STATUS OF THE RIVER TANA SALMON POPULATIONS
2015

Report of the Working Group on Salmon Monitoring
and Research in the Tana River System

CONTENTS

SUMMARY

The Group and its mandate

The permanent monitoring and research group was formally appointed in 2010 by the Ministry of Agriculture and Forestry in Finland and the Ministry of Environment in Norway, based on the Memorandum of Understanding signed in February 2010. Among other points defined in its mandate, the Group should deliver annual reports on the status of the salmon stocks, evaluate their management, and give advice on relevant monitoring and research.

The Tana, its salmon stocks and fisheries

The subarctic River Tana forms the border between northernmost Norway and Finland. The river drains an area of 16 386 km^2 consisting of a multitude of small and large tributaries, most of which (>1 200km) are readily accessible for ascending salmon. The river Tana is also one of the few remaining large river systems that still support abundant Atlantic salmon stocks with little or no human impact to the system, except for fishing.

Tana today supports the largest wild stock of Atlantic salmon in the world, with annual river catches fluctuating between 70 and 250 tonnes, equivalent to an average of 30-50 000 salmon being harvested annually. The total salmon stock with a minimum of 30 different populations consists of a wide variety of life histories. The sea-age groups are ranging from one-sea-winter to five-sea-winter salmon, with various types of previously spawned fish. Proportion of escaped farm fish in the Tana salmon catches has so far been very low, although their proportion after the fishing season is not known (with some few exceptions).

The riverine salmon fisheries in Tana include net fishing methods such as weir, gill net, seine and drift net, in addition to the use of rod and line. In the last five years, the rod catch comprised about 60 % of the total catch of the river system, and the proportions of different fishing methods has remained about the same over the past 30 years. The fishery in all parts of the main stem Tana represents a mixed-stocks fishery. According to the telemetry tagging experiments, harvest rates in the river fisheries could reach the levels of more than 60 %. Together with the sea fishery, the effective exploitation rates for some Tana salmon populations can be significantly high, up to 90 %.

Management of the Tana salmon

Both Norway and Finland (through EU) are members of the North Atlantic Salmon Conservation Organization (NASCO), which is an international organization with an objective to conserve, restore, enhance and rationally manage Atlantic salmon. Bilaterally, the Tana fishery agreement has been negotiated between the Ministries of Foreign Affairs, Ministry of Forestry and Agriculture (Finland) and the Norwegian Ministry of the Environment (Norway). The latest general agreement dates back to 1990. Tourist angling is regulated by regional authorities in both countries (Department of Environmental Affairs, Office of the County Governor of Finnmark, Norway, and the Fishery Unit, Centre for Economic Development, Transport and the Environment in Lapland, Finland). The tourist fishing regulations can be amended on a yearly basis. Local organizations in both countries, especially the newly established River Tana Fisheries Management Board in Norway, also play a role in managing the fishery. Coastal fisheries are regulated nationally in Norway, and in recent years, more restrictive measures have been introduced.

Local/traditional knowledge

The Group recognizes the potential positive contribution from local/traditional (ecological) knowledge, and currently makes use of relevant knowledge in its work.

Threat factors

A review of threat factors possibly affecting salmon stocks in Tana show that overexploitation of salmon in the different parts of the salmon migratory system is the major threat factor currently affecting Tana salmon.

There are minor or no effects from other human activities like pollution, hydropower development or fish farming. Mining, salmon lice, escaped farmed salmon and *Gyrodactylus salaris* are identified as the main potential future threats of Tana salmon, followed by infections and introduced species.

Stock status evaluation and management recommendations

In accordance with NASCOs Precautionary Approach, we are taking a target-based approach to the stock status evaluation. The basic procedure of this approach is (1) the definition of stock-specific spawning targets (i.e. the number of spawning female salmon needed to fill the production potential of a stock), (2) an estimation of the number of spawning females in a stock after a fishing season, and (3) a probabilistic comparison of the target and the spawning stock estimate.

