankijoki river mouth.

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 the 5-year average from Genmix.

We have no spawning stock counts from the main stem, so the exploitation estimates 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, we reduced the exploitation estimate down to 55 % due to the implementation of new fishing rules.

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	0.56
2010	75 340	0.47	35 161	0.60	0.56
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	0.56
2014	83 312	0.47	38 881	0.60	0.56
2015	65 287	0.47	30 469	0.60	0.56
2016	72 814	0.47	33 982	0.60	0.56
2017	52 880	0.47	24 679	0.55	0.56

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.

Estimated truncated target attainment reached 100 % in 2008 (Figure 9). Lowest attainment was 42 % in 2009. The highest probability of reaching the spawning target was 62 % in 2008. The probability was zero in 2009, 2011-2013, 2015 and 2017, and 1 % in 2006, 2010 and 2016. The management target was not reached, as the last 4 years' (2014-2017) overall probability of reaching the spawning target was 0 % with an overall attainment of 54 %.

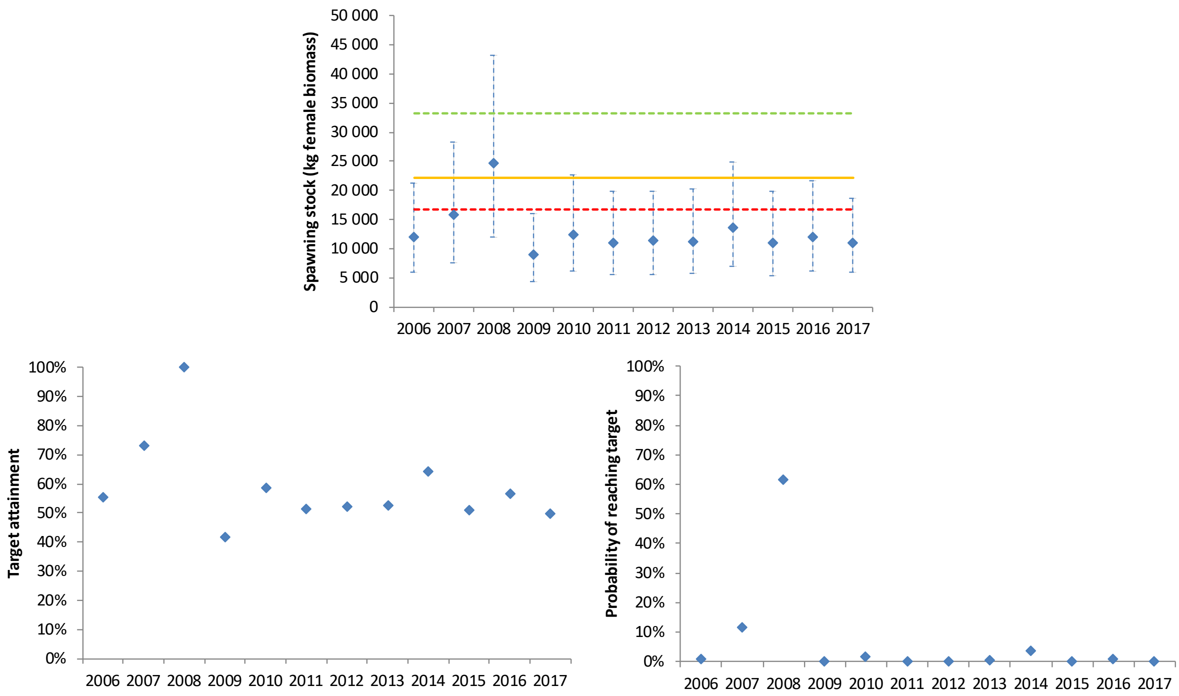

Figure 9. The estimated spawning stock (top row), percent truncated spawning target attainment (bottom row, left) and probability of reaching the spawning target (bottom row, right) in the period 2006-2017 for the Tana MS stock.

3.1.2 Exploitation

The estimated total exploitation rate (based on weight) of Tana MS salmon was 67 % in the years 2014-2017 (Figure 10), with 18 % of the pre-fishery abundance caught in coastal fisheries and 49 % in main stem fisheries. The average estimated total pre-fishery abundance for Tana MS salmon was 64 442 kg and the average total catch was 43 288 kg in the period 2014-2017.

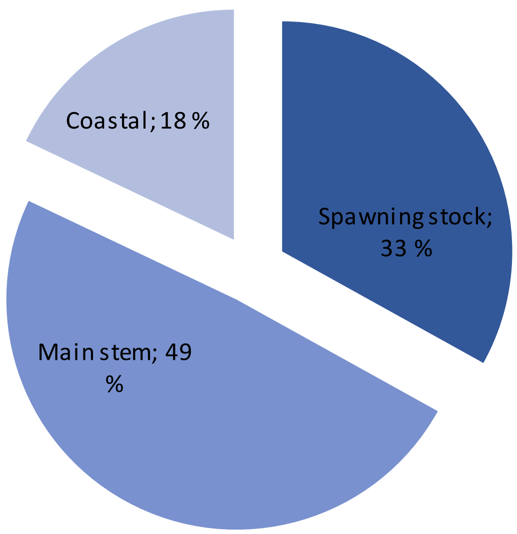

Figure 10. The total amount of salmon belonging to Tana MS in 2014-2017, distributed into surviving spawning stock and salmon caught in fisheries in either coastal or main stem fisheries. The percentages in the figure represent the proportion of the pre-fishery abundance that survives to spawning or 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 2014-2017, 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 2017, the first year with the new agreement in place. Numbers from 2017 must be interpreted with caution due to it only being a singular year and its basis on a year with difficult conditions both for fisheries and monitoring.

	2014-2017	2006-2016	2017
Coastal	18 %	18 %	21 %
Main stem	60 %	61 %	56 %

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 2014-2017, overexploitation varied between 38 % (2014) and 51 % (2015, 2017). The average overexploitation was estimated at 47 %. This means that exploitation on average was responsible for reducing the spawning stock size by an amount of 47 % below the spawning target.

Maximum sustainable exploitation varied between 29 % (2017) and 47 % (2014). The average maximum sustainable total exploitation rate in the period was 38 %, lower than the estimated average total exploitation of 67 %.

3.1.3 Stock recovery

Over the last 4 years, the overall probability that the spawning target was reached for the Tana MS stock was 0 %. Target attainment therefore needs to be significantly improved to reach the 75 % 4-year probability specified by the management target.

The median spawning stock size in the period 2014-2017 was 11 419 kg (6 046-20 768 kg). With the current exploitation and uncertainty estimates, we would need a spawning stock of approximately 26 500 kg to reach the management target of a 75 % probability of meeting the spawning target and over 45 000 kg to reach 100 % probability. In the years 2014-2017, we have, therefore, on average lacked a female biomass of approximately 15 000 kg to reach the management target.

A management target probability below 40 % means that a stock recovery plan should be initiated for the Tana MS stock. The starting point of this recovery plan is the estimated exploitation rate experienced by the Tana MS stock in the years 2006-2016 (before the new Tana agreement). There are two stock recovery trajectories shown in Figure 11 below. One is the stock recovery trajectory that follows from the 30 % reduction that was used as an overall guideline in the negotiations. The second is the recovery trajectory corresponding to the minimum reduction in exploitation needed to complete the stock recovery of Tana MS salmon after two generations.

The starting point of the recovery trajectories are the stock-specific management target attainment. The simulation then calculates a new management target attainment based on the number of spawners that would have survived in the years before the regulation if the total exploitation had been reduced by a certain percentage. The resulting percentage increase is applied to subsequent generations, resulting in a ladder-like recovery trajectory.

Please note that the reductions in exploitation in Figure 11 are in comparison with the situation in 2006-2016. The reductions that are listed here are therefore not reductions on top of the fishing rules that were implemented in 2017.

Compared with the period 2006-2016, the minimum reduction in exploitation for the years 2017 and onwards that would lead to a stock recovery after two generations is 19 %.

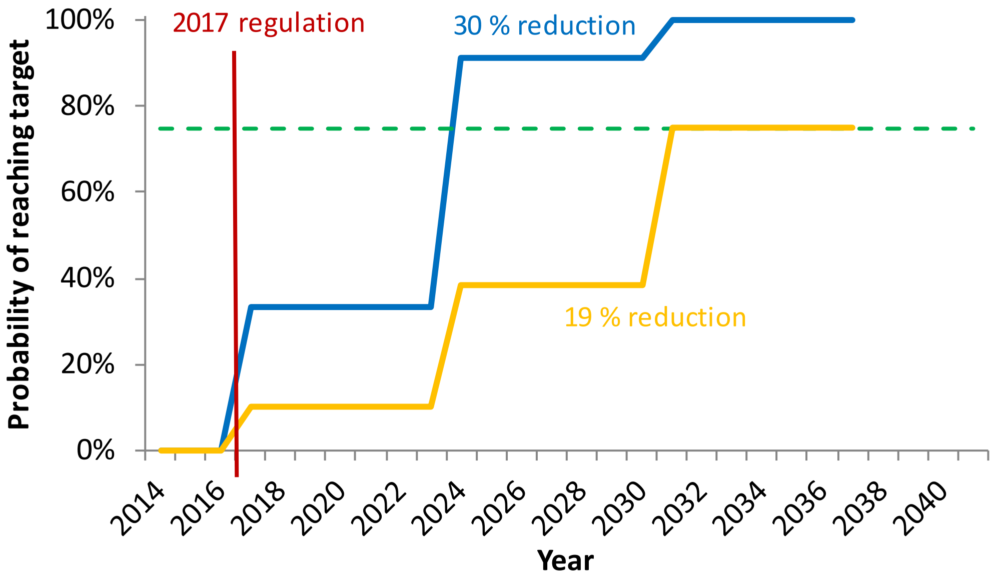

Figure 11. Stock recovery trajectories for Tana MS salmon, corresponding to two scenarios of reduced total exploitation. (Orange) This is the trajectory showing stock recovery at a 19 % reduction from the average exploitation level in 2006-2016, this is the minimum reduction in exploitation needed to achieve stock recovery after two generations, and (Blue) a recovery trajectory following the stock development after a 30 % reduction in exploitation compared to the years 2006-2016. The green dotted line represents the management target (75 % probability that spawning target is reached).

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 the 5-year average from Genmix.

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 results in Forseth et al. (2013), 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 due to the new fishing regulations that were put in place before this season.

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

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.

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.

Estimated truncated target attainment reached 100 % in the years 2008, 2010, 2016 and 2017 (Figure 12). Lowest attainment was 61 % in 2013. The highest probability of reaching the spawning target was 99 % in 2008 followed by 97 % in 2017 and 96 % in 2016. The management target was reached, as the last 4 years' (2014-2017) overall probability of reaching the spawning target was 80 % with an overall untruncated attainment of 118 %.

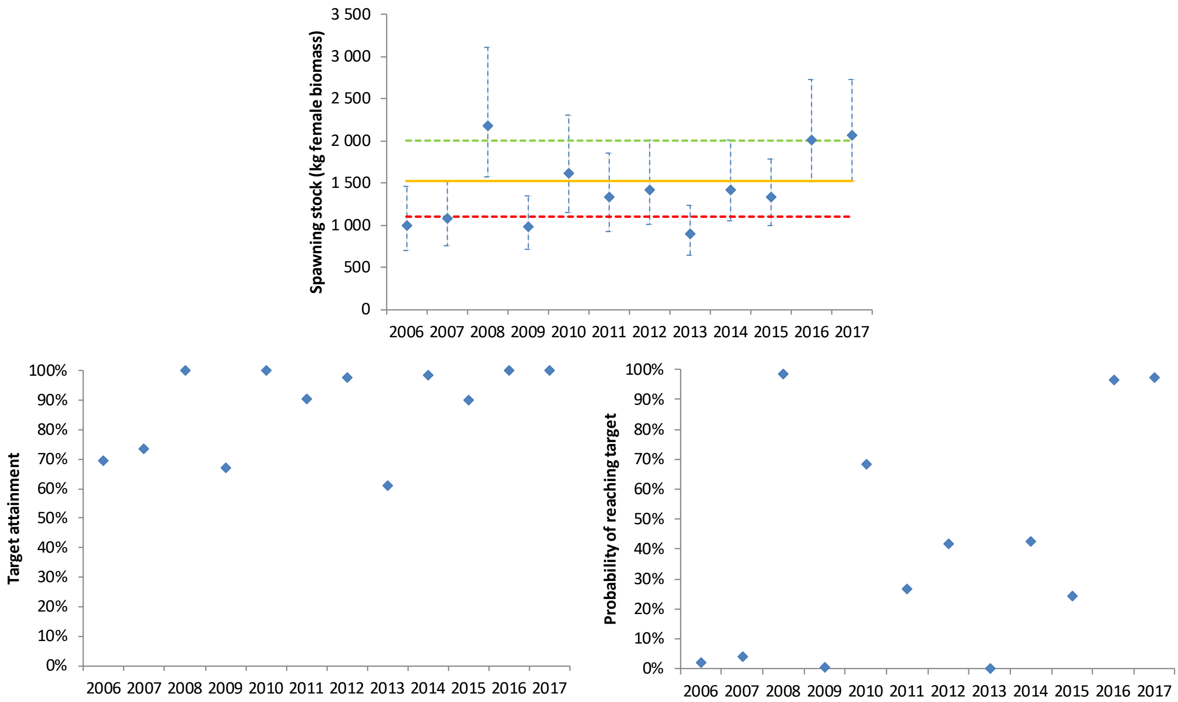

Figure 12. The estimated spawning stock (top row), percent truncated spawning target attainment (bottom row, left) and probability of reaching the spawning target (bottom row, right) in the period 2006-2017 in the Norwegian tributary Máskejohka.

3.2.2 Exploitation

The estimated total exploitation rate (based on weight) of Máskejohka salmon was 51 % in the years 2014-2017 (Figure 13), with 14 % of the pre-fishery abundance caught in coastal fisheries, 17 % in main stem fisheries and 20 % in Máskejohka. The average estimated total pre-fishery abundance for Máskejohka salmon was 6 806 kg and the average total catch was 3 496 kg in the period 2014-2017.

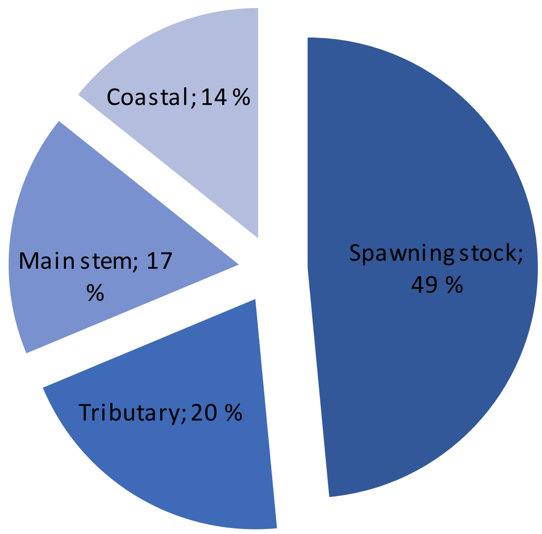

Figure 13. The total amount of salmon belonging to Máskejohka in 2014-2017, distributed into surviving spawning stock and salmon caught in fisheries in either coastal, main stem or Máskejohka fisheries. The percentages in the figure represent the proportion of the pre-fishery abundance that survives 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 2014-2017, 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 2017, the first year with the new agreement in place. Numbers from 2017 must be interpreted with caution due to it only being a singular year and its basis on a year with difficult conditions both for fisheries and monitoring.

	2014-2017	**2006-2016**	**2017**
Coastal	14 %	14 %	18 %
Main stem	20 %	23 %	16 %
Tributary	29 %	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 2014-2017, overexploitation varied between 0 % (2016, 2017) and 13 % (2015). The average overexploitation was estimated at 5 %. This means that exploitation on average was responsible for reducing the spawning stock size by an amount of 5 % below the spawning target. Maximum sustainable exploitation varied between 27 % (2015) and 54 % (2016, 2017). The average maximum sustainable total exploitation rate in the period was 43 %, lower than the estimated average total exploitation of 51 %.

3.2.3 Stock recovery

Over the last 4 years, the overall probability that the spawning target was reached in Máskejohka was 80 %. The management target was therefore met in Máskejohka and no stock recovery plan is needed for this tributary.

The median spawning stock size in the period 2014-2017 was 1 711 (1 285-2 367 kg). With the current exploitation and uncertainty estimates, we would need a spawning stock of close to 1 700 kg to reach the management target of a 75 % probability of meeting the spawning target and approximately 2 200 kg to reach 100 % probability.

The estimates of maximum sustainable exploitation and the total exploitation of Máskejohka-salmon indicate that over the last four years, the total exploitation have 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

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.

Estimated truncated target attainment reached 100 % in the years 2006 and 2012-2016 (Figure 14). Lowest attainment was 28 % in 2004. The highest probability of reaching the spawning target was 100 % in 2012 and 2014. The management target was not reached, as the last 4 years' (2014-2017) overall probability of reaching the spawning target was 66 % with an overall attainment of 113 %.

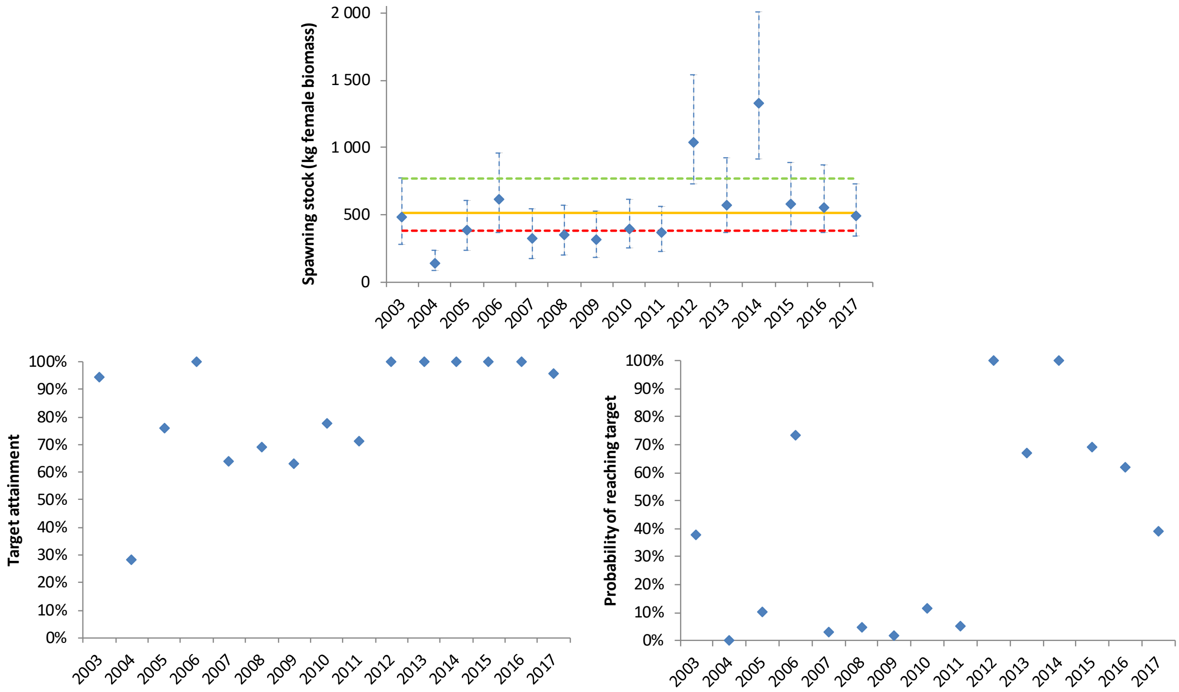

Figure 14. The estimated spawning stock (top row), percent truncated spawning target attainment (bottom row, left) and probability of reaching the spawning target (bottom row, right) in the period 2003-2017 in the Norwegian/Finnish tributary Buolbmátjohka/Pulmankijoki.

3.3.2 Exploitation

The estimated total exploitation rate (based on weight) of Buolbmátjohka/Pulmankijoki salmon was 49 % in the years 2014-2017 (Figure 15), with 11 % of the pre-fishery abundance caught in coastal fisheries, 12 % in main stem fisheries and 25 % in Buolbmátjohka/Pulmankijoki. The average estimated total pre-fishery abundance for Buolbmátjohka/Pulmankijoki salmon was 2 695 kg and the average total catch was 1 315 kg in the period 2014-2017.

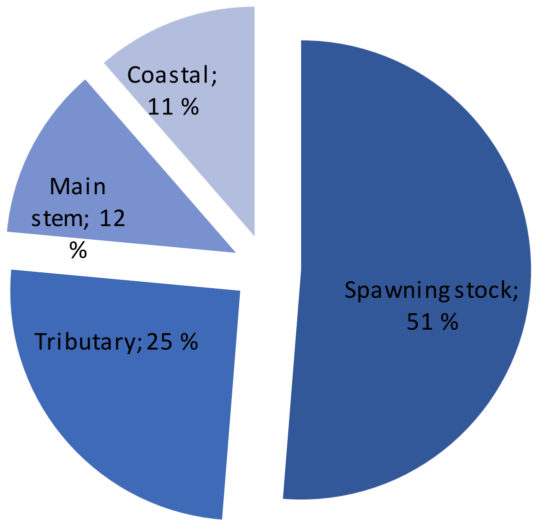

Figure 15. The total amount of salmon belonging to Buolbmátjohka/Pulmankijoki in 2014-2017, distributed into surviving spawning stock and salmon caught in fisheries in either coastal, main stem or Buolbmátjohka/Pulmankijoki fisheries. The percentages in the figure represent the proportion of the pre-fishery 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 2014-2017, 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 2017, the first year with the new agreement in place. Numbers from 2017 must be interpreted with caution due to it only being a singular year and its basis on a year with difficult conditions both for fisheries and monitoring.

	2014-2017	**2006-2016**	**2017**
Coastal	11 %	10 %	15 %
Main stem	14 %	16 %	16 %
Tributary	33 %	41 %	26 %

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 2014-2017, overexploitation varied between 0 % (2014-2016) 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 72 % (2014). The average maximum sustainable total exploitation rate in the period was 47 %, slightly lower than the estimated average total exploitation of 49 %.

3.3.3 Stock recovery

Over the last 4 years, the overall probability that the spawning target was reached in Buolbmátjohka/Pulmankijoki was 66 %. Target attainment therefore needs to be improved to reach the 75 % 4-year probability specified by the management target.

The median spawning stock size in the period 2014-2017 was 569 kg (381-879 kg). With the current exploitation and uncertainty estimates, we would need a spawning stock of approximately 600 kg to reach the management of a 75 % probability of meeting the spawning target and approximately 850 kg to reach 100 % probability. In the years 2014-2017, we have, therefore, on average lacked a female biomass of approximately 30 kg to reach the management target.

The management target probability was under 75 % but still over 40 %, meaning that minor adjustments to the exploitation rate would be sufficient to increase the target attainment sufficiently. There are two stock recovery trajectories shown in Figure 16 below. One is the stock recovery trajectory that follows from the 30 % reduction that was used as an overall guideline in the negotiations. The second is the recovery trajectory corresponding to the minimum reduction in exploitation needed to complete the stock recovery of Buolbmátjohka/Pulmankijoki salmon after two generations.

The starting point of the recovery trajectories are the stock-specific management target attainment. The simulation then calculates a new management target attainment based on the number of spawners that would have survived in the years before the regulation if the total exploitation had been reduced by a certain percentage. The resulting percentage increase is applied to subsequent generations, resulting in a ladder-like recovery trajectory.

Please note that the reductions in exploitation in Figure 16 are in comparison with the situation in 2006-2016. The reductions that are listed here are therefore not reductions on top of the fishing rules that were implemented in 2017.

Compared with the period 2006-2016, the minimum reduction in exploitation for the years 2017 and onwards that would lead to a stock recovery after two generations is 3 %.

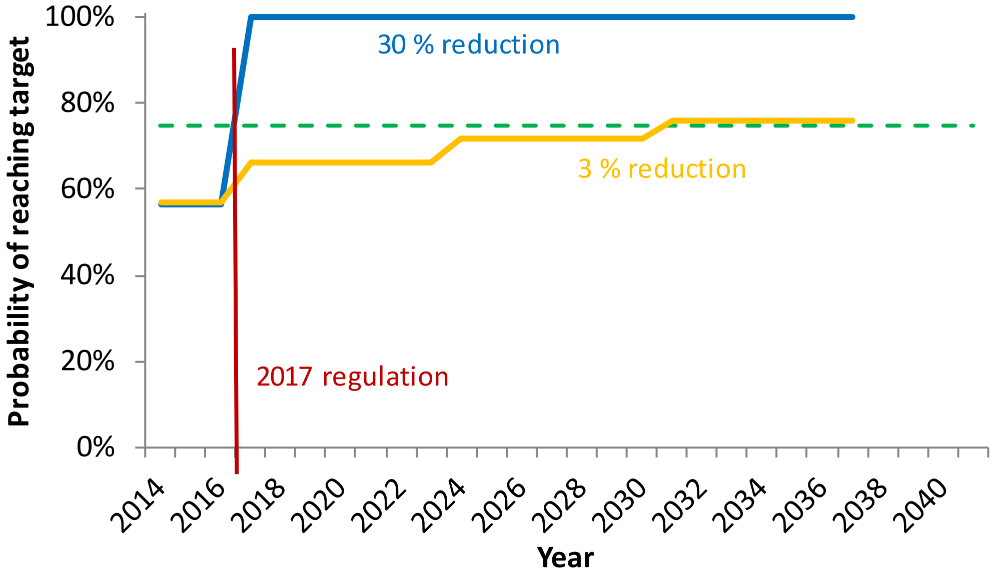

Figure 16. Stock recovery trajectories for Buolbmátjohka/Pulmankijoki salmon, corresponding to two scenarios of reduced total exploitation. (Orange) This is the trajectory showing stock recovery at a 3 % reduction from the average exploitation level in 2006-2016, this is the minimum reduction in exploitation needed to achieve stock recovery after two generations, and (Blue) a recovery trajectory following the stock development after a 30 % reduction in exploitation compared to the years 2006-2016. The green dotted line represents the management target (75 % probability that spawning target is reached).

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 2014-2017 have been in the range 8-14 %. 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.

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

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.

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.

Estimated truncated target attainment reached 92 % in 2006 (Figure 17). Lowest attainment was 19 % in 2011 and 32 in 2013. The highest probability of reaching the spawning target was 32 % in 2006. The management target was not reached, as the last 4 years' (2014-2017) overall probability of reaching the spawning target was 0 % with an overall attainment of 56 %.

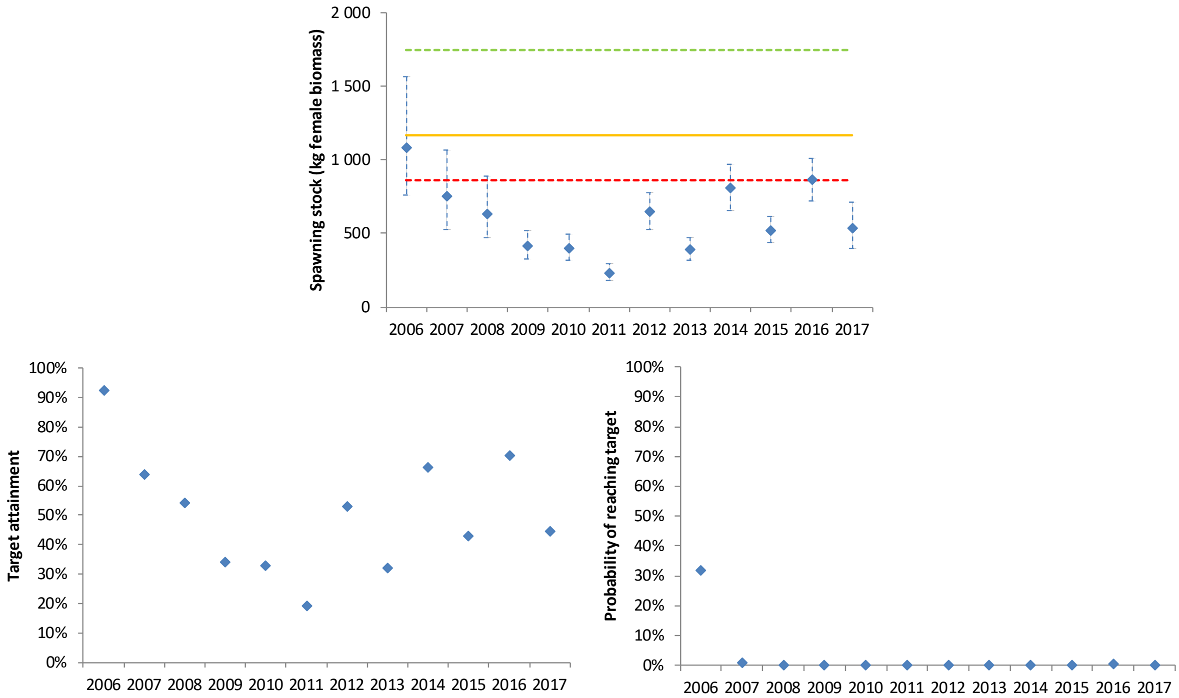

Figure 17. The estimated spawning stock (top row), percent truncated spawning target attainment (bottom row, left) and probability of reaching the spawning target (bottom row, right) in the period 2006-2017 in the Norwegian tributary Lákšjohka.

3.4.2 Exploitation

The estimated total exploitation rate (based on weight) of Lákšjohka salmon was 49 % in the years 2014-2017 (Figure 18), with 15 % of the pre-fishery abundance caught in coastal fisheries, 28 % in main stem fisheries and 6 % in Lákšjohka. The average estimated total pre-fishery abundance for Lákšjohka salmon was 1 937 kg and the average total catch was 940 kg in the period 2014-2017.

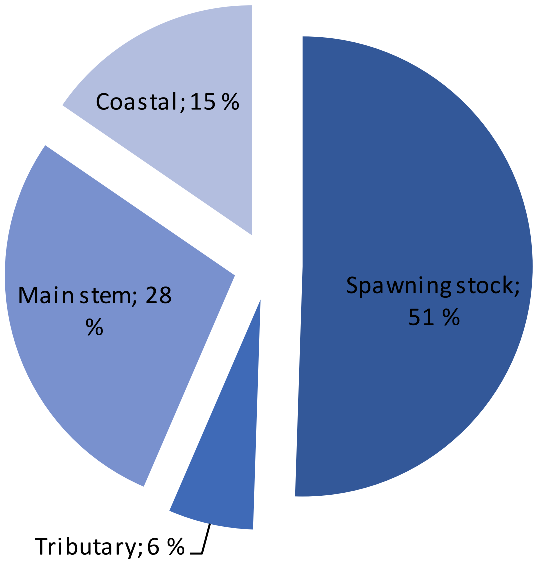

Figure 18. The total amount of salmon belonging to Lákšjohka in 2014-2017, distributed into surviving spawning stock and salmon caught in fisheries in either coastal, main stem or Lákšjohka fisheries. The percentages in the figure represent the proportion of the pre-fishery abundance that survives to 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 2014-2017, 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 2017, the first year with the new agreement in place. Numbers from 2017 must be interpreted with caution due to it only being a singular year and its basis on a year with difficult conditions both for fisheries and monitoring.

	2014-2017	**2006-2016**	**2017**
Coastal	15 %	15 %	19 %
Main stem	32 %	33 %	32 %
Tributary	10 %	24 %	7 %

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 2014-2017, overexploitation varied between 26 % (2016) and 49 % (2015). The average overexploitation was estimated at 37 %. This means that exploitation on average was responsible for reducing the spawning stock size by an amount of 37 % below the spawning target. Maximum sustainable exploitation varied between 0 % (2015, 2017) and 23 % (2016). A maximum exploitation of 0 % in 2015 and 2017 indicates no exploitable surplus. The average maximum sustainable total exploitation rate in the period was 11 %, significantly lower than the estimated average total exploitation of 50 %.

3.4.3 Stock recovery

Over the last 4 years, the overall probability that the spawning target was reached in Lákšjohka was 0 %. Target attainment therefore needs to be significantly improved to reach the 75 % 4-year probability specified by the management target.

The median spawning stock size in the period 2014-2017 was 674 (550-842 kg). With the current exploitation and uncertainty estimates, we would need a spawning stock of approximately 1 350 kg to reach the management target of a 75 % probability of meeting the spawning target and approximately 1 750 kg to reach 100 % probability. In the years 2014-2017, we have, therefore, on average lacked a female biomass of approximately 650 kg to reach the management target.

A management target probability below 40 % means that a stock recovery plan should be initiated for the Lákšjohka stock. The starting point of this recovery plan is the estimated exploitation rate experienced by the Lákšjohka stock in the years 2006-2016 (before the new Tana agreement). There are two stock recovery trajectories shown in Figure 19 below. One is the stock recovery trajectory that follows from the 30 % reduction that was used as an overall guideline in the negotiations. The second is the recovery trajectory corresponding to the minimum reduction in exploitation needed to complete the stock recovery of Lákšjohka salmon after two generations.

The starting point of the recovery trajectories are the stock-specific management target attainment. The simulation then calculates a new management target attainment based on the number of spawners that would have survived in the years before the regulation if the total exploitation had been reduced by a certain percentage. The resulting percentage increase is applied to subsequent generations, resulting in a ladder-like recovery trajectory.

Please note that the reductions in exploitation in Figure 19 are in comparison with the situation in 2006-2016. The reductions that are listed here are therefore not reductions on top of the fishing rules that were implemented in 2017.

Compared with the period 2006-2016, the minimum reduction in exploitation for the years 2017 and onwards that would lead to a stock recovery after two generations is 23 %.

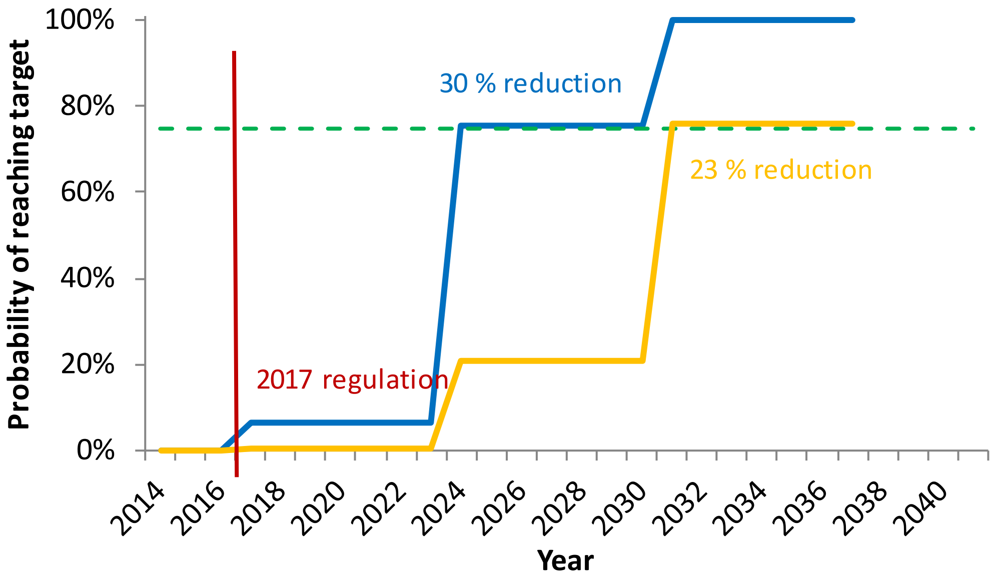

Figure 19. Stock recovery trajectories for Lákšjohka salmon, corresponding to two scenarios of reduced total exploitation. (Orange) This is the trajectory showing stock recovery at a 23 % reduction from the average exploitation level in 2006-2016, this is the minimum reduction in exploitation needed to achieve stock recovery after two generations, and (Blue) a recovery trajectory following the stock development after a 30 % reduction in exploitation compared to the years 2006-2016. The green dotted line represents the management target (75 % probability that spawning target is reached).

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 higher exploitation rate (20 %) was selected for 2006-2015 and 2017.

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

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 were 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.

Estimated truncated target attainment reached 100 % in all years except 2008, 2013 and 2017 (Figure 20). Lowest attainment was 79 % in 2013. The highest probability of reaching the spawning target was 100 % in 2006, 2010, 2011, 2014-2016. The management target was reached, as the last 4 years' (2014-2017) overall probability of reaching the spawning target was 100 % with an overall untruncated attainment of 197 %.

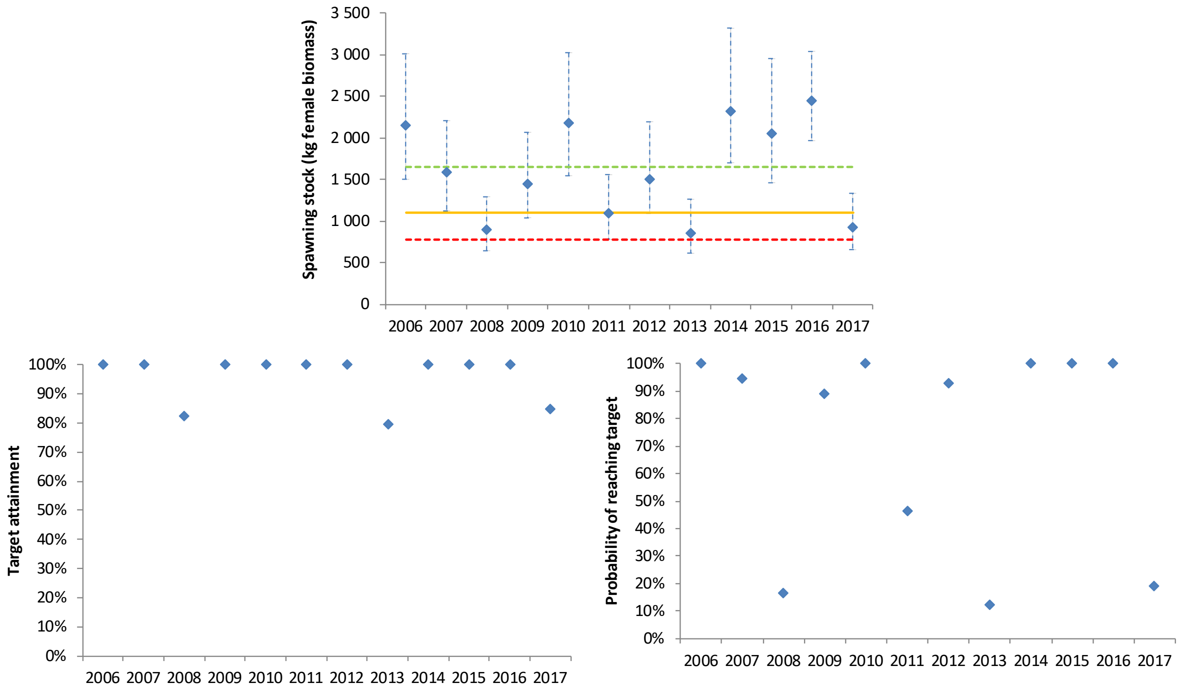

Figure 20. The estimated spawning stock (top row), percent truncated spawning target attainment (bottom row, left) and probability of reaching the spawning target (bottom row, right) in the period 2006-2017 in the Finnish tributary Veahčajohka/Vetsijoki.

3.5.2 Exploitation

The estimated total exploitation rate (based on weight) of Veahčajohka/Vetsijoki salmon was 54 % in the years 2014-2017 (Figure 21), with 15 % of the pre-fishery abundance caught in coastal fisheries, 28 % in main stem fisheries and 11 % in Veahčajohka/Vetsijoki. The average estimated total pre-fishery abundance for Veahčajohka/Vetsijoki salmon was 7 112 kg and the average total catch was 3 837 kg in the period 2014-2017.