Spawning targets have now been established for all parts of the Tana river system, both in Norway and Finland (Falkegård et al. 2014). In this report we present a stock status evaluation of the following areas: Tana/Teno main stem, Máskejohka, Lákšjohka, Veahčajohka/Vetsijoki, Ohcejohka/Utsjoki, Váljohka, Áhkojohka/Akujoki, Kárášjohka (+tributaries), Iešjohka, Anárjohka/Inarijoki (+tributaries) and Tana/Teno total. The full stock status evaluation provide assessments based on two different methodological approaches to the spawning target: one based on a fixed fecundity level and the other based on a stock-specific fecundity. All summaries and recommendations are based on the results from the stock-specific fecundity based targets.

Average target attainment over the last 4 years (2011-2014) was highest in Ohcejohka/Utsjoki with 158 %, followed by Váljohka (137 %), Áhkojohka/Akujoki (94 %), Tana/Teno main stem (85 %), Máskejohka (74 %), Veahčajohka/Vetsijoki (60 %), Lákšjohka (55 %), Kárášjohka + tributaries (48 %), Anárjohka/Inarijoki + tributaries (44 %) and Iešjohka (33 %).

The status assessment demonstrated that the management target (the last 4 years average probability of reaching the spawning target) was below 40 % in all investigated parts of the Tana river system except Ohcejohka/Utsjoki, Váljohka and Áhkojohka/Akujoki. Worst off were Lákšjohka, Kárášjohka (+tributaries), Iešjohka and Anárjohka/Inarijoki (+tributaries), all of which had a management target of 0 %. In all three main headwater areas, the average target attainment over the last 4 years was below 50 %.

The overall exploitation rate in Tana (all stocks) was estimated to 66 % in the period 2006-2014. Of the investigated stocks, the highest accumulated exploitation rates were at over 70 %, with Iešjohka at 75 %, Anárjohka/Inarijoki (+tributaries) at 74 % and Veahčajohka/Vetsijoki at 72 %. Just below 70 % was Kárášjohka (+tributaries) at 67 %, Ohcejohka/Utsjoki (+ tributaries) at 63 %, Lákšjohka at 61 %, Máskejohka at 66 % and Tana (main stem) at 63 %. The lowest accumulated exploitation rate was estimated for Váljohka at 55 %.

Overexploitation as a threat factor is defined as the extent of a reduction in spawning stock below the spawning target that can be attributed to exploitation. There was extensive overexploitation in all examined parts of the Tana river system in the period 2006-2014, except in Váljohka.

An estimate of maximum sustainable exploitation (the maximum level of exploitation a stock could sustain while still reaching its spawning target) demonstrates that some of the stocks are depleted to the point of having a very low sustainable surplus. The lowest average maximum sustainable total exploitation rate over the period 2006-2014 was estimated for Lákšjohka at 19 %.

Stock recovery trajectories were constructed for all investigated parts of the Tana river system under three different regulation scenarios. All investigated areas would attain a 75 % probability of reaching their spawning target over a period of three salmon generations if total accumulated exploitation rates were reduced by 30 %.

Long-term monitoring recommendations

Stock status evaluation within an adaptive knowledge-based management regime should be based on the best possible monitoring data, provided through a consistent, long-term monitoring programme. Such a programme should provide (1) a detailed and accurate catch statistics from all different areas and fisheries of the system, (2) catch samples that provide life history data and enable genetic stock identification of the catch in mixed-stock fisheries, and (3) accurate fish counting, either on fish entering e.g. a tributary or in the main stem (by electronic devices), or in the form of spawner counts after the fishing season (by snorkelling).

There is substantial variation in the exploitation rates experienced by different stocks in different fisheries; the Tana main stem exploitation of salmon being much lower in the lower tributaries compared to that of the tributaries further up in the river system. Therefore, long-term monitoring must be spatially distributed in the lower, middle and upper parts of the Tana system.

The Group strongly endorses finding arenas that allows the communication of local environmental knowledge to the Group and allows dissemination of scientific knowledge to local communities in an accessible manner.