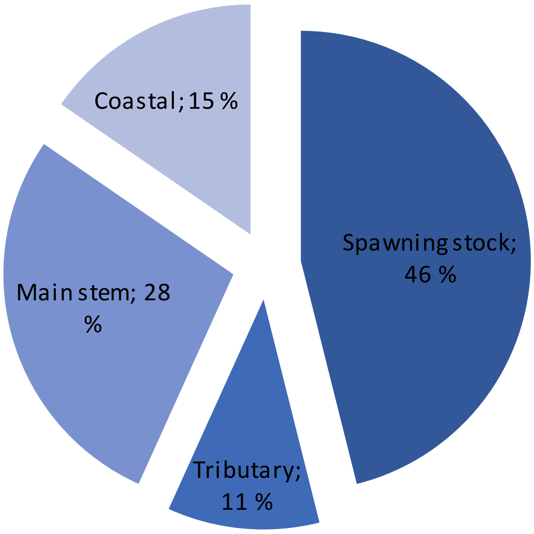

Figure 21. The total amount of salmon belonging to Veahčajohka/Vetsijoki in 2014-2017, distributed into surviving spawning stock and salmon caught in fisheries in either coastal, main stem or Veahčajohka/Vetsijoki fisheries. The percentages in the figure represent the proportion of the pre-fishery abundance 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 2014-2017, 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 2017, the first year with the new agreement in place. Numbers from 2017 must be interpreted with caution due to it only being a singular year and its basis on a year with difficult conditions both for fisheries and monitoring.

	2014-2017	**2006-2016**	**2017**
Coastal	15 %	15 %	19 %
Main stem	33 %	39 %	44 %
Tributary	19 %	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 2014-2017, overexploitation was 0 % for 2014-2016 and 17 % 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 % (2017) and 76 % (2016). The average maximum sustainable total exploitation rate in the period was 68 %, significantly higher than the estimated average total exploitation of 54 %.

3.5.3 Stock recovery

Over the last 4 years, the overall probability that the spawning target was reached in Veahčajohka/Vetsijoki was 100 %. The management target was therefore met in Veahčajohka/Vetsijoki and no stock recovery plan is needed for this tributary.

The median spawning stock size in the period 2014-2017 was 2 181 (1 579-2 996 kg). With the current exploitation and uncertainty estimates, we would need a spawning stock of approximately 1 300 kg to reach the management target of a 75 % probability of meeting the spawning target and approximately 2 050 kg to reach 100 % probability.

The estimates of maximum sustainable exploitation and the total exploitation of Veahčajohka/Vetsijoki-salmon indicate that over the last four years, the total exploitation has been lower than the estimated maximum sustainable exploitation.

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.

Table 12. Summary of stock data used to estimate annual spawning stock sizes in Ohcejohka/Utsjoki.

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

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 were 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.

Estimated truncated target attainment reached 100 % in all years except 2002-2005, 2008, 2010 and 2017 (Figure 22). Lowest attainment was 37 % in 2008 and 38 % in 2004. The highest probability of reaching the spawning target was 100 % in 2006, 2012-2014 and 2016. The management target was reached, as the last 4 years' (2014-2017) overall probability of reaching the spawning target was 99 % with an overall untruncated attainment of 152 %.

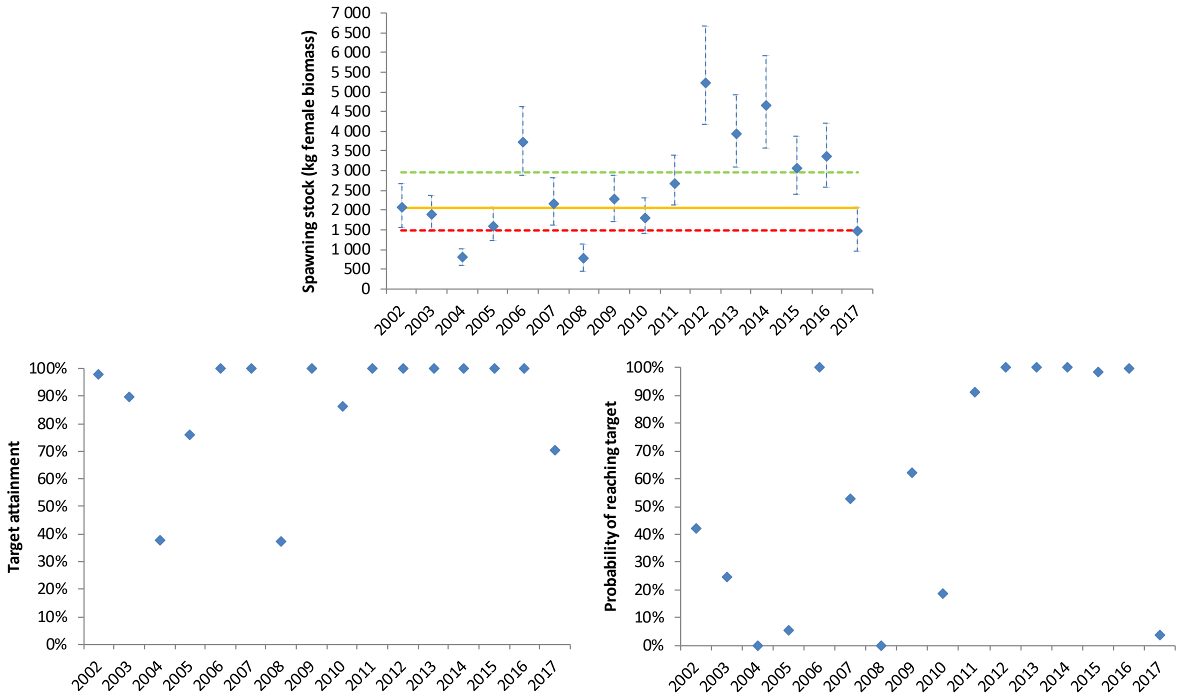

Figure 22. The estimated spawning stock (top row), percent truncated spawning target attainment (bottom row, left) and probability of reaching the spawning target (bottom row, right) in the period 2002-2017 in the Finnish tributary Ohcejohka/Utsjoki.

3.6.2 Exploitation

The estimated total exploitation rate (based on weight) of Ohcejohka/Utsjoki salmon was 56 % in the years 2014-2017 (Figure 23), with 14 % of the pre-fishery abundance caught in coastal fisheries, 22 % in main stem fisheries and 20 % in Ohcejohka/Utsjoki. The average estimated total pre-fishery abundance for Ohcejohka/Utsjoki salmon was 11 452 kg and the average total catch was 6 355 kg in the period 2014-2017.

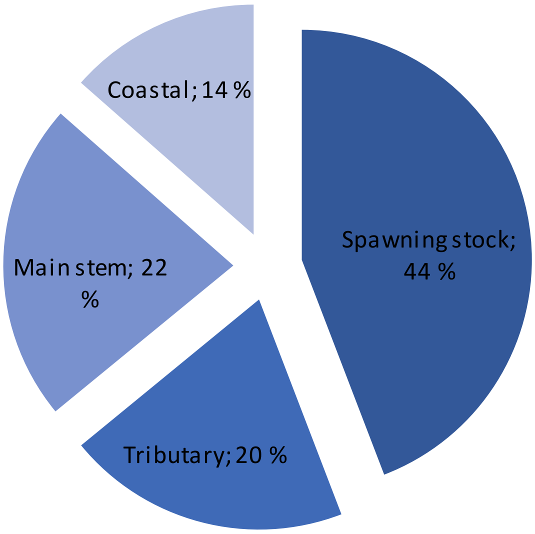

Figure 23. The total amount of salmon belonging to Ohcejohka/Utsjoki in 2014-2017, distributed into surviving spawning stock and salmon caught in fisheries in either coastal, main stem or Ohcejohka/Utsjoki fisheries. The percentages in the figure represent the proportion of the pre-fishery abundance 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 2014-2017, 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 2017, the first year with the new agreement in place. Numbers from 2017 must be interpreted with caution due to it only being a singular year and its basis on a year with difficult conditions both for fisheries and monitoring.

	2014-2017	**2006-2016**	**2017**
Coastal	14 %	14 %	16 %
Main stem	26 %	28 %	32 %
Tributary	31 %	28 %	45 %

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 2014-2017, overexploitation was 0 % for 2014-2016 and 29 % in 2017. The average overexploitation was estimated at 7 %. This means that exploitation on average was responsible for reducing the spawning stock size by an amount of 7 % below the spawning target. Maximum sustainable exploitation varied between 41 % (2017) and 74 % (2016). The average maximum sustainable total exploitation rate in the period was 60 %, higher than the estimated average total exploitation of 56 %.

3.6.3 Stock recovery

Over the last 4 years, the overall probability that the spawning target was reached in Ohcejohka/Utsjoki was 99 %. The management target was therefore met in Ohcejohka/Utsjoki and no stock recovery plan is needed for this tributary.

The median spawning stock size in the period 2014-2017 was 3 202 (2 483-4 040 kg). With the current exploitation and uncertainty estimates, we would need a spawning stock of approximately 2 350 kg to reach the management target of a 75 % probability of meeting the spawning target and approximately 3 300 kg to reach 100 % probability.

The estimates of maximum sustainable exploitation and the total exploitation of Ohcejohka/Utsjoki-salmon indicate that over the last four years, the total exploitation has been lower than the estimated maximum sustainable exploitation.

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. 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 2006-2017. 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 in 2017 was reduced by 5 % due to the implementation of new fishing rules in Tana.

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	0.35	0.43

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 were 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.

Estimated truncated target attainment reached 100 % in all years except 2011 with 73 % (Figure 24). The highest probability of reaching the spawning target was 100 % in 2007 and 2008 followed by 99 % in 2006. The management target was reached, as the last 4 years' (2014-2017) overall probability of reaching the spawning target was 85 % with an overall untruncated attainment of 131 %.

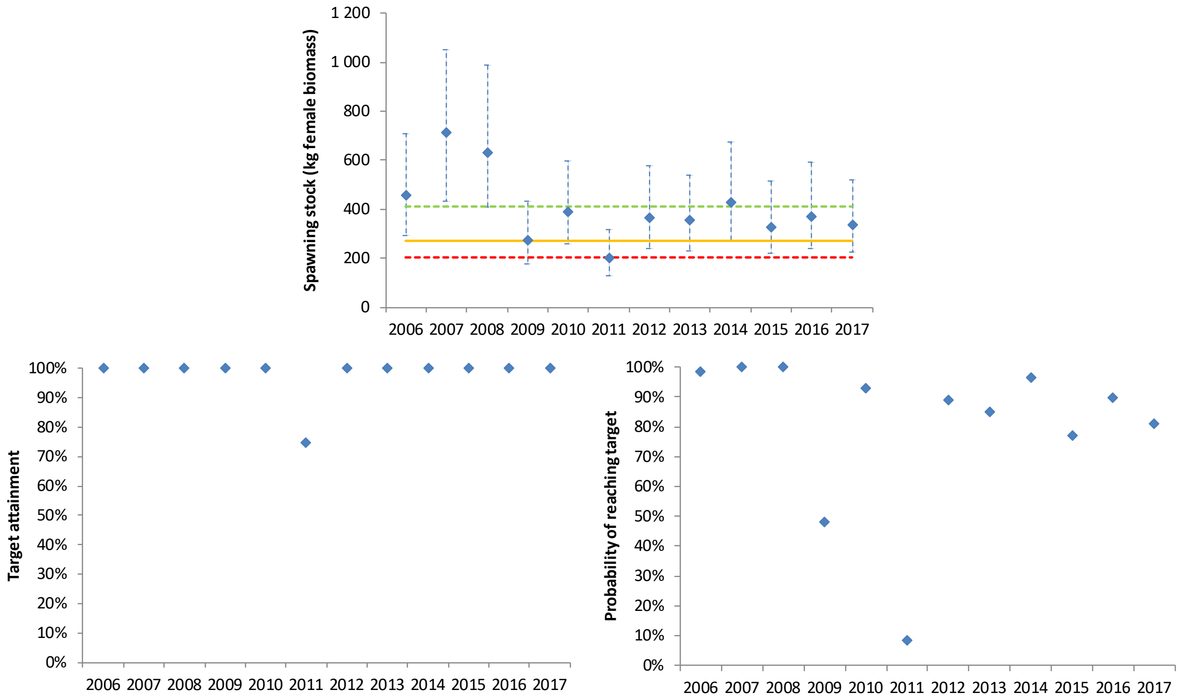

Figure 24. The estimated spawning stock (top row), percent truncated spawning target attainment (bottom row, left) and probability of reaching the spawning target (bottom row, right) in the period 2006-2017 in the Finnish tributary Goahppelašjohka/Kuoppilasjoki.

3.7.2 Exploitation

The estimated total exploitation rate (based on weight) of Goahppelašjohka/Kuoppilasjoki salmon was 49 % in the years 2014-2017 (Figure 25), with 15 % of the pre-fishery abundance caught in coastal fisheries, 34 % in main stem fisheries and 0 % in Goahppelašjohka/Kuoppilasjoki. The average estimated total pre-fishery abundance for Goahppelašjohka/Kuoppilasjoki salmon was 1 669 kg and the average total catch was 816 kg in the period 2014-2017.

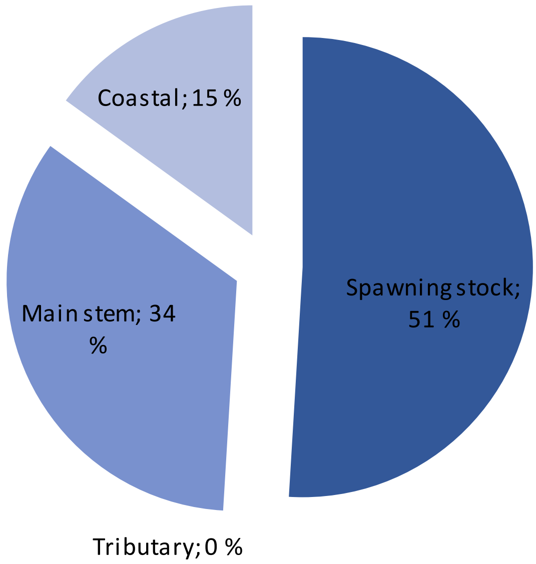

Figure 25. The total amount of salmon belonging to Goahppelašjohka/Kuoppilasjoki in 2014-2017, distributed into surviving spawning stock and salmon caught in fisheries in either coastal, main stem or Goahppelašjohka/Kuoppilasjoki fisheries. The percentages in the figure represent the proportion of the 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 2014-2017, 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 2017, the first year with the new agreement in place. Numbers from 2017 must be interpreted with caution due to it only being a singular year and its basis on a year with difficult conditions both for fisheries and monitoring.

	2014-2017	**2006-2016**	**2017**
Coastal	15 %	15 %	18 %
Main stem	40 %	41 %	36 %
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 2014-2017, overexploitation was 0 % for all years and the average overexploitation was therefore estimated at 0 %. Maximum sustainable exploitation varied between 57 % (2015, 2017) and 67 % (2014). The average maximum sustainable total exploitation rate in the period was 61 %, significantly higher than the estimated average total exploitation of 49 %.

3.7.3 Stock recovery

Over the last 4 years, the overall probability that the spawning target was reached in Goahppelašjohka/Kuoppilasjoki was 82 %. The management target was therefore met in Goahppelašjohka/Kuoppilasjoki and no stock recovery plan is needed for this tributary.

The median spawning stock size in the period 2014-2017 was 355 kg (233-551 kg). With the current exploitation and uncertainty estimates, we would need a spawning stock of approximately 320 kg to reach the management target of a 75 % probability of meeting the spawning target and approximately 450 kg to reach 100 % probability.

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 2006-2017. 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 in 2017 was reduced by 5 % due to the implementation of new fishing rules in Tana.

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	0.63
2010	981	0.0130	0.40	0.63
2011	415	0.0061	0.40	0.59
2012	1 037	0.0113	0.40	0.48
2013	890	0.0130	0.40	0.63
2014	1 085	0.0130	0.40	0.63
2015	850	0.0130	0.40	0.63
2016	948	0.0130	0.40	0.63
2017	689	0.0130	0.35	0.63

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 were 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.

Estimated truncated target attainment reached 100 % in all years (Figure 26). The probability of reaching the spawning target was 100 % in all years except 99 % in 2011. The management target was reached, as the last 4 years' (2014-2017) overall probability of reaching the spawning target was 100 % with an overall untruncated attainment of 444 %.

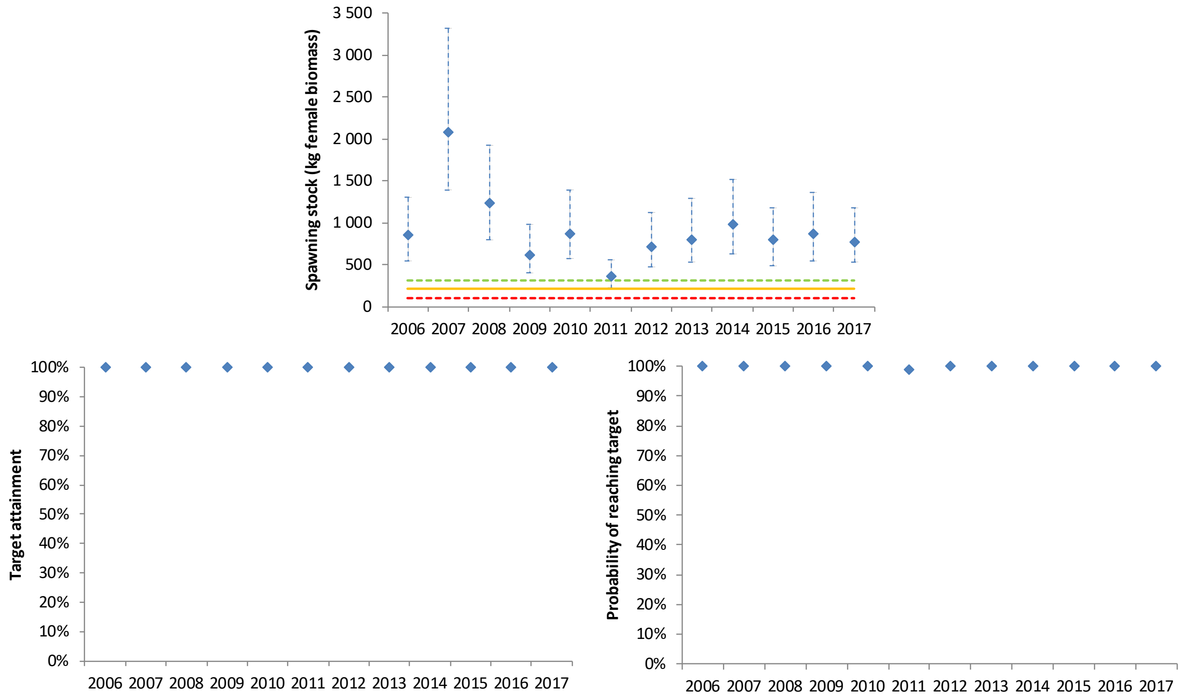

Figure 26. The estimated spawning stock (top row), percent truncated spawning target attainment (bottom row, left) and probability of reaching the spawning target (bottom row, right) in the period 2006-2017 in the Norwegian tributary Leavvajohka.

3.8.2 Exploitation

The estimated total exploitation rate (based on weight) of Leavvajohka salmon was 50 % in the years 2014-2017 (Figure 27), with 17 % of the pre-fishery abundance caught in coastal fisheries, 33 % in main stem fisheries and 0 % in Leavvajohka. The average estimated total pre-fishery abundance for Leavvajohka salmon was 2 683 kg and the average total catch was 1 329 kg in the period 2014-2017.

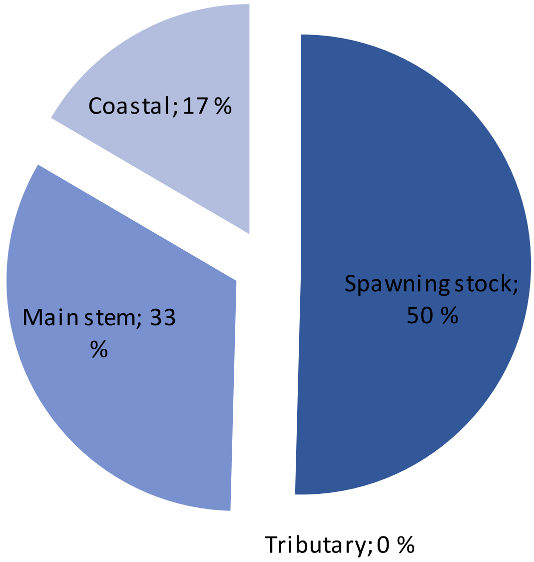

Figure 27. The total amount of salmon belonging to Leavvajohka in 2014-2017, distributed into surviving spawning stock and salmon caught in fisheries in either coastal, main stem or Leavvajohka fisheries. The percentages in the figure represent the proportion of the pre-fishery abundance that survives 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 2014-2017, 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 2017, the first year with the new agreement in place. Numbers from 2017 must be interpreted with caution due to it only being a singular year and its basis on a year with difficult conditions both for fisheries and monitoring.

	2014-2017	2006-2016	2017
Coastal	16 %	17 %	20 %
Main stem	40 %	41 %	36 %
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 2014-2017, overexploitation was 0 % for all years and the average overexploitation was therefore estimated at 0 %. Maximum sustainable exploitation varied between 86 % (2015, 2017) and 89 % (2014). The average maximum sustainable total exploitation rate in the period was 88 %, significantly higher than the estimated average total exploitation of 50 %.

3.8.3 Stock recovery

Over the last 4 years, the overall probability that the spawning target was reached in Leavvajohka was 100 %. The management target was therefore met in Leavvajohka and no stock recovery plan is needed for this tributary. This is likely true even if the spawning target is revised upwards.

The median spawning stock size in the period 2014-2017 was 828 kg (540-1 269 kg). With the current exploitation and uncertainty estimates and the current spawning target, we would need a spawning stock of approximately 260 kg to reach the management target of a 75 % probability of meeting the spawning target and approximately 350 kg to reach 100 % probability.

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 2006-2017. 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 estimate in 2017 was reduced with 5 % due to the implementation of new fishing rules in Tana.

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

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 were 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 estimated truncated target attainment reached 100 % in 2007, 2008, 2012 and 2014 (Figure 28). Lowest attainment was 28 % in 2011. The highest probability of reaching the spawning target was 100 % in 2007 followed by 99 % in 2008. The management target was not reached, as the last 4 years' (2014-2017) overall probability of reaching the spawning target was 31 % with an overall untruncated attainment of 91 %.

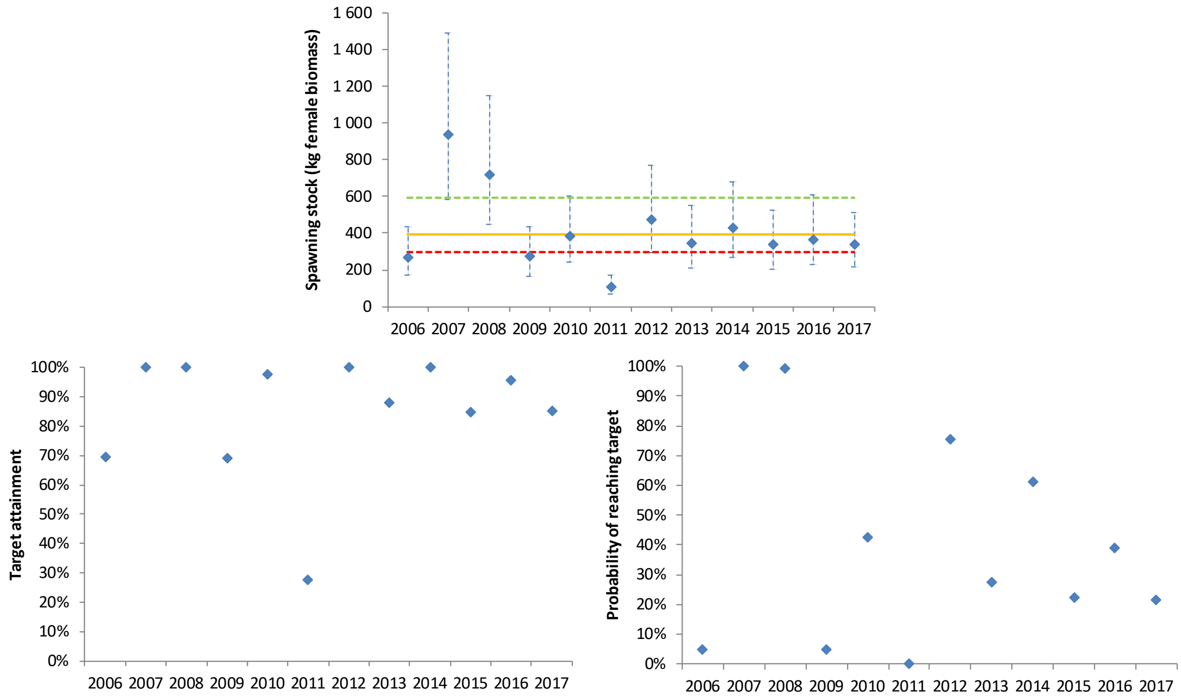

Figure 28. The estimated spawning stock (top row), percent truncated spawning target attainment (bottom row, left) and probability of reaching the spawning target (bottom row, right) in the period 2006-2017 in the Norwegian tributary Báišjohka.

3.9.2 Exploitation

The estimated total exploitation rate (based on weight) of Báišjohka salmon was 53 % in the years 2014-2017 (Figure 29), with 16 % of the pre-fishery abundance caught in coastal fisheries, 37 % in main stem fisheries and 0 % in Báišjohka. The average estimated total pre-fishery abundance for Báišjohka salmon was 1 299 kg and the average total catch was 691 kg in the period 2014-2017.

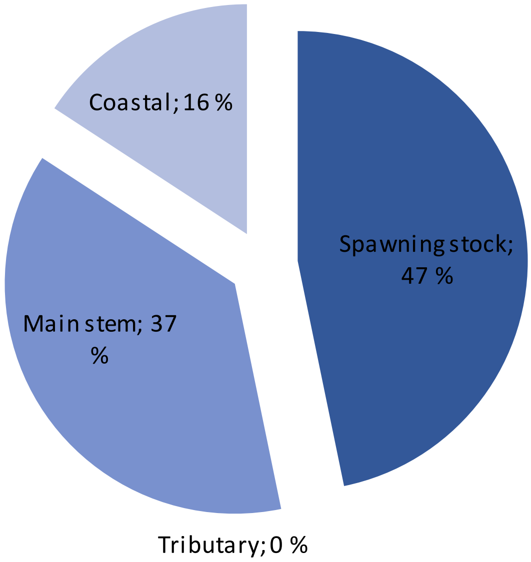

Figure 29. The total amount of salmon belonging to Báišjohka in 2014-2017, distributed into surviving spawning stock and salmon caught in fisheries in either coastal, main stem or Báišjohka fisheries. The percentages in the figure represent the proportion of the pre-fishery abundance that survives to 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 2014-2017, 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 2017, the first year with the new agreement in place. Numbers from 2017 must be interpreted with caution due to it only being a singular year and its basis on a year with difficult conditions both for fisheries and monitoring.

	2014-2017	**2006-2016**	**2017**
Coastal	16 %	16 %	19 %
Main stem	45 %	46 %	40 %
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 2014-2017, overexploitation varied between 0 % (2014) and 14 % (2015, 2017) and the average overexploitation was estimated at 9 %. Maximum sustainable exploitation varied between 44 % (2015, 2017) and 57 % (2014). The average maximum sustainable total exploitation rate in the period was 49 %, lower than the estimated average total exploitation of 53 %.

3.9.3 Stock recovery

Over the last 4 years, the overall probability that the spawning target was reached in Báišjohka was 31 %. The management target was therefore not met in Báišjohka.

The median spawning stock size in the period 2014-2017 was 352 kg (223-567 kg). With the current exploitation and uncertainty estimates, we would need a spawning stock of approximately 460 kg to reach the management target of a 75 % probability of meeting the spawning target and approximately 630 kg to reach 100 % probability. In the years 2014-2017, we have, therefore, on average lacked a female biomass of around 110 kg to reach the management target.

A management target probability below 40 % means that a stock recovery plan should be initiated for the Báišjohka stock. The starting point of this recovery plan is the estimated exploitation rate experienced by the Báišjohka stock in the years 2006-2016 (before the new Tana agreement). There are two stock recovery trajectories shown in Figure 30 below. One is the stock recovery trajectory that follows from the 30 % reduction that was used as an overall guideline in the negotiations. The second is the recovery trajectory corresponding to the minimum reduction in exploitation needed to complete the stock recovery of Báišjohka salmon after two generations.

The starting point of the recovery trajectories are the stock-specific management target attainment. The simulation then calculates a new management target attainment based on the number of spawners that would have survived in the years before the regulation if the total exploitation had been reduced by a certain percentage. The resulting percentage increase is applied to subsequent generations, resulting in a ladder-like recovery trajectory.

Please note that the reductions in exploitation in Figure 30 are in comparison with the situation in 2006-2016. The reductions that are listed here are therefore not reductions on top of the fishing rules that were implemented in 2017.

Compared with the period 2006-2016, the minimum reduction in exploitation for the years 2017 and onwards that would lead to a stock recovery after two generations is 8 %.

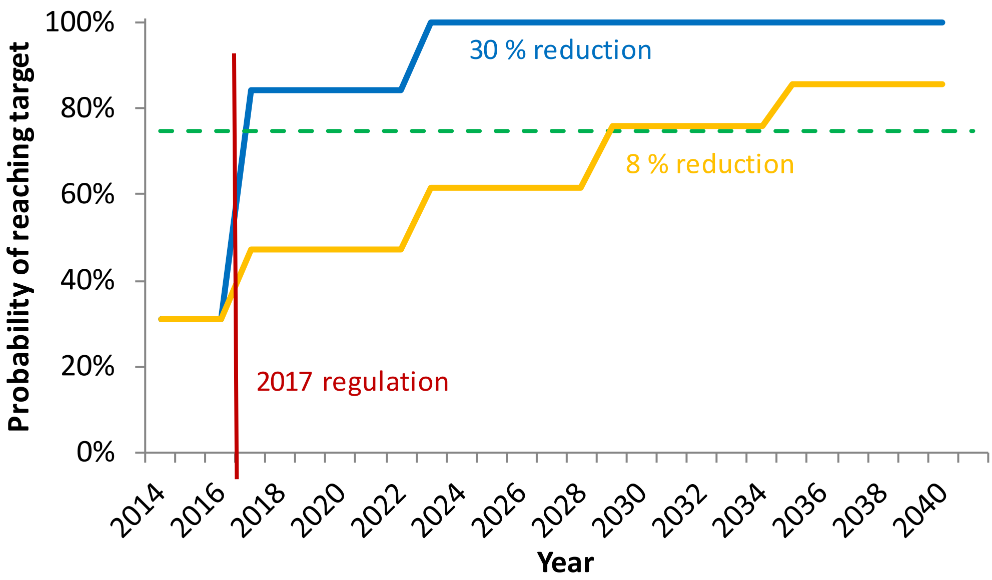

Figure 30. Stock recovery trajectories for Báišjohka salmon, corresponding to two scenarios of reduced total exploitation. (Orange) This is the trajectory showing stock recovery at a 9 % reduction from the average

exploitation level in 2006-2016, this is the minimum reduction in exploitation needed to achieve stock recovery after two generations, and (Blue) a recovery trajectory following the stock development after a 30 % reduction in exploitation compared to the years 2006-2016. The green dotted line represents the management target (75 % probability that spawning target is reached).

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 2006-2017, 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 proportion*

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.

There is very little fishing pressure in Njiljohka/Nilijoki and no catch statistics. 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

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				

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 were 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 estimated truncated target attainment reached 100 % in 2007 and 2008 (Figure 31). Lowest attainment was 52 % in 2010. The highest probability of reaching the spawning target was 100 % in 2007. The management target was not reached, as the last 4 years' (2014-2017) overall probability of reaching the spawning target was 28 % with an overall untruncated attainment of 91 %.

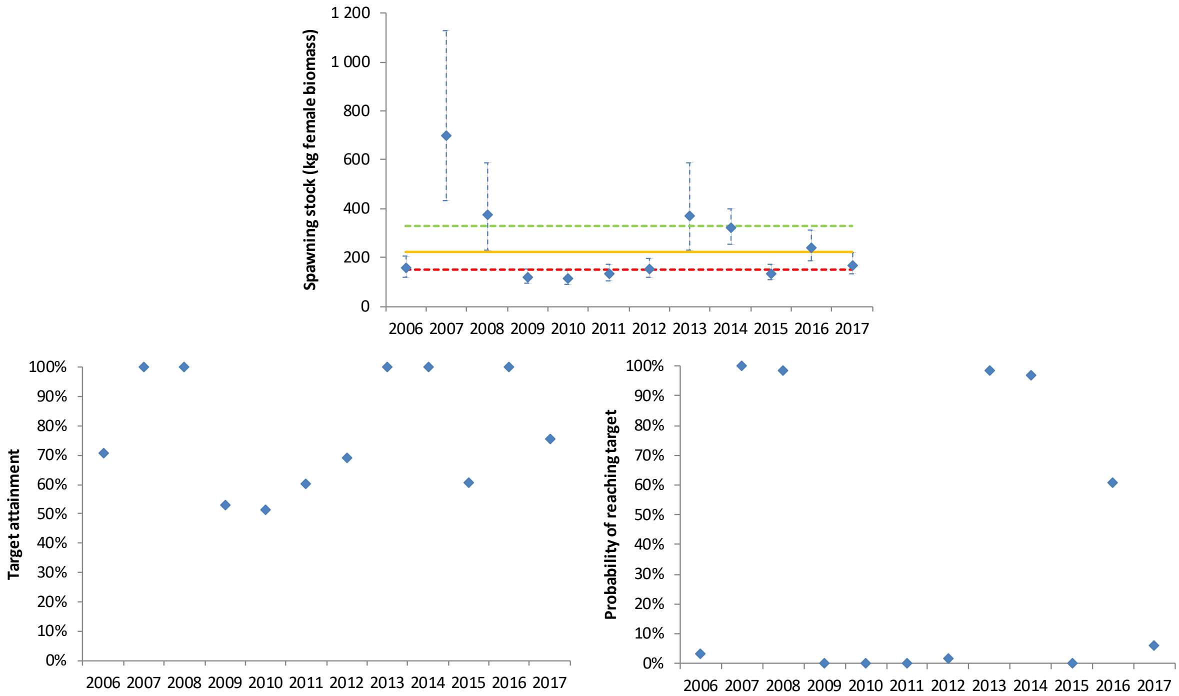

Figure 31. The estimated spawning stock (top row), percent truncated spawning target attainment (bottom row, left) and probability of reaching the spawning target (bottom row, right) in the period 2006-2017 in the Finnish tributary Njiljohka/Nilijoki.

3.10.2 Exploitation

The estimated total exploitation rate (based on weight) of Njiljohka/Nilijoki salmon was 63 % in the years 2014-2017 (Figure 32), with 16 % of the pre-fishery abundance caught in coastal fisheries, 47 % in main stem fisheries and 0 % in Njiljohka/Nilijoki. The average estimated total pre-fishery abundance for Njiljohka/Nilijoki salmon was 1 155 kg and the average total catch was 728 kg in the period 2014-2017.

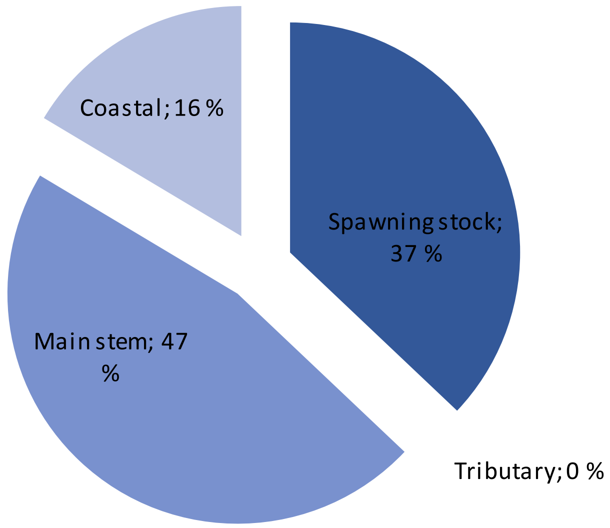

Figure 32. The total amount of salmon belonging to Njiljohka/Nilijoki in 2014-2017, distributed into surviving spawning stock and salmon caught in fisheries in either coastal, main stem or Njiljohka/Nilijoki fisheries. The percentages in the figure represent the proportion of the pre-fishery abundance 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 2014-2017, 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 2017, the first year with the new agreement in place. Numbers from 2017 must be interpreted with caution due to it only being a singular year and its basis on a year with difficult conditions both for fisheries and monitoring.

	2014-2017	2006-2016	2017
Coastal	16 %	17 %	20 %
Main stem	56 %	59 %	53 %
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 2014-2017, overexploitation varied between 0 % (2014, 2016) and 39 % (2015). The average overexploitation was estimated at 16 %. Maximum sustainable exploitation varied between 46 % (2015) and 72 % (2014). The average maximum sustainable total exploitation rate in the period was 59 %, lower than the estimated average total exploitation of 63 %.

3.10.3 Stock recovery

Over the last 4 years, the overall probability that the spawning target was reached in Njiljohka/Nilijoki was 28 %. The management target was therefore not met in Njiljohka/Nilijoki.

The median spawning stock size in the period 2014-2017 was 202 kg (159-264 kg). With the current exploitation and uncertainty estimates, we would need a spawning stock of approximately 255 kg to reach the management target of a 75 % probability of meeting the spawning target and over 350 kg to reach 100 % probability. In the years 2014-2017, we have, therefore, on average lacked a female biomass of 50 kg to reach the management target.

A management target probability below 40 % means that a stock recovery plan should be initiated for the Njiljohka/Nilijoki stock. The starting point of this recovery plan is the estimated exploitation rate experienced by the Njiljohka/Nilijoki stock in the years 2006-2016 (before the new Tana agreement). There are two stock recovery trajectories shown in Figure 33 below. One is the stock recovery trajectory that follows from the 30 % reduction that was used as an overall guideline in the negotiations. The second is the recovery trajectory corresponding to the minimum reduction in exploitation needed to complete the stock recovery of Njiljohka/Nilijoki salmon after two generations.

The starting point of the recovery trajectories are the stock-specific management target attainment. The simulation then calculates a new management target attainment based on the number of spawners that would have survived in the years before the regulation if the total exploitation had been reduced by a certain percentage. The resulting percentage increase is applied to subsequent generations, resulting in a ladder-like recovery trajectory.

Please note that the reductions in exploitation in Figure 33 are in comparison with the situation in 2006-2016. The reductions that are listed here are therefore not reductions on top of the fishing rules that were implemented in 2017.

Compared with the period 2006-2016, the minimum reduction in exploitation for the years 2017 and onwards that would lead to a stock recovery after two generations is 5 %.

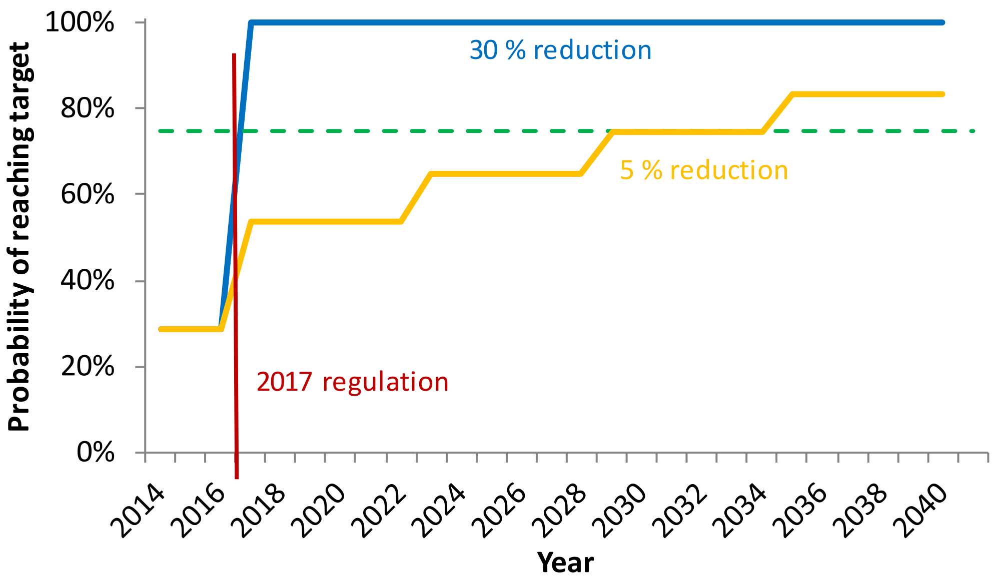

Figure 33. Stock recovery trajectories for Njiljohka/Nilijoki salmon, corresponding to two scenarios of reduced total exploitation. (Orange) This is the trajectory showing stock recovery at a 5 % reduction from

the average exploitation level in 2006-2016, this is the minimum reduction in exploitation needed to achieve stock recovery after two generations, and (Blue) a recovery trajectory following the stock development after a 30 % reduction in exploitation compared to the years 2006-2016. The green dotted line represents the management target (75 % probability that spawning target is reached).