Currently, there is a lack of long-term predictability in most of the research and monitoring activities in the Tana, making it impossible to plan activities for more than 1-2 years ahead. The Group therefore strongly recommends the joint establishment of a permanent Norwegian-Finnish research and monitoring programme for Tana. This programme, including financial sources and monitoring details and priorities, should be specified in a binding way in the forthcoming new fishery agreement between the two countries.

THE GROUP MANDATE AND PRESENTATION OF MEMBERS

The Working Group on Salmon Monitoring and Research in the Tana River System (referred hereafter as the Group or the Tana Group) was formally appointed in 2010 by the Ministry of Agriculture and Forestry in Finland and the Ministry of Environment in Norway, based on the Memorandum of Understanding signed in February 2010. Among other points defined in its mandate, the Group should deliver annual reports on the status of the salmon stocks, evaluate their management, and give advice on relevant monitoring and research.

The following mandate was given for the Group:

1. *To deliver annual reports on the status of the salmon stocks, including trends in stock development.*
2. *To evaluate the management of stocks in light of relevant NASCO guidelines.*
3. *To integrate local and traditional knowledge of the stocks in their evaluations.*
4. *To identify gaps in knowledge and give advice on relevant monitoring and research.*
5. *To give scientific advice on specific questions from management authorities.*
6. *To collect information from local communities and organizations and cooperate with such bodies in the dissemination of scientific results to the public.*

It was further detailed that the group shall consist of four scientists, two appointed from Norway and two appointed from Finland. The following group members have been appointed:

- Jaakko Erkinaro (Natural Resources Institute Finland, LUKE), leader
- Morten Falkegård (Norwegian Institute for Nature Research, NINA), secretary
- Eero Niemelä (LUKE), assistant secretary
- Tor G. Heggberget (NINA), assistant leader

The first three of the members listed above are individually appointed on the basis of their experience and detailed knowledge about the Tana river system, and are as such not acting as representatives of their working institutions. The fourth member was appointed to represent the Norwegian Institute for Nature Research, thus linking the work in the Group with the vast experience of other scientists in NINA.

1 INTRODUCTION

1.1 PURPOSE OF THE REPORT

The Tana Group is tasked with providing annual status evaluations of Tana salmon stocks, and otherwise answer questions asked by the management authorities. Currently, the main management process concerning the Tana is the ongoing negotiations between the two countries, aiming to agree on a new target-based, adaptive knowledge-based management regime for salmon fisheries in the Tana. The contents of the present Group report reflect the information needs of the negotiation process.

In summary, the present report covers the following topics:

1) Give an updated account of the developments of the Tana salmon fisheries (chapter 2).
2) Outline a decision structure for and implementation of stock recovery plans in Tana (chapter 4).
3) Evaluate the threat factors possibly affecting Tana salmon (chapter 3).
4) Give an updated evaluation of the status of Tana stocks based on spawning and management targets, exploitation patterns and stock rebuilding (chapter 4).
5) Outline a Tana monitoring programme designed to meet the knowledge demanded by a target-based adaptive management regime (chapter 6).

1.2 PREMISES OF THE REPORT

1.2.1 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 in order 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 by the use of 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 in an effort to comply with the Precautionary Approach.

1.2.2 SINGLE- VS. MIXED-STOCK FISHERIES

The management of salmon fisheries should be based on advice from the International Council for the Exploiration 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.

1.2.3 MANAGEMENT AND SPAWNING TARGETS

It follows from the Precautionary Approach that managers should specify stock-specific reference points which 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.

1.2.4 DATA BASIS

The Tana Group has based its assessments on all information and data sets currently available to the Group. This includes vocal sources that the Group have been presented with.

1.3 EXPLANATION OF TERMS USED IN THE REPORT

Accumulated (sequential) 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 particular example.

Exploitation rate. 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 efficiency. See exploitation rate above.