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 the 5-year average from Genmix.

There is very little fishing pressure in Váljohka with only a few fishermen every year and a limited reported catch ranging from 88 kg and 89 kg (2017 and 2016, respectively) up 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 license combined with low accessibility for fishermen in combination with the recent monitoring results indicates a low exploitation level throughout the status assessment period (2006-2017). 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. We are therefore changing the status assessment method for Váljohka in the present report.

We extend the evaluation to include main stem fisheries and the genetic stock identification results there 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 from these five years to cover the remaining years in the period 2006-2017. The reported Váljohka catch is added to the estimated main stem catch every year. The main stem exploitation is estimated at 40 % 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 used for the status assessment becomes 45 %. We subtracted 5 % from the combined exploitation rate in 2017 due to the implementation of new fishing rules in Tana.

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

Year	Estimated main stem catch (kg)	Main stem proportion	Main stem exploitation rate	Female proportion
2006	901	0.0101	0.45	0.35
2007	877	0.0099	0.45	0.54
2008	792	0.0076	0.45	0.55
2009	443	0.0083	0.45	0.43
2010	624	0.0083	0.45	0.43
2011	343	0.0050	0.45	0.40
2012	764	0.0083	0.45	0.33
2013	566	0.0083	0.45	0.43
2014	690	0.0083	0.45	0.43
2015	541	0.0083	0.45	0.43
2016	603	0.0083	0.45	0.43
2017	438	0.0083	0.40	0.43

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 were 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 estimated truncated target attainment reached 100 % in all years except 2009 with 95 % (Figure 34). The highest probability of reaching the spawning target was 100 % in 2012 followed by 99 % in 2007. The management target was nearly reached, as the last 4 years' (2014-2017) overall probability of reaching the spawning target was 73 % with an overall untruncated attainment of 121 %.

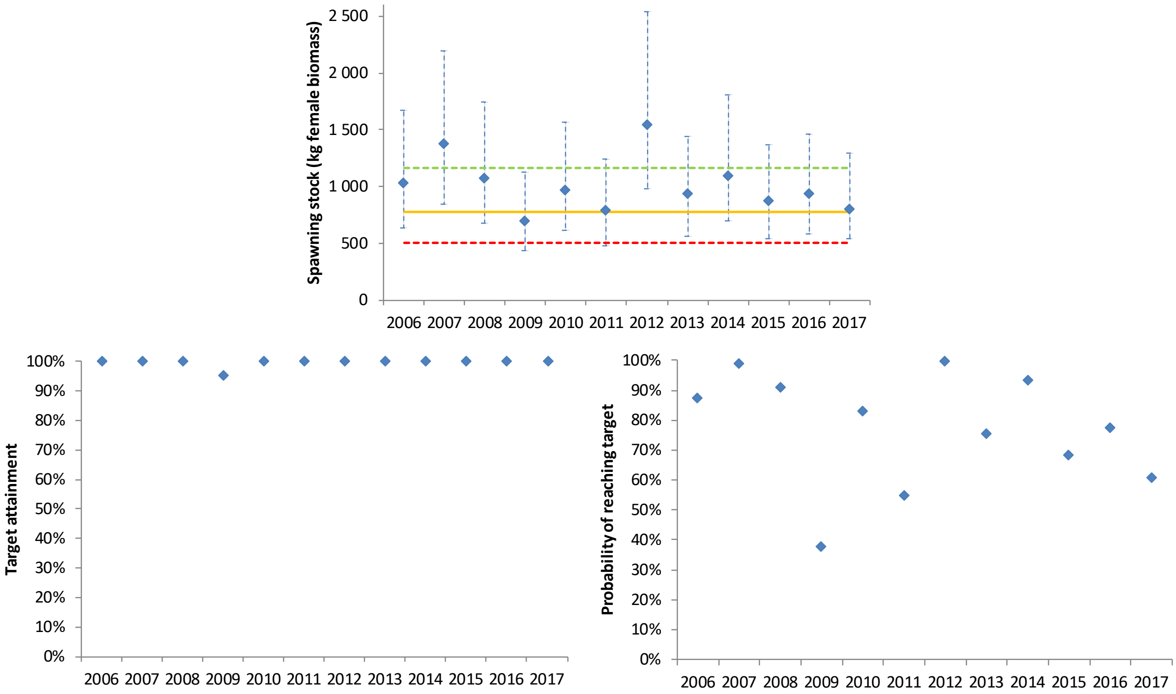

Figure 34. The estimated spawning stock (top row), percent truncated spawning target attainment (bottom row, left) and probability of reaching the spawning target (bottom row, right) in the period 2006-2017 in the Norwegian tributary Váljohka.

3.11.2 Exploitation

The estimated total exploitation rate (based on weight) of Váljohka salmon was 52 % in the years 2014-2017 (Figure 35), with 17 % of the pre-fishery abundance caught in coastal fisheries, 31 % in main stem fisheries and 4 % in Váljohka. The average estimated total pre-fishery abundance for Váljohka salmon was 3 337 kg and the average total catch was 1 736 kg in the period 2014-2017.

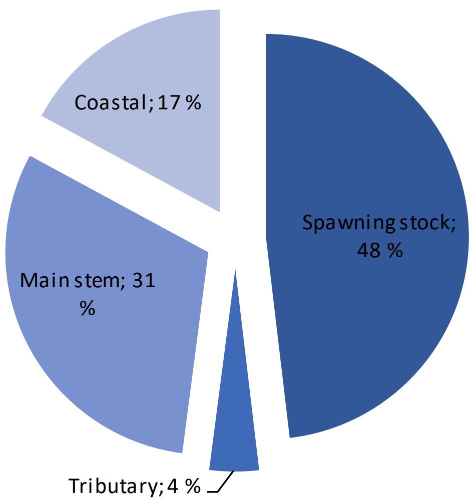

Figure 35. The total amount of salmon belonging to Váljohka in 2014-2017, distributed into surviving spawning stock and salmon caught in fisheries in either coastal, main stem or Váljohka fisheries. The

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 2014-2017, 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 2017, the first year with the new agreement in place. Numbers from 2017 must be interpreted with caution due to it only being a singular year and its basis on a year with difficult conditions both for fisheries and monitoring.

	2014-2017	**2006-2016**	**2017**
Coastal	17 %	16 %	21 %
Main stem	38 %	37 %	36 %
Tributary	8 %	9 %	6 %

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 2014-2017, overexploitation was 0 % for all years and the average overexploitation was therefore estimated at 0 %. Maximum sustainable exploitation varied between 54 % (2017) and 66 % (2014). The average maximum sustainable total exploitation rate in the period was 59 %, higher than the estimated average total exploitation of 52 %.

3.11.3 Stock recovery

Over the last 4 years, the overall probability that the spawning target was reached in Váljohka was 73 %. The management target was therefore nearly met in Váljohka.

The median spawning stock size in the period 2014-2017 was 905 kg (559-1 415 kg). With the current exploitation and uncertainty estimates, we would need a spawning stock of approximately 925 kg to reach the management target of a 75 % probability of meeting the spawning target and approximately 1 250 kg to reach 100 % probability. In the years 2014-2017, we have, therefore, on average lacked a female biomass of around 20 kg to reach the management target.

The management target probability was under 75 % but still over 40 %, meaning that minor adjustments to the exploitation rate would be sufficient to increase the target attainment sufficiently. There are two stock recovery trajectories shown in Figure 36 below. One is the stock recovery trajectory that follows from the 30 % reduction that was used as an overall guideline in the negotiations. The second is the recovery trajectory corresponding to the minimum reduction in exploitation needed to complete the stock recovery of Váljohka salmon after two generations.

The starting point of the recovery trajectories are the stock-specific management target attainment. The simulation then calculates a new management target attainment based on the number of spawners that would have survived in the years before the regulation if the total exploitation had been reduced by a certain percentage. The resulting percentage increase is applied to subsequent generations, resulting in a ladder-like recovery trajectory.

Please note that the reductions in exploitation in Figure 36 are in comparison with the situation in 2006-2016. The reductions that are listed here are therefore not reductions on top of the fishing rules that were implemented in 2017.

Compared with the period 2006-2016, the minimum reduction in exploitation for the years 2017 and onwards that would lead to a stock recovery after two generations is less than 1 %.

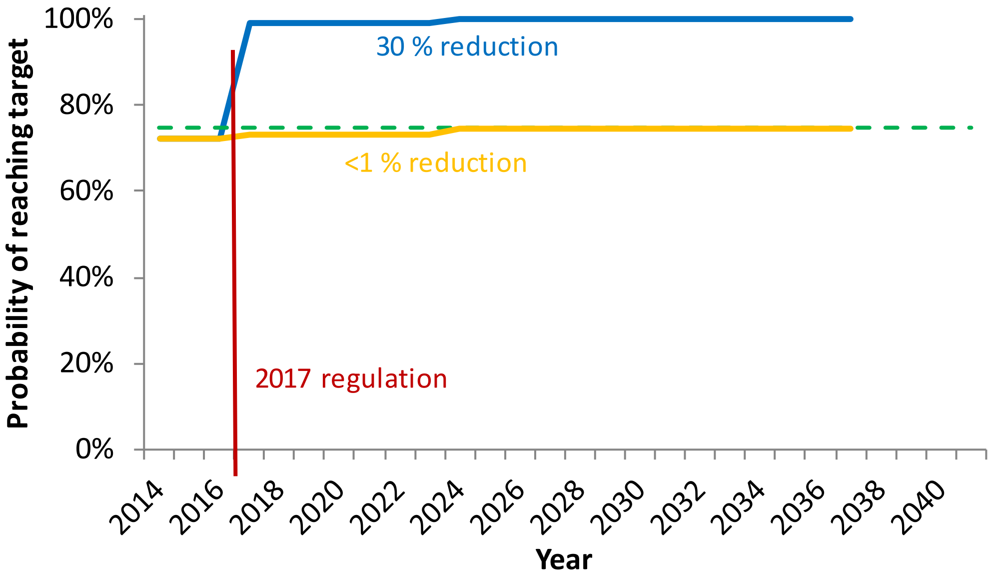

Figure 36. Stock recovery trajectories for Váljohka salmon, corresponding to two scenarios of reduced total exploitation. (Orange) This is the trajectory showing stock recovery at <1 % reduction from the average exploitation level in 2006-2016, this is the minimum reduction in exploitation needed to achieve stock recovery after two generations, and (Blue) a recovery trajectory following the stock development after a 30 % reduction in exploitation compared to the years 2006-2016. The green dotted line represents the management target (75 % probability that spawning target is reached).

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.

There is very little fishing pressure in Áhkojohka/Akujoki and 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

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 were 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 estimated truncated target attainment reached 100 % in 2012 (Figure 37). Lowest attainment was 29 % in 2017. The highest probability of reaching the spawning target was 85 % in 2012. The management target was not reached, as the last 4 years' (2014-2017) overall probability of reaching the spawning target was 0 % with an overall untruncated attainment of 64 %.

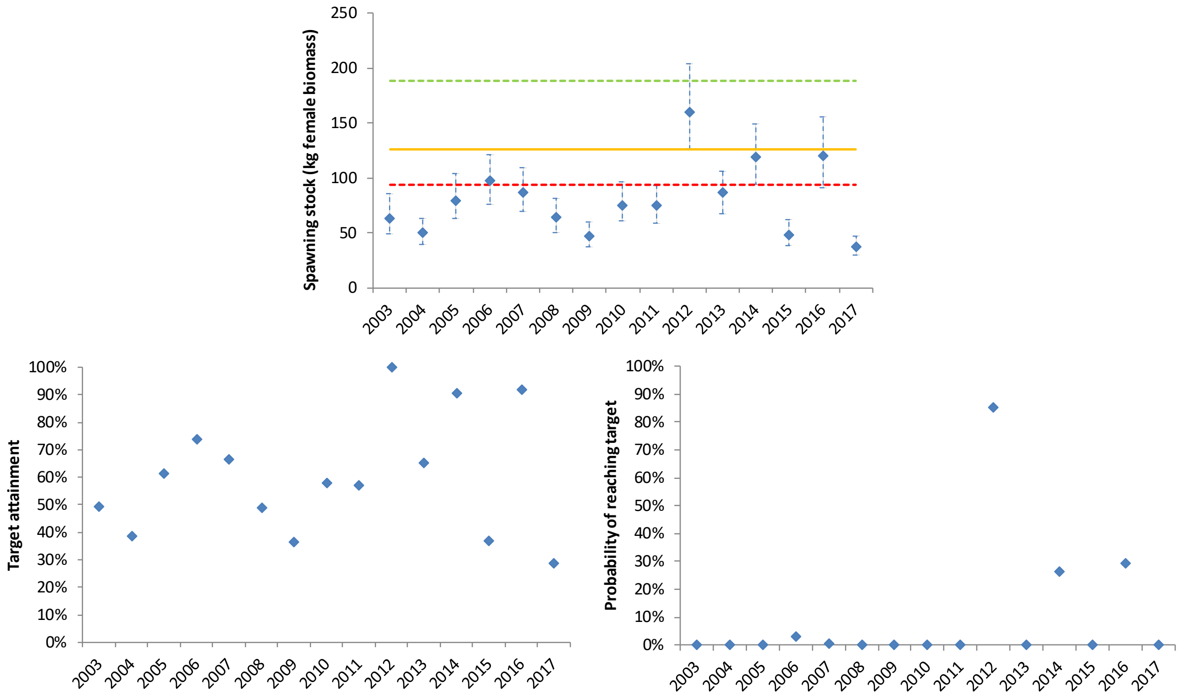

Figure 37. The estimated spawning stock (top row), percent truncated spawning target attainment (bottom row, left) and probability of reaching the spawning target (bottom row, right) in the period 2006-2017 in the Finnish tributary Áhkojohka/Akujoki.

3.12.2 Exploitation

The estimated total exploitation rate (based on weight) of Áhkojohka/Akujoki salmon was 79 % in the years 2014-2017 (Figure 38), with 16 % 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 839 kg and the average total catch was 666 kg in the period 2014-2017.

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 38 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.

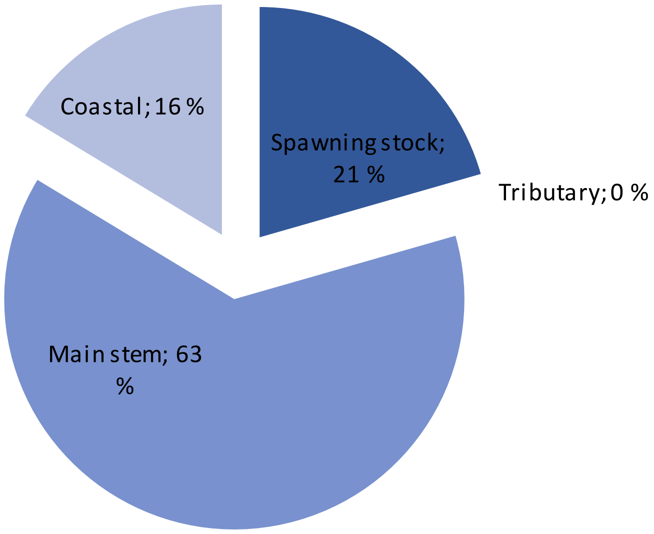

Figure 38. The total amount of salmon belonging to Áhkojohka/Akujoki in 2014-2017, distributed into surviving spawning stock and salmon caught in fisheries in either coastal, main stem or Áhkojohka/Akujoki fisheries. The percentages in the figure represent the proportion of the pre-fishery abundance 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 2014-2017, 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 2017, the first year with the new agreement in place. Numbers from 2017 must be interpreted with caution due to it only being a singular year and its basis on a year with difficult conditions both for fisheries and monitoring.

	2014-2017	**2006-2016**	**2017**
Coastal	16 %	16 %	20 %
Main stem	75 %	75 %	81 %
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 2014-2017, overexploitation varied between 5 % (2014) and 70 % (2017). The average overexploitation was estimated at 36 %. Maximum sustainable exploitation varied between 49 % (2017) and 75 % (2014). The average maximum sustainable total exploitation rate in the period was 65 %, lower than the estimated average total exploitation of 79 %. 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 overestimated maximum sustainable exploitation estimate.

3.12.3 Stock recovery

Over the last 4 years, the overall probability that the spawning target was reached in Áhkojohka/Akujoki was 0 %. The management target was therefore not met in Áhkojohka/Akujoki.

The median spawning stock size in the period 2014-2017 was 84 kg (65-105 kg). With the current exploitation and uncertainty estimates, we would need a spawning stock of approximately 150 kg to reach the management target of a 75 % probability of meeting the spawning target and over 200 kg to reach 100 % probability. In the years 2014-2017, we have, therefore, on average lacked a female biomass of around 65 kg to reach the management target.

A management target probability below 40 % means that a stock recovery plan should be initiated for the Áhkojohka/Akujoki stock. The starting point of this recovery plan is the estimated exploitation rate experienced by the Áhkojohka/Akujoki stock in the years 2006-2016 (before the new Tana agreement). There are two stock recovery trajectories shown in Figure 39 below. One is the stock recovery trajectory that follows from the 30 % reduction that was used as an overall guideline in the negotiations. The second is the recovery trajectory corresponding to the minimum reduction in exploitation needed to complete the stock recovery of Áhkojohka/Akujoki salmon after two generations.

The starting point of the recovery trajectories are the stock-specific management target attainment. The simulation then calculates a new management target attainment based on the number of spawners that would have survived in the years before the regulation if the total exploitation had been reduced by a certain percentage. The resulting percentage increase is applied to subsequent generations, resulting in a ladder-like recovery trajectory.

Please note that the reductions in exploitation in Figure 39 are in comparison with the situation in 2006-2016. The reductions that are listed here are therefore not reductions on top of the fishing rules that were implemented in 2017.

Compared with the period 2006-2016, the minimum reduction in exploitation for the years 2017 and onwards that would lead to a stock recovery after two generations is 8 %.

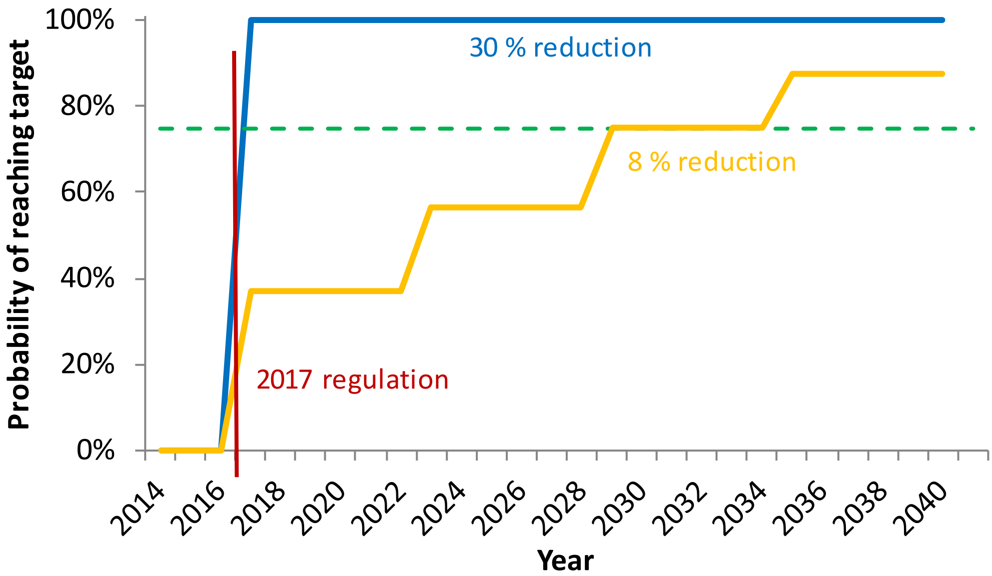

Figure 39. Stock recovery trajectories for Áhkojohka/Akujoki salmon, corresponding to two scenarios of reduced total exploitation. (Orange) This is the trajectory showing stock recovery at a 8% reduction from the average exploitation level in 2006-2016, this is the minimum reduction in exploitation needed to achieve stock recovery after two generations, and (Blue) a recovery trajectory following the stock development after a 30 % reduction in exploitation compared to the years 2006-2016. The green dotted line represents the management target (75 % probability that spawning target is reached).

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 at Heastanjárga (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 in 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.

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	1254	687	0.25	0.45	0.45	0.23	0.70	0.82
2008	235	1140	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

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.

Estimated truncated target attainment reached 44 % in 2008 (Figure 40). Lowest attainment was 11 % in 2009. The probability of reaching the spawning target was 0 % for all years in the period 2006-2017. The management target was therefore not reached, as the last 4 years' (2014-2017) overall probability of reaching the spawning target was also 0 % with an overall attainment of 35 %.

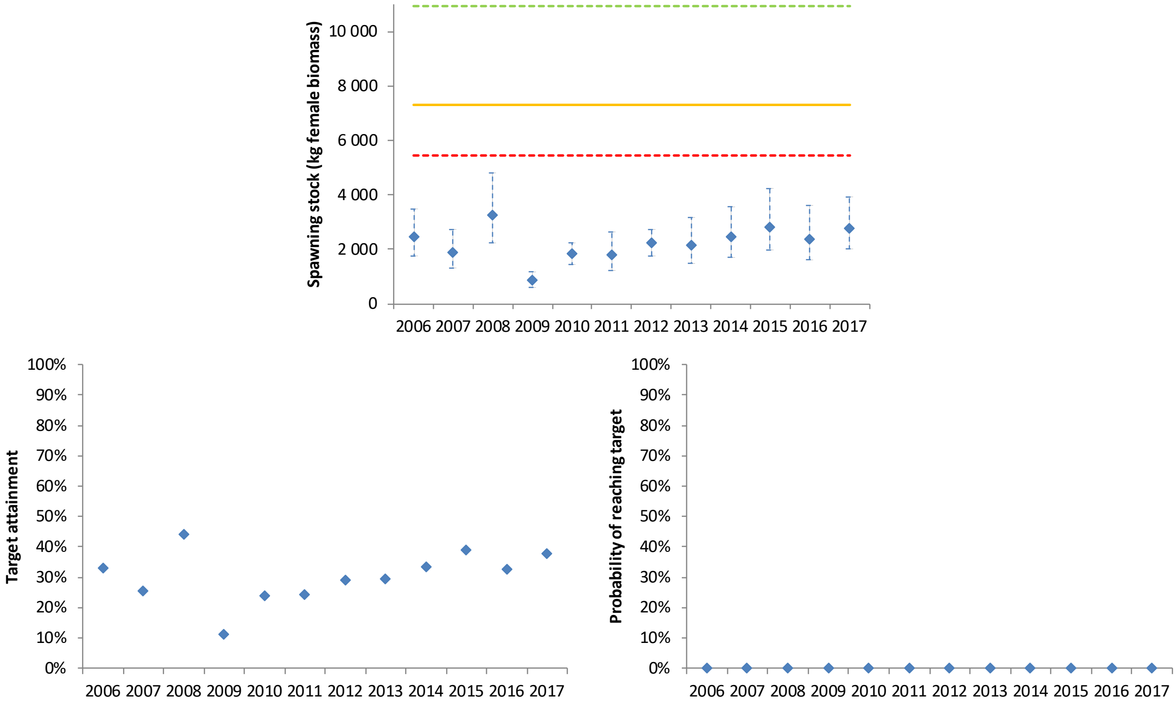

Figure 40. The estimated spawning stock (top row), percent truncated spawning target attainment (bottom row, left) and probability of reaching the spawning target (bottom row, right) in the period 2006-2017 in the Norwegian tributary Kárášjohka.

3.13.2 Exploitation

The estimated total exploitation rate (based on weight) of Kárášjohka salmon was 76 % in the years 2014-2017 (Figure 41), with 14 % of the pre-fishery abundance caught in coastal fisheries, 44 % in main stem fisheries and 18 % in Kárášjohka. The average estimated total pre-fishery abundance for Kárášjohka salmon was 17 015 kg and the average total catch was 12 979 kg in the period 2014-2017.

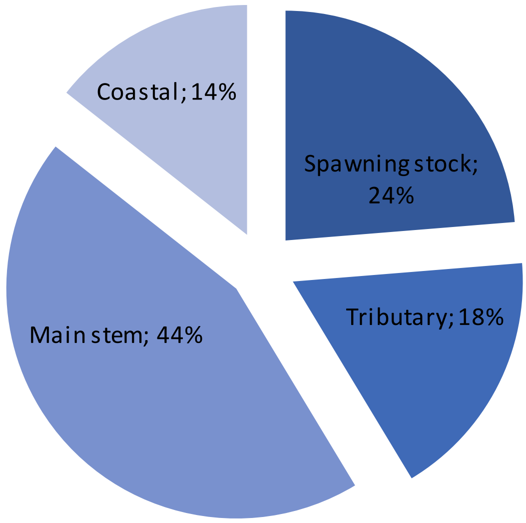

Figure 41. The total amount of salmon belonging to Kárášjohka in 2014-2017, distributed into surviving spawning stock and salmon caught in fisheries in either coastal, main stem or Kárášjohka fisheries. The percentages in the figure represent the proportion of the pre-fishery abundance that survives 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 2014-2017, 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 2017, the first year with the new agreement in place. Numbers from 2017 must be interpreted with caution due to it only being a singular year and its basis on a year with difficult conditions both for fisheries and monitoring.

	2014-2017	**2006-2016**	**2017**
Coastal	14 %	14 %	18 %
Main stem	52 %	56 %	49 %
Tributary	43 %	45 %	33 %

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 2014-2017, overexploitation varied between 61 % (2015) and 68 % (2016). The average overexploitation was estimated at 64 %. This means that exploitation on average was responsible for reducing the spawning stock size by an amount of 64 % below the spawning target. Maximum sustainable exploitation varied between 16 % (2015, 2017) and 25 % (2016). The average maximum sustainable total exploitation rate in the period was 19 %, significantly lower than the estimated average total exploitation of 76 %.

3.13.3 Stock recovery

Over the last 4 years, the overall probability that the spawning target was reached in Kárášjohka was 0 %. Target attainment therefore needs to be significantly improved to reach the 75 % 4-year probability specified by the management target.

The median spawning stock size in the period 2014-2017 was 2 622 kg (1 830-3 778 kg). With the current exploitation and uncertainty estimates, we would need a spawning stock of over 8 500 kg to reach the management target of a 75 % probability of meeting the spawning target and over 11 500 kg to reach 100 % probability. In the years 2014-2017, we have, therefore, on average lacked a female biomass of close to 6 000 kg to reach the management target.

A management target probability below 40 % means that a stock recovery plan should be initiated for the Kárášjohka stocks. The starting point of this recovery plan is the estimated exploitation rate experienced by the Kárášjohka stocks in the years 2006-2016 (before the new Tana agreement). There are two stock recovery trajectories shown in Figure 42 below. One is the stock recovery trajectory that follows from the 30 % reduction that was used as an overall guideline in the negotiations. The second is the recovery trajectory corresponding to the minimum reduction in exploitation needed to complete the stock recovery of Kárášjohka salmon after two generations.

The starting point of the recovery trajectories are the stock-specific management target attainment. The simulation then calculates a new management target attainment based on the number of spawners that would have survived in the years before the regulation if the total exploitation had been reduced by a certain percentage. The resulting percentage increase is applied to subsequent generations, resulting in a ladder-like recovery trajectory.

Please note that the reductions in exploitation in Figure 42 are in comparison with the situation in 2006-2016. The reductions that are listed here are therefore not reductions on top of the fishing rules that were implemented in 2017.

Compared with the period 2006-2016, the minimum reduction in exploitation for the years 2017 and onwards that would lead to a stock recovery after two generations is 23 %.

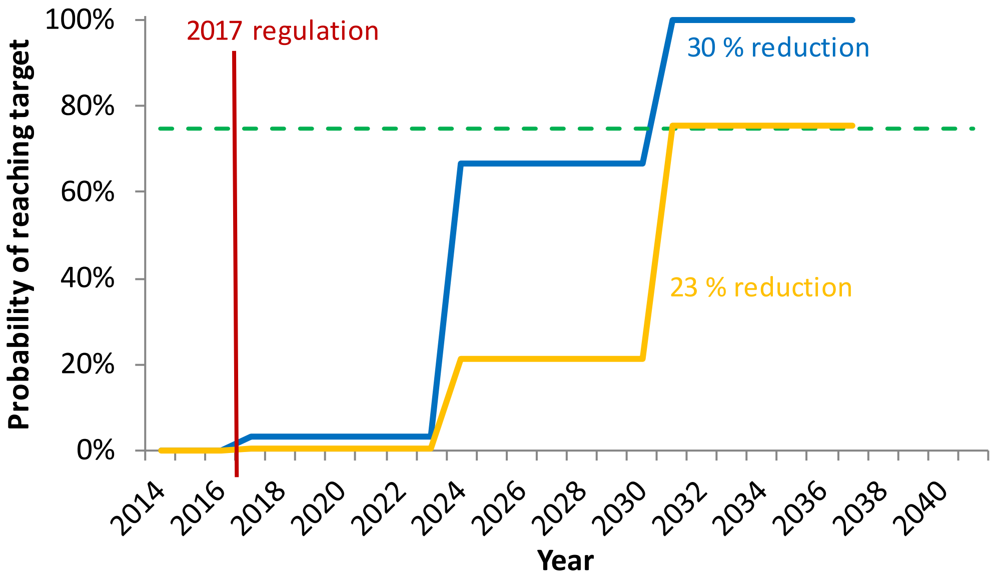

Figure 42. Stock recovery trajectories for Kárášjohka salmon, corresponding to two scenarios of reduced total exploitation. (Orange) This is the trajectory showing stock recovery at a 23 % reduction from the average exploitation level in 2006-2016, this is the minimum reduction in exploitation needed to achieve stock recovery after two generations, and (Blue) a recovery trajectory following the stock development after a 30 % reduction in exploitation compared to the years 2006-2016. The green dotted line represents the management target (75 % probability that spawning target is reached).

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.

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

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.

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.

Estimated truncated target attainment reached 69 % in 2008 (Figure 43). Lowest attainment was 17 % in 2009. The probability of reaching the spawning target was 0 % for all years in the period 2006-2017 except for 3 % in 2008. The management target was therefore not reached, as the last 4 years' (2014-2017) overall probability of reaching the spawning target was 0 % with an overall attainment of 37 %.

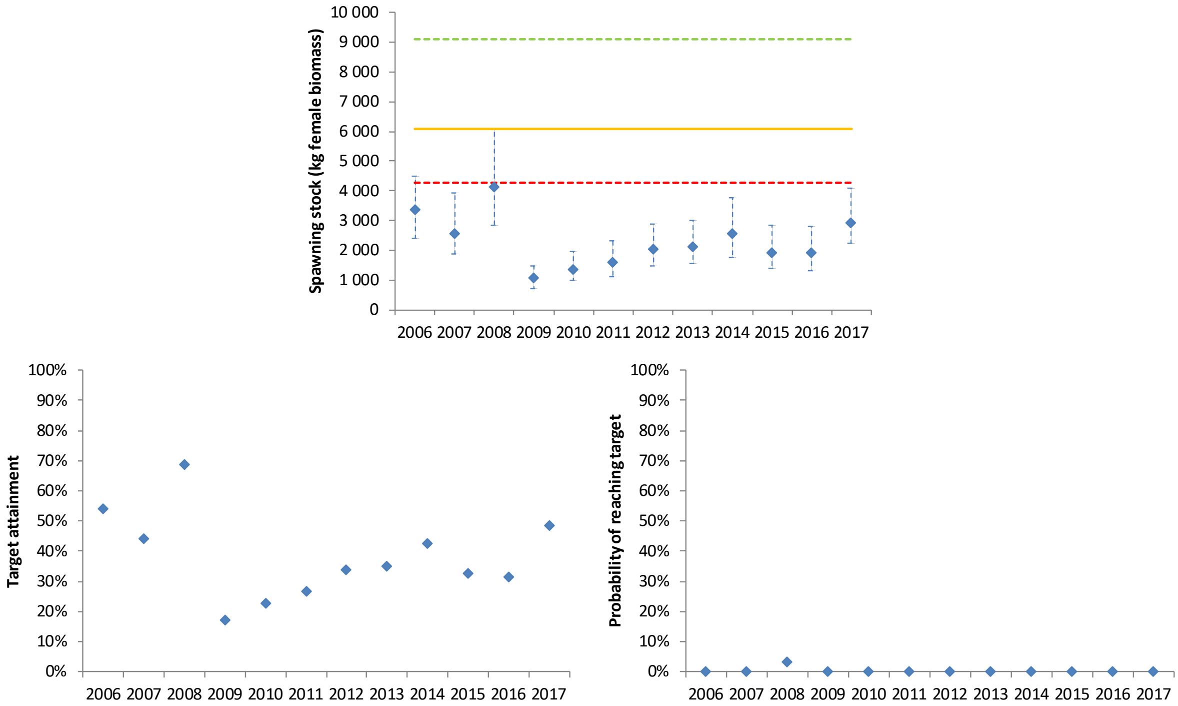

Figure 43. The estimated spawning stock (top row), percent truncated spawning target attainment (bottom row, left) and probability of reaching the spawning target (bottom row, right) in the period 2006-2017 in the Norwegian tributary Iešjohka.

3.14.2 Exploitation

The estimated total exploitation rate (based on weight) of Iešjohka salmon was 76 % in the years 2014-2017 (Figure 44), with 15 % of the pre-fishery abundance caught in coastal fisheries, 48 % in main stem fisheries and 13 % in Iešjohka. The average estimated total pre-fishery abundance for Iešjohka salmon was 15 550 kg and the average total catch was 11 855 kg in the period 2014-2017.

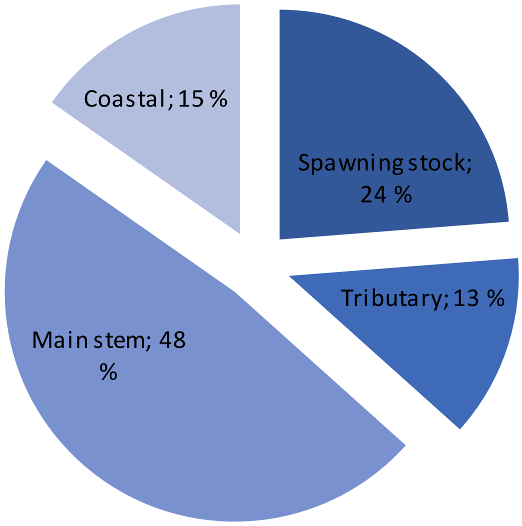

Figure 44. The total amount of salmon belonging to Iešjohka in 2014-2017, distributed into surviving spawning stock and salmon caught in fisheries in either coastal, main stem or Iešjohka fisheries. The percentages in the figure represent the proportion of the pre-fishery abundance that survives to spawning 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 2014-2017, 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 2017, the first year with the new agreement in place. Numbers from 2017 must be interpreted with caution due to it only being a singular year and its basis on a year with difficult conditions both for fisheries and monitoring.

	2014-2017	2006-2016	2017
Coastal	15 %	15 %	20 %
Main stem	57 %	57 %	50 %
Tributary	35 %	39 %	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 Iešjohka salmon divided by the estimated amount of salmon that have survived the coastal fisheries.

In the years 2014-2017, overexploitation varied between 52 % (2017) and 69 % (2016). The average overexploitation was estimated at 62 %. This means that exploitation on average was responsible for reducing the spawning stock size by an amount of 62 % below the spawning target. Maximum sustainable exploitation varied between 19 % (2015) and 36 % (2014). The average maximum sustainable total exploitation rate in the period was 29 %, significantly lower than the estimated average total exploitation of 76 %.

3.14.3 Stock recovery

Over the last 4 years, the overall probability that the spawning target was reached in Iešjohka was 0 %. Target attainment therefore needs to be significantly improved to reach the 75 % 4-year probability specified by the management target.

The median spawning stock size in the period 2014-2017 was 2 256 kg (1 570-3 300 kg). With the current exploitation and uncertainty estimates, we would need a spawning stock of over 7 000 kg to reach the management target of a 75 % probability of meeting the spawning target and over 9 000 kg to reach 100 % probability. In the years 2014-2017, we have, therefore, on average lacked a female biomass of approximately 4 500 kg to reach the management target.

A management target probability below 40 % means that a stock recovery plan should be initiated for the Iešjohka stocks. The starting point of this recovery plan is the estimated exploitation rate experienced by the Iešjohka stocks in the years 2006-2016 (before the new Tana agreement). There are two stock recovery trajectories shown in Figure 45 below. One is the stock recovery trajectory that follows from the 30 % reduction that was used as an overall guideline in the negotiations. The second is the recovery trajectory corresponding to the minimum reduction in exploitation needed to complete the stock recovery of Iešjohka salmon after two generations.

The starting point of the recovery trajectories are the stock-specific management target attainment. The simulation then calculates a new management target attainment based on the number of spawners that would have survived in the years before the regulation if the total exploitation had been reduced by a certain percentage. The resulting percentage increase is applied to subsequent generations, resulting in a ladder-like recovery trajectory.

Please note that the reductions in exploitation in Figure 45 are in comparison with the situation in 2006-2016. The reductions that are listed here are therefore not reductions on top of the fishing rules that were implemented in 2017.

Compared with the period 2006-2016, the minimum reduction in exploitation for the years 2017 and onwards that would lead to a stock recovery after two generations is 22 %.

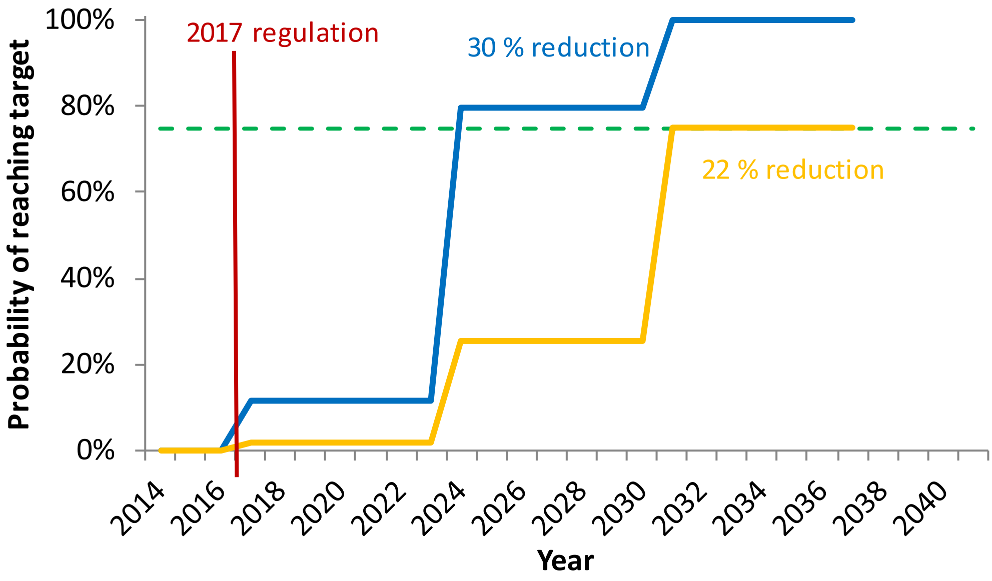

Figure 45. Stock recovery trajectories for Iešjohka salmon, corresponding to two scenarios of reduced total exploitation. (Orange) This is the trajectory showing stock recovery at a 22 % reduction from the average exploitation level in 2006-2016, this is the minimum reduction in exploitation needed to achieve stock recovery after two generations, and (Blue) a recovery trajectory following the stock development after a 30 % reduction in exploitation compared to the years 2006-2016. The green dotted line represents the management target (75 % probability that spawning target is reached).