Exploitation estimate. See exploitation rate above. Ideally, we want to have a direct estimate of the exploitation rate through the use of 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).

Maximum sustainable exploitation. This is the amount of salmon that can be taken in a given 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 target that can be attributed to exploitation. See chapter 5.4 for a detailed definition.

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. See Chapter 5.2.

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. This is the management target, defined as the amount of females needed to make sure that the stock reaches its production potential.

Total exploitation. See accumulated exploitation above.

2 THE RIVER TANA, THE TANA SALMON AND SALMON FISHERIES

2.1 THE TANA AND ITS SALMON

The subarctic River Tana (Teno in Finnish, Deatnu in Sami) forms the border between northernmost Norway and Finland (70 ° N, 28 ° E). The river drains an area of 16 386 km^2 (of which almost 70 % is in Norway) and the river system consists of a multitude of small and large tributaries (Figure 1), most of which are readily accessible for ascending salmon. Historically, salmon have been found distributed over a total of over 1 200 km (Table 1).

Figure 1. Map of the Tana river system. The orange line indicates the historical distribution of salmon based on historical sources and interviews. The numbers correspond to Table 1. Map from Eero Niemelä, LUKE.

Table 1. The historical distribution of salmon in the Tana river system. + occurs on a regular basis, (+) occurs occasionally. Distribution numbers are collected and systematized by Eero Niemelä, LUKE, based on various scattered historical sources (unpublished) and interviews with local people.

	River	**km**	**1SW**	**2SW**	**3SW**	**4-5SW**
1	Tana/Teno	211.0	+	+	+	+
2	Maske	30.9	+	+	+	
2.1	Geasis	6.9	+	+	+	
2.1.1	Uvjaladnja	6.7	+	+		
2.2	Ciicujohka	10.9	+			
3	Buolbmát/Pulmanki	39	+	+	(+)	
3.1	Gálddaš	13.5	+	+		
3.2.	Luossa	6.8	+	(+)		
3.2.1	Skiihpa	6.7	+			
3.3	Morešveai	3.4	+			
4	Lákš	13.7	+	+	(+)	
4.1	Garpe	0.7	+	+		
4.2	Gurte	9.4		(+)	(+)	
4.3	Deavkehan	17.5		(+)	(+)	
5	Veahća/Vetsi	42.6	+	+	+	
5.1	Váis	5.8	+			
6	Utsjoki (lower)	22.2	+	+	+	+
6.1	Ćárse/Tsars	31.2	+	+		
6.1.1	Njiðgu	4.9	+			
6.1.2	Liŋkin	5	+	(+)		
6.1.3	Uhtsa-Ćárse	3.9	+			
6.2	Geavvu/Kevo	35.7	+	+	+	
6	Utsjoki (upper)	36	(+)	+	+	(+)
6.3	Cuoggá	7.6	+	+	(+)	
6.4	Gukće	7.3	+	(+)	(+)	
7	Goahppelaš/Kuoppilas	13.4	+	+	(+)	
7.1	Birke	9.7	+	+		
7.1.1	Koaskim	2.6	+	+		
8	Borse	5	+	+		
9	Leavva	24.1	+	+	+	
10	Nuvvos	7.9	+	+		
11	Njilj	12.7	+	+		
11.1	Mávnnáveai	2.1				
12	Báiš	19	+	+	(+)	
13	Válj	45.1	+	+	+	(+)
13.1	Áste	18.7	+			
14	Jeagelveai	4.3	+			
15	Áhko	5.1	+	+	(+)	
16	Káráš	73.5	+	+	+	+
16.1	Geaimme	9.8	+	+		
16.2	Noaidat	7.9	+			
16.3	Suolga	3.9	+			
16.4	Bavta	44.9	(+)	+	+	+
16.5	Suorbmu	2.7	+	(+)		
16.6	Ieš	87.1	+	+	+	+
16.6.1	Áste	8.2	+	+		
16.6.2	Vuottaš	15	+	+		
16.6.3	Ráges	14.7	+	+	+	
16.6.4	Molleš	4.3	+	+	+	
17	Inari	93.2	+	+	+	(+)
17.1	Gáregas	18.2	+	+	(+)	
17.1.1	Vuorgoćearáv	0.9	+			
17.2	Iškoras	5	+			
17.3	Guoldná	6.1	+			
17.4	Gorzze	38.1	+	+	+	
17.4.1	Vuzzul	17.4	+	+		
17.5	Vuopmaveai	12.9	+			
17.6	Casken	8	+	(+)		
17.7	Skiehććan	37.1	+	+	+	
17.7.1	Njuolas	8	+	+		
17.7.2	Rádjá	2.5	+	+		
	Total length (km)	**1 268**				