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.

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 the 5-year average from Genmix.

There have so far been no attempts at counting salmon in Anárjohka/Inarijoki. A comparison of 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 together led to significantly reduced exploitation. A comparison with catches in the nearby Kárášjohka and the main stem and the genetic proportions from Genmix all indicate an exploitation rate at approximately 10 % in Anárjohka/Inarijoki in 2017. We base the status evaluation on this estimate for now, but the need to base this important parameter estimate on such indirect evidence firmly points to the need for actual fish counts also in Anárjohka/Inarijoki in the coming years.

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	0.55
2010	2 442	0.25	0.55
2011	1 908	0.25	0.45
2012	4 285	0.25	0.50
2013	1 986	0.25	0.55
2014	2 832	0.25	0.55
2015	1 881	0.25	0.55
2016	1 654	0.25	0.55
2017	639	0.10	0.55

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.

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.

Estimated truncated target attainment reached 77 % in 2012 (Figure 46). Lowest attainment was 31 % in 2011. The probability of reaching the spawning target was 0 % for all years in the period 2006-2017 except for 10 % in 2012 and 4 % in 2006. The management target was not reached, as the last 4 years' (2014-2017) overall probability of reaching the spawning target was 0 % with an overall attainment of 38 %.

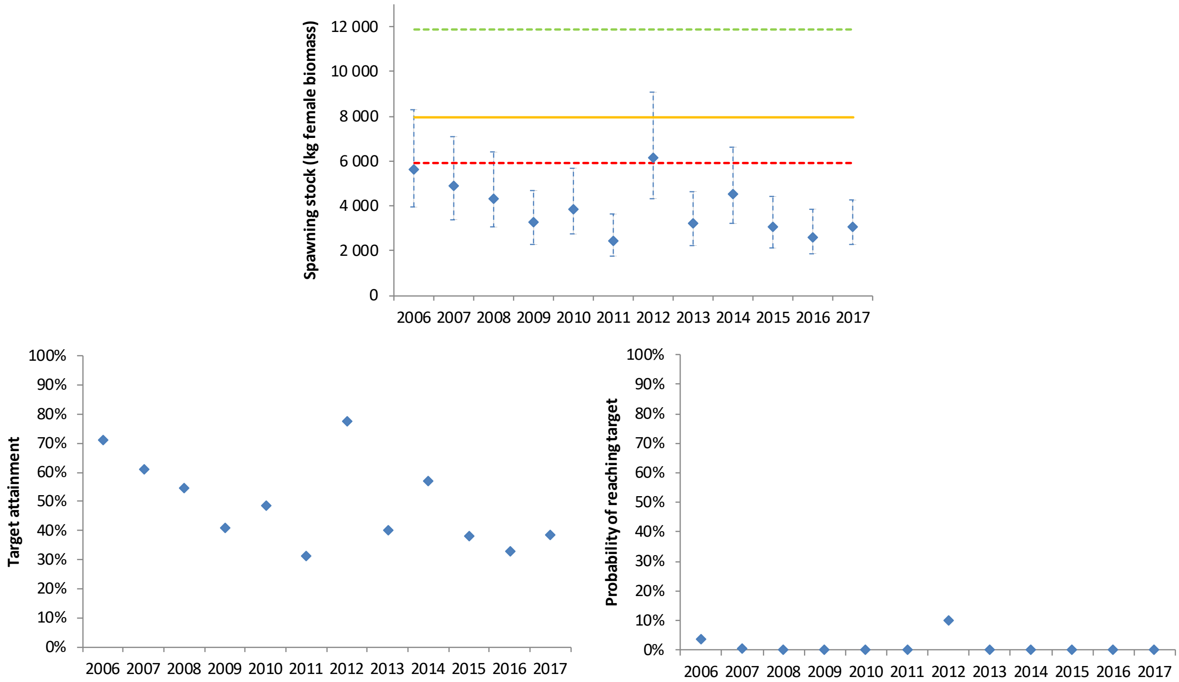

Figure 46. The estimated spawning stock (top row), percent truncated spawning target attainment (bottom row, left) and probability of reaching the spawning target (bottom row, right) in the period 2006-2017 in the tributary Anárjohka/Inarijoki.

3.15.2 Exploitation

The estimated total exploitation rate (based on weight) of Anárjohka/Inarijoki salmon was 72 % in the years 2014-2017 (Figure 47), with 16 % of the pre-fishery abundance caught in coastal fisheries, 48 % in main stem fisheries and 8 % in Anárjohka/Inarijoki. The average estimated total pre-fishery abundance for Anárjohka/Inarijoki salmon was 21 525 kg and the average total catch was 15 508 kg in the period 2014-2017.

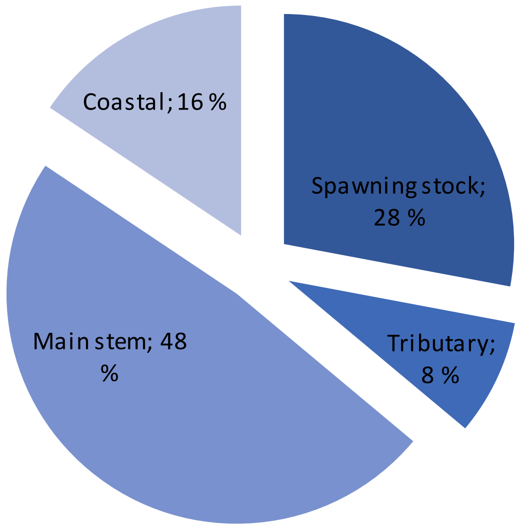

Figure 47. The total amount of salmon belonging to Anárjohka/Inarijoki in 2014-2017, distributed into surviving spawning stock and salmon caught in fisheries in either coastal, main stem or Anárjohka/Inarijoki fisheries. The percentages in the figure represent the proportion of the pre-fishery abundance 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 2014-2017, 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 2017, the first year with the new agreement in place. Numbers from 2017 must be interpreted with caution due to it only being a singular year and its basis on a year with difficult conditions both for fisheries and monitoring.

	2014-2017	2006-2016	2017
Coastal	16 %	15 %	20 %
Main stem	57 %	55 %	56 %
Tributary	23 %	26 %	10 %

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 2014-2017, overexploitation varied between 43 % (2014) and 67 % (2016). The average overexploitation was estimated at 58 %. This means that exploitation on average was responsible for reducing the spawning stock size by an amount of 58 % below the spawning target. Maximum sustainable exploitation varied between 16 % (2017) and 41 % (2014). The average maximum sustainable total exploitation rate in the period was 26 %, significantly lower than the estimated average total exploitation of 72 %.

3.15.3 Stock recovery

Over the last 4 years, the overall probability that the spawning target was reached in Anárjohka/Inarijoki was 0 %. Target attainment therefore needs to be significantly improved to reach the 75 % 4-year probability specified by the management target.

The median spawning stock size in the period 2014-2017 was 3 057 kg (2 211-4 358 kg). With the current exploitation and uncertainty estimates, we would need a spawning stock of almost 9 400 kg to reach the management target of a 75 % probability of meeting the spawning target and approximately 13 000 kg to reach 100 % probability. In the years 2014-2017, we have, therefore, on average lacked a female biomass of approximately 6 500 kg to reach the management target.

A management target probability below 40 % means that a stock recovery plan should be initiated for the Anárjohka/Inarijoki stocks. The starting point of this recovery plan is the estimated exploitation rate experienced by the Anárjohka/Inarijoki stocks in the years 2006-2016 (before the new Tana agreement). There are two stock recovery trajectories shown in Figure 48 below. One is the stock recovery trajectory that follows from the 30 % reduction that was used as an overall guideline in the negotiations. The second is the recovery trajectory corresponding to the minimum reduction in exploitation needed to complete the stock recovery of Anárjohka/Inarijoki salmon after two generations.

The starting point of the recovery trajectories are the stock-specific management target attainment. The simulation then calculates a new management target attainment based on the number of spawners that would have survived in the years before the regulation if the total exploitation had been reduced by a certain percentage. The resulting percentage increase is applied to subsequent generations, resulting in a ladder-like recovery trajectory.

Please note that the reductions in exploitation in Figure 48 are in comparison with the situation in 2006-2016. The reductions that are listed here are therefore not reductions on top of the fishing rules that were implemented in 2017.

Compared with the period 2006-2016, the minimum reduction in exploitation for the years 2017 and onwards that would lead to a stock recovery after two generations is 23 %.

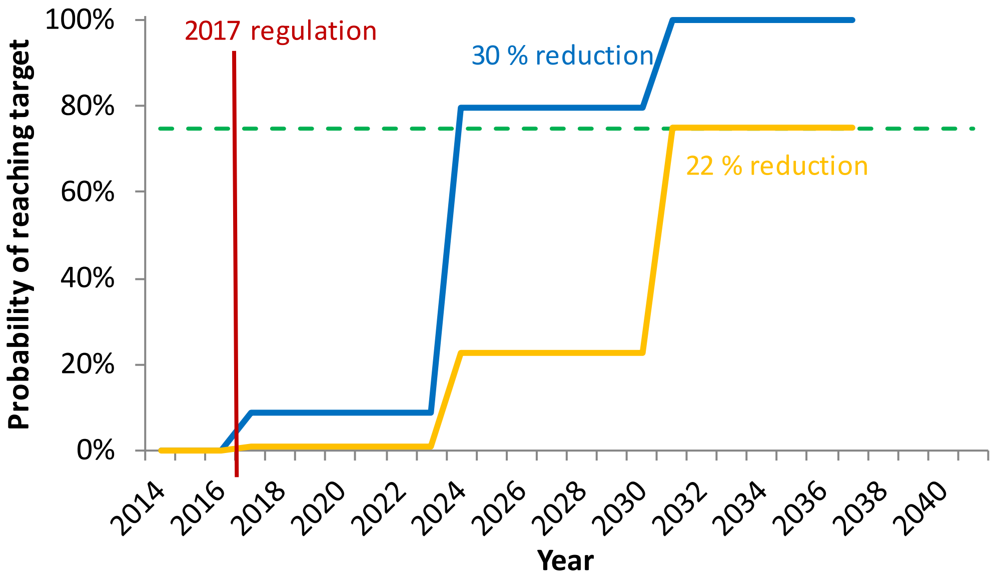

Figure 48. Stock recovery trajectories for Anárjohka/Inarijoki salmon, corresponding to two scenarios of reduced total exploitation. (Orange) This is the trajectory showing stock recovery at a 23 % reduction from the average exploitation level in 2006-2016, this is the minimum reduction in exploitation needed to achieve stock recovery after two generations, and (Blue) a recovery trajectory following the stock development after a 30 % reduction in exploitation compared to the years 2006-2016. The green dotted line represents the management target (75 % probability that spawning target is reached).

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.

Table 33. Summary of stock data used to estimate annual spawning stock sizes of the Tana MS stock.

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	0.57
2017	60 610	0.55	0.57

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.

Estimated truncated target attainment reached 100 % in 1994, 2000-2003 and 2008 (Figure 49). Lowest attainment was 51 % in 2005. The highest probability of reaching the spawning target was 96 % in 2001. The management target was not reached, as the last 4 years' (2014-2017) overall probability of reaching the spawning target was 2 % with an overall attainment of 60 %.

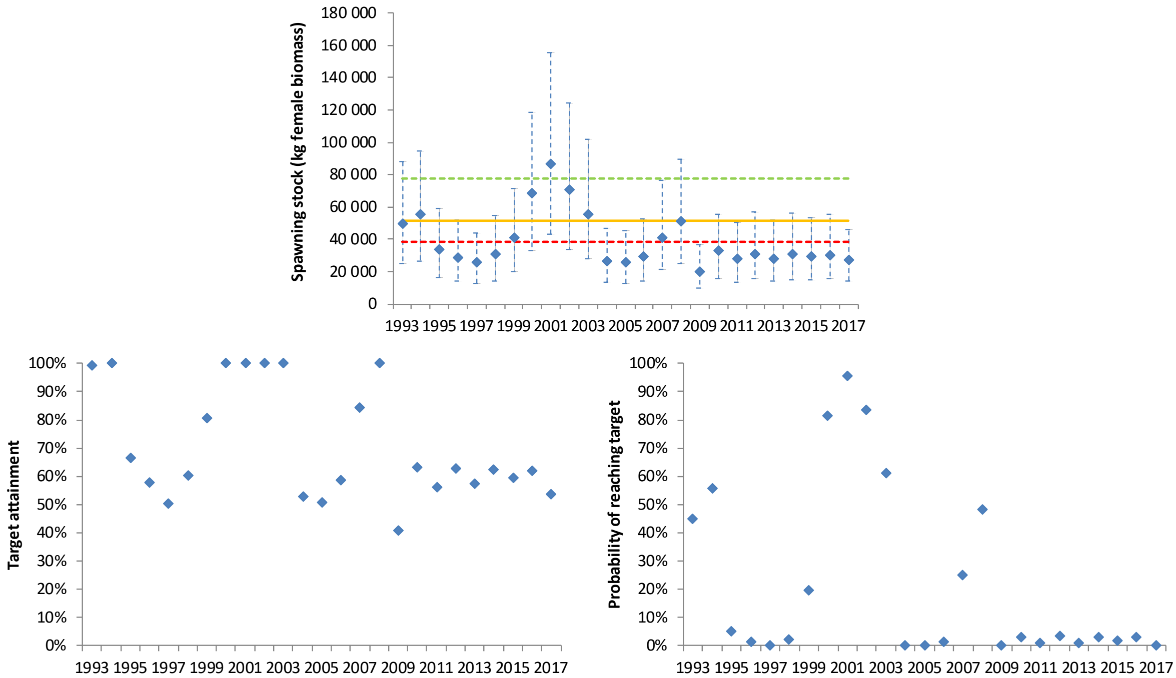

Figure 49. The estimated spawning stock (top row), percent truncated spawning target attainment (bottom row, left) and probability of reaching the spawning target (bottom row, right) in the period 2006-2017 for Tana/Teno (total).

3.16.2 Exploitation

The estimated total exploitation rate (based on weight) of Tana/Teno (total) salmon was 67 % in the years 2014-2017 (Figure 50), with 16 % of the pre-fishery abundance caught in coastal fisheries and 51 % in river fisheries. The average estimated total pre-fishery abundance for Tana/Teno salmon was 159 514 kg and the average total catch was 105 538 kg in the period 2014-2017.

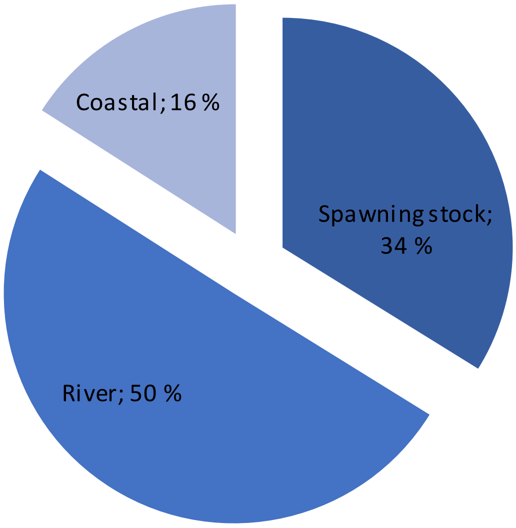

Figure 50. The total amount of salmon belonging to all Tana/Teno stocks in 2014-2017, distributed into surviving spawning stock and salmon caught in fisheries in either coastal or main stem fisheries. The percentages in the figure represent the proportion of the pre-fishery abundance that survives to 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 2014-2017, 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 2017, the first year with the new agreement in place. Numbers from 2017 must be interpreted with caution due to it only being a singular year and its basis on a year with difficult conditions both for fisheries and monitoring.

	2014-2017	2006-2016	2017
Coastal	16 %	16 %	20 %
Tana/Teno	60 %	62 %	56 %

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 (2014-2017) was poor in 8 of the 15 stocks that we evaluated (Figure 51). The best status was found in Máskejohka, Veahčajohka/Vetsijoki, Ohcejohka/Utsjoki, Goahppelašjohka/Kuoppilasjoki, and Leavvajohka. Most of these are low-exploitation tributaries, either partly (Veahčajohka/Vetsijoki, Utsjoki) or fully (Goahppelašjohka/Kuoppilasjoki and Leavvajohka). While exploitation within Máskejohka is likely substantial, it is also the lowermost tributary of the Tana/Teno and thus experiences low main stem exploitation.

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 have lacked a total of 32 000 kg female spawners to reach their management targets.

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.

A lower than 40 % overall probability of reaching the spawning target over the last 4 years (corresponding to the orange colour in Figure 51) 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. It is important to note here that the worst status was found for stocks that have little or no monitoring (except for Lákšjohka). 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.

It is, however, important to realize that the spawning stock estimates of the three main headwater rivers deviate so significantly from their respective spawning targets that it is highly unlikely, regardless of the use of conservative exploitation estimates, that these stocks might be anywhere close to a healthy status.

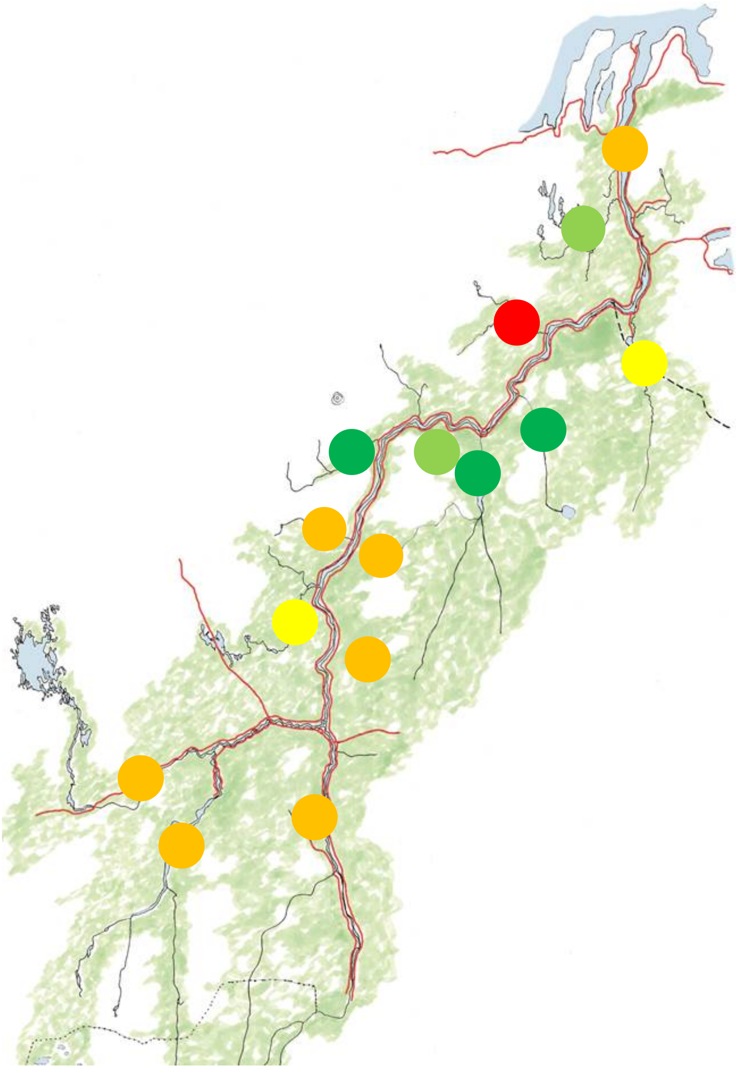

Figure 51. Map summary of the 2014-2017 stock status of the evaluated parts of the Tana/Teno river system. Symbol colour designates stock status over the last four years. Possible colours are: Dark green = overall probability of attaining spawning target higher than 75 %, overall target attainment over 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 51, 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 Utsjoki river system, the two tributaries Kevojoki and Tsarsjoki seem to do better than the Utsjoki, while within the Anárjohka/Inarijoki system, the main source of the poor target attainment seem to be the Anárjohka/Inarijoki while the tributaries, particularly Goššjohka, seem to do better.

Table 35. Lower main stem female catch proportion (5-year average from the Genmix-project) compared with spawning target proportions. Catch proportion smaller than spawning target proportion indicates stock doing worse than expected in comparison to other stocks, catch proportion higher than spawning target proportion indicates 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 %
Utsjoki	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 51 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. 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. The Tana 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 2014-2017 showed a large effect in the upper headwater rivers and the main stem (Figure 52). Figure 52 therefore illustrates how the fisheries regulation have been negatively favouring the headwater stocks. 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.

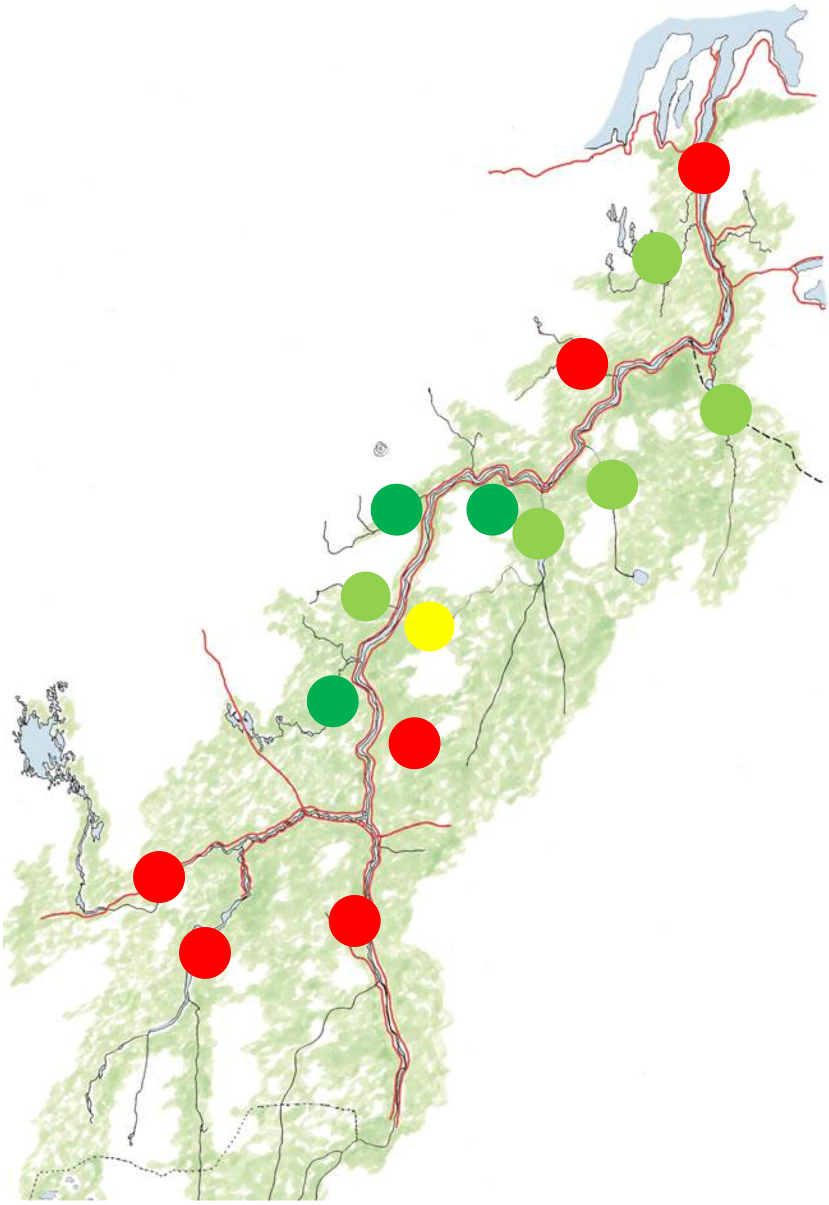

Figure 52. Map summary of the estimated overexploitation experienced in various parts of the Tana/Teno river system in the years 2014-2017. Symbol colour represents the extent of the overexploitation (in terms of percentages of the spawning target). Dark green = no effect (0 % of the spawning target), light green = small effect (<10 %), yellow = moderate effect (10-30 %), red = large effect (>30 %).

5 Recommendations for an annual Tana/Teno monitoring programme

The following are the recommendations for an annual Tana/Teno monitoring programme from the MRG that was previously delivered as a separate note dated 15.12.2017. The text is included for reference in this report.

The NASCO Precautionary Approach emphasises the use of management targets as a primary tool when evaluating stock status, and the establishment of management actions that are triggered when stock status fails to meet the designated target. This management procedure, which the new agreement between Norway and Finland is built on, turns the salmon management into an adaptive knowledge-based regime which is transparent and predictable in its decision-making, away from the more abstract, obscure and rigid regimes of earlier agreements that have historically proven insufficient in stopping the negative stock developments in Tana.

The following are the important points that must be covered by the monitoring programme to fulfil the knowledge requirements given by the agreement:

1) Spawning stock sizes (to assess management target attainment, basically data on the live fish migrating and surviving in the Tana)
2) Stock-specific data from the mixed-stock fisheries (needed to quantify stock-effects of mixed-stock fisheries, basically data on the fisheries that remove live salmon)
3) Catch statistics

Given these three sources of information, it becomes possible to stock-specifically 1) assess spawning target attainments, 2) evaluate overexploitation and maximum sustainable exploitation rates, 3) estimate the relative importance of fisheries (both spatially and temporally), 4) assess stock recovery development, and 5) evaluate the effect of regulatory measures and the potential need for implementation of new regulations.

The MRG propose a combination of activities, in addition to a comprehensive and accurate catch statistics, that together will provide a sufficient basis for implementing stock recovery processes in Tana while simultaneously keeping fisheries operating as much as possible. The proposed activities are a combination of fish counting at selected index sites and genetic stock identification of mixed-stock fisheries catch samples.

5.1 Fish counting of index sites

Fish counting at selected sites in the river system provides a measure of the number of ascending salmon passing.

Previously, the MRG have only recommended fish counting in selected tributaries. However, there is a strong local push towards including main stem counting as part of the monitoring, and it is our opinion now that existing technology should allow for such counting to be successful. A bit more background on the proposed main stem counting can be found below.

We suggest prioritizing some index sites for annual fixed monitoring, while the remaining index sites are operated on a rotating basis.

5.1.1 Major annual index sites

1) Tana main stem (Polmak area, see own section below) (sonar)
2) Lower Kárášjohka (at the Ássebákti area just below the confluence between upper Kárášjohka and Iešjohka) (sonar)
3) Anárjohka/Inarijoki (sonar)
4) Utsjoki (video)
5) Lákšjohka (video)

Counting at the Ássebákti-site would cover two of the major headwater rivers in Tana, and genetic stock identification would allow for separating the Ássebákti-counts into different stocks (Iešjohka, Kárášjohka, Bávttajohka). It is also suggested to have an annual counting in the nearby Anárjohka/Inarijoki system. The run timing of salmon from Anárjohka/Inarijoki differs significantly from Kárášjohka/Iešjohka, meaning that salmon from the three main headwater areas will be affected differently both temporally and in terms of various fishing gear. In terms of counting method, sonar counting is the only feasible approach for these large headwater rivers.

The latter two sites represent a continuation of two long-term time series that have operated since 2002 and 2009 in Utsjoki and Lákšjohka, respectively. Both counting sites are based on video.

5.1.2 Rotating major index sites

1) Máskejohka (sonar)
2) Vetsijoki (video or sonar)
3) Váljohka (video or sonar)
4) Goššjohka (video or sonar)

One feasible way of rotating among these would be to do the rivers every fourth year. Ideally, we would want annual counting to fully cover annual variations in run size and exploitation, but counting on a rotating basis will provide us with important baseline counting data that will significantly increase confidence in stock status evaluations.

Possible counting sites have been established in Vetsijoki and Váljohka, while there have been no counting attempts so far in Máskejohka and Goššjohka.

5.1.3 Annual monitoring of small tributaries

Some smaller tributaries are currently monitored annually with snorkelling counts, which is a highly cost-effective method. The snorkelling counts form an important supplement to the counting in larger tributaries and it is recommended that this smaller-scale counting should continue annually. List of tributaries:

1) Akujoki
2) Nilijoki
3) Upper Pulmankijoki

5.1.4 Main stem counting

Together with the new Tana fishing agreement the Finnish government resourced Tana main stem fish count by sonars. Potential fish counting sites and possible set-up of sonar monitoring were evaluated during summer-autumn 2017 at the lower part of the Tana. A promising site was found from the Polmak area, just above the confluence of the River Buolbmátjohka/Pulmankijoki and the Tana, 55 km upstream from the river mouth (Figure 1). A pilot main stem sonar count will be conducted there during the salmon migration season in 2018 by using multiple sonar units to cover most of the river width. If the pilot study succeeds main stem sonar monitoring will be continued on annual basis.

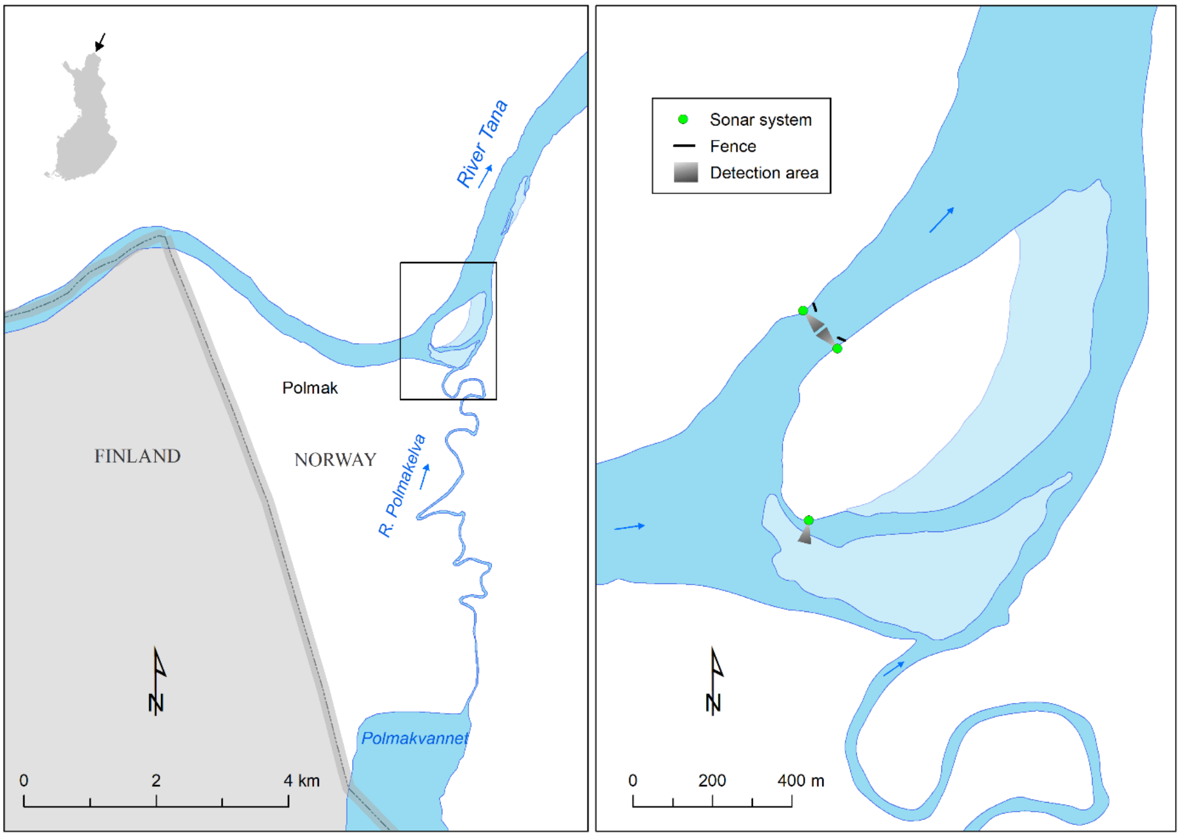

Figure 53. Proposed main stem counting site.

When successful, main stem fish counts will significantly improve the Tana salmon monitoring program and simplify the estimation of exploitation rates and pre-fishery abundances. However, to fully exploit the main stem count results for management purposes supplemental genetic stock identification (GSI) of the main stem catch samples together with fish counting in selected tributaries are needed.

Theoretically, it would be entirely possible to evaluate the status of stocks in Tana based on genetic stock identification and either tributary counts or main stem counts. It is a concern, however, that the main stem counting might be more vulnerable to the high-water levels occurring in the first weeks of the summer than tributary counting. Considering that some of the most depleted stock components in Tana do their spawning migration during the earliest weeks of the summer, it is recommended to minimize risk by doing tributary counting in addition to main stem counting.

5.2 Genetic stock identification of main stem mixed-stock fisheries samples

The complex stock situation in Tana, with around 30 uniquely different stocks, means that large parts of the Tana fisheries are mixed-stock fisheries. This is especially the case for the Tana main stem fisheries, which affects all stocks within the Tana river system. However, due to differences in stock life history compositions and run timings, various stocks within the river system will be affected differently by the main stem fisheries, and these differences will have both a spatial and a temporal variation to them.

Within the context of a future adaptive management regime in Tana, the target attainment of each stock is evaluated individually, resulting in stock-specific recommendations about exploitation pressure with poor target attainment resulting in a recommendation of lowered overall exploitation rates. In this system, it is imperative that we can separate how each stock is exploited within the main stem mixed-stock fishery. And this knowledge must be stock-specific for different areas of the main stem, different fishing gears, various times of the season and different life history classes.

Taken together, the following annual monitoring activities will provide the necessary knowledge to quantify the stock-specific effects of the mixed-stock fishery:

1) Collection of **catch samples** (fish scales) from all main stem fisheries (all fishing gears, all areas, all weeks of the season)
2) **Scale reading**. This part of the monitoring provides essential information about the life history composition of the catch.
3) **Genetic stock identification**. With this tool, it becomes possible to assign a stock of origin for every catch sample. This is necessary to identify the extent of exploitation of the different stocks.

An important consideration is that the genetic stock identification would be most beneficial when combined with the best possible catch statistics from the main stem. That would enable estimates of total numbers of fish exploited in the mixed-stock fisheries of the main stem for each stock.

5.3 Monitoring activities and running cost estimates

The following table summarizes the proposed monitoring activities with current annual running cost estimates (€).

	Method	**Running cost (€)**
Coordination of monitoring/Finland Coordination of monitoring/Norway Fish counting		10 000 10 000
Main stem	Acoustic	100 000
Kárášjohka/Iešjohka	Acoustic	60 000
Anárjohka/Inarijoki	Acoustic	50 000
Utsjoki	Video	51 200
Lakšjohka	Video	40 500
Rotating site	Acoustic/video	50 000
Akujoki	Snorkeling	1 750
Nilijoki	Snorkeling	1 750
Upper Pulmanki	Snorkeling	1 750
Mixed-stock fishery		
Scale sampling/Finland Scale sampling/Norway		20 000 20 000
Scale reading (3000 pieces)		30 000
Genetic stock identification		100 000
Total		**546 950**

Current cost estimates for the acoustic counting are based on doing manual counts. The quality of software-based automatic counting is continuously getting improved and we should be able to decrease the extent of manual work in the coming years. This will lead to significantly reduced cost.

5.4 Validation of acoustic counting

Validation studies of acoustic counting methods have demonstrated that high resolution imaging acoustic systems are well-suited for monitoring the migration of fish larger than 30 cm in rivers. This means that the systems work great for counting adult salmon and trout, but are not suited for smolt counts.

There are, however, some limitations that need to be accounted for when deploying acoustic counting systems. Most importantly, site selection is critical. The sonar performance is significantly decreased at sub-optimal sites. When deploying at new sites, it is therefore important to do proper verification studies to ensure that 1) the sonar performs well and all migrating fish (both upstream and downstream) are observed throughout the observation window, and 2) that fish length measures are reliable. Funding for validation of observation sites should therefore be reserved when establishing new monitoring sites.

6 References

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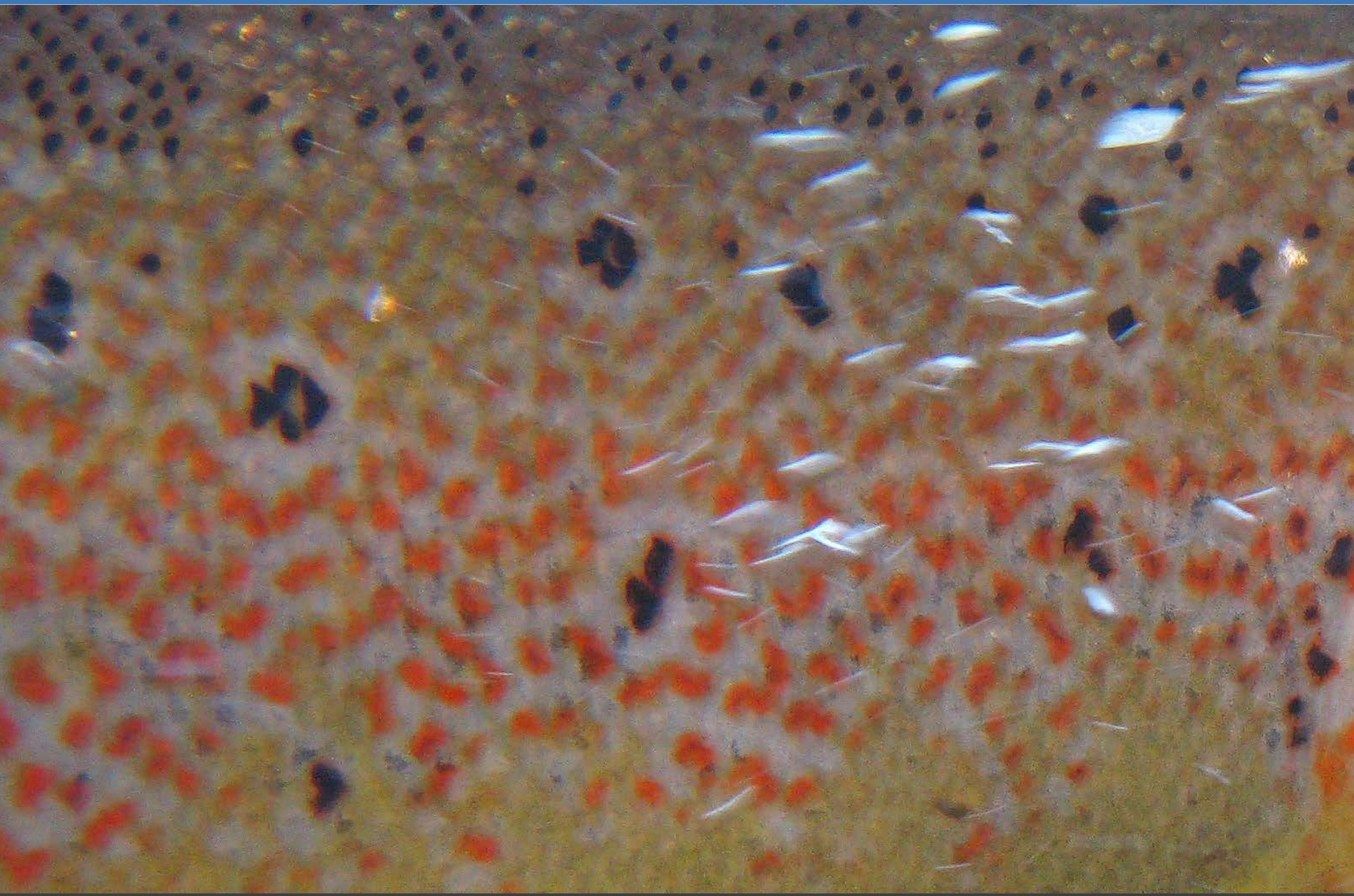
Tana Monitoring and Research Group



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