The Tana salmon shows an extremely large variation in life histories, with smolt ages ranging from two to eight years (mostly 3-6 years), and adult sea-ages ranging from one (one-sea-winter-salmon, 1SW) to five sea-winters. In addition, there are different types of previously spawned salmon. The smallest tributaries are dominated by 1SW fish (both males and females) with a small to medium percentage 2SW females (Figure 2). Multi-sea-winter (MSW) salmon are mainly found in the Tana main stem, the Norwegian tributary Máskejohka, Finnish tributary Utsjoki, and the uppermost large tributaries Anárjohka, Kárášjohka and Iešjohka. In these tributaries, the female spawning stocks are almost exclusively 2- and 3SW fish and previous spawners.

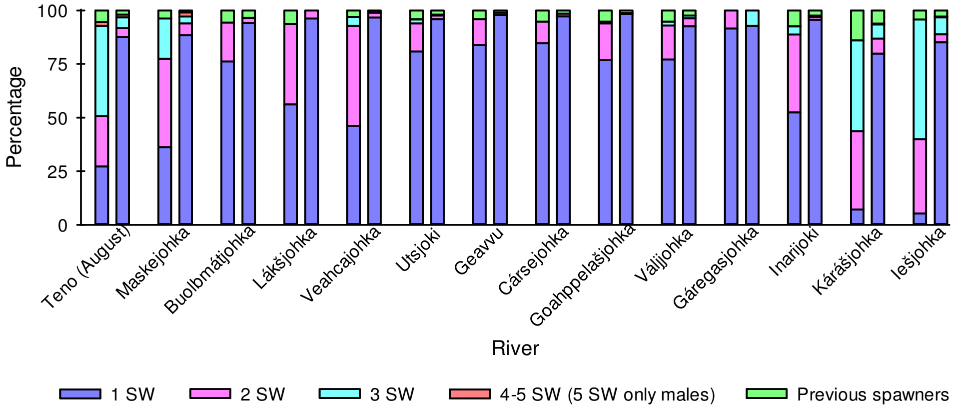

Figure 2. Sea-age distribution of salmon catch in different parts of the Tana river system. Left-hand bars: female salmon; right-hand bars: males. Figure from Niemelä (2004).

In addition to the productive main stem, there are more than 30 tributaries supporting distinct spawning stocks (Berg 1964; Moen 1991; Elo *et al.* 1994; Figure 1), and a high genetic differentiation among stocks from the different tributaries has been revealed through the use of polymorphic microsatellite markers (Vähä *et al.* 2007) (Figure 3). DNA microsatellite analyses have indicated pairwise F_{ST}[1] values between inferred populations ranging from 1 % to 19 % with an average of 6.5 %.

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[1] F_{ST} refers to the proportion of the total genetic variance contained in a subpopulation relative to the total genetic variance. Values can range from 0 to 100% (or from 0 to 1). High F_{ST} implies a considerable degree of differentiation among populations.

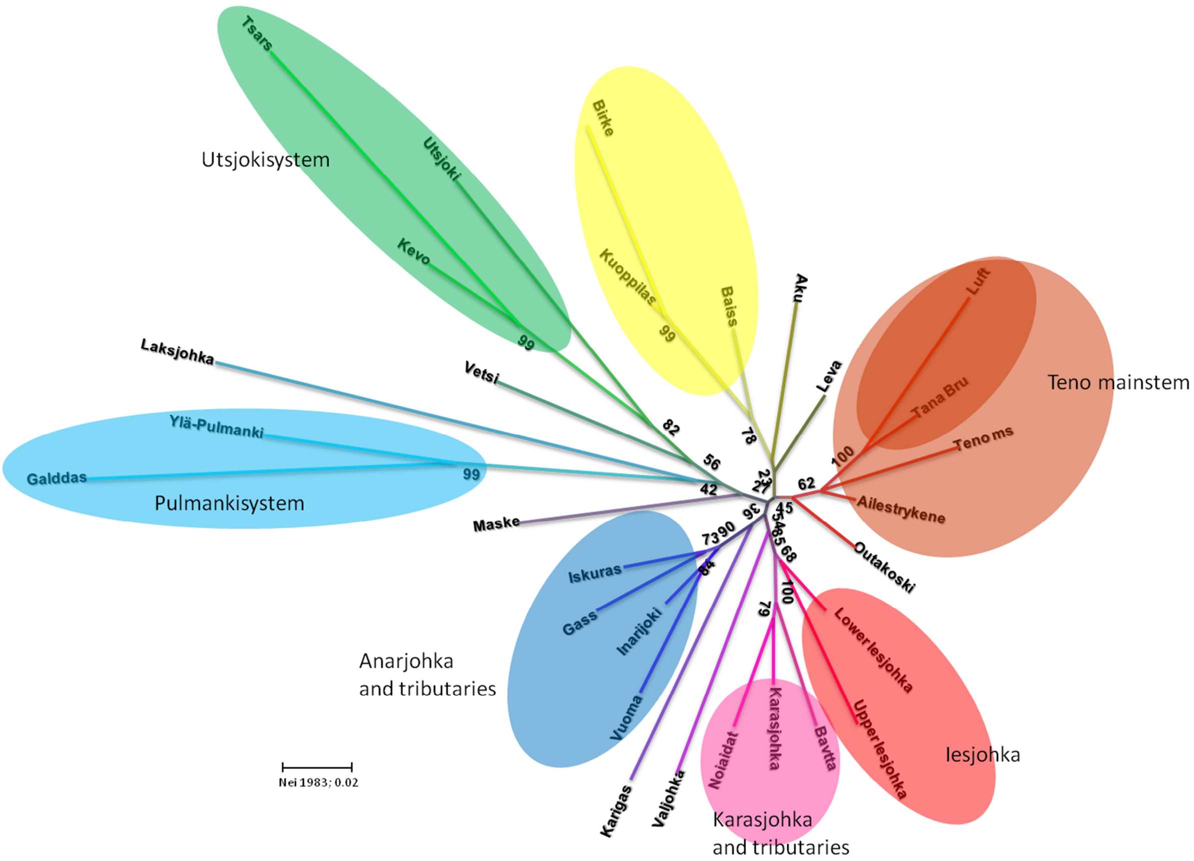


Figure 3. Stock complex of the Tana river system, based on genetic baseline samples from various tributaries and areas (figure from J.-P. Vähä, University of Turku).

Salmon migrating to the upper parts of the river system must cover long distances. From this it could be expected that salmon belonging to upper tributaries such as Anárjohka/Inarijoki, Kárášjohka and Iešjohka, are harvested relatively late in the season. Data from catch records and scale samples, however, show that most of the MSW salmon in Kárášjohka and Iešjohka are caught by the end of June (Figure 4). Median dates of capture in these uppermost areas are comparable to median dates for the lower part of Tana main stem (and slightly earlier than median dates for the middle part of Tana main stem), indicating that the salmon ascending to Kárášjohka and Iešjohka enter the River Tana very early in the season. This early run timing also indicates that these stocks are exposed early in the summer in the coastal fisheries and river fisheries in the main stem Tana.

While return rates of adult salmon has decreased significantly during the last half of the 1900s in most salmon rivers on both sides of the Atlantic, the northernmost salmon stocks in Finnmark (including the river Tana) and the Kola Peninsula have fluctuated in a cyclic manner with no clear declining trend. Since early 2000s, however, some negative developments have been observed in the Tana river system. A negative trend for large MSW (3- and 4SW) salmon (Figure 5), especially the females, is particularly worrying. Even though the numbers vary from year to year, there is a negative trend indicating that the return of large fish has been decreasing during the two last decades. During the same period, the trend for 2SW fish is positive while the abundance of 1SW salmon in the river system has been below the long-term average during most of the last ten-year period (Figure 5). Earlier observations of positive correlations among Tana and some other western Finnmark rivers seem to have changed during the last 10 years, i.e. supporting these negative trends. This could be due to factors connected with heavy exploitation (sea and/or river fishery), changes in prey availability in the Barents Sea, climate change and so on. However, Tana still today likely supports the largest wild stock complex of Atlantic salmon in the world.

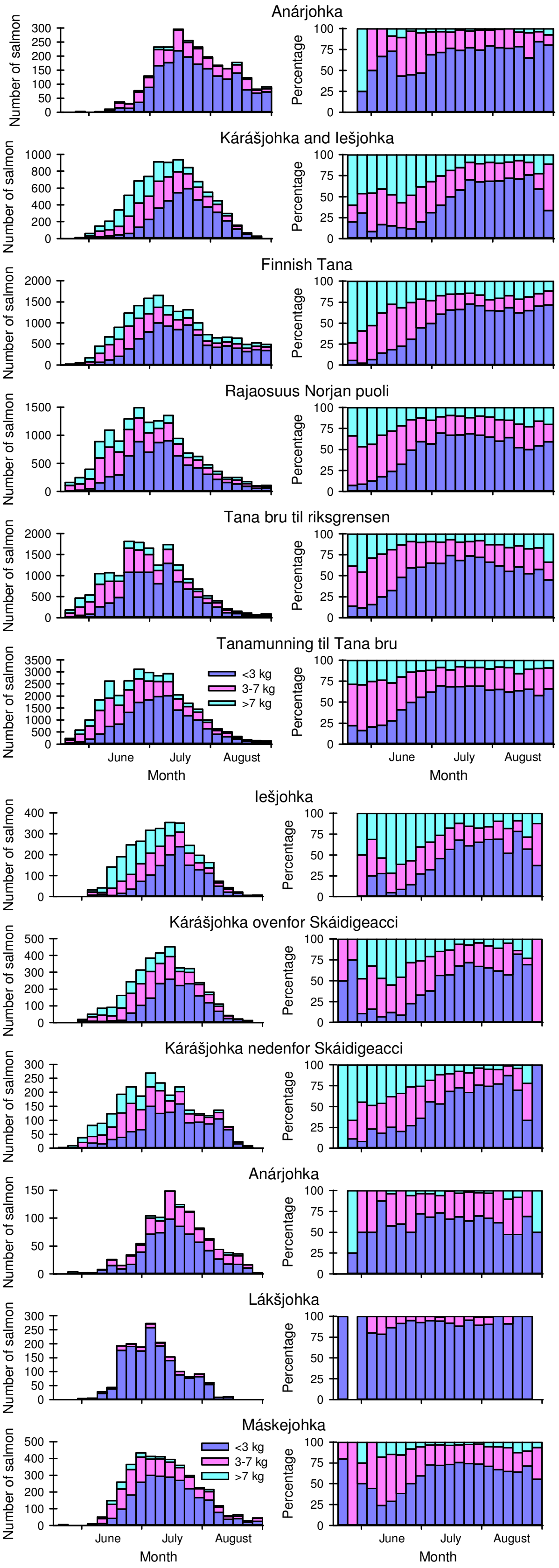


Figure 4. Catch distribution throughout the summer in the different parts of the Tana main stem and some tributaries. Data from the years 2004-2013 are combined.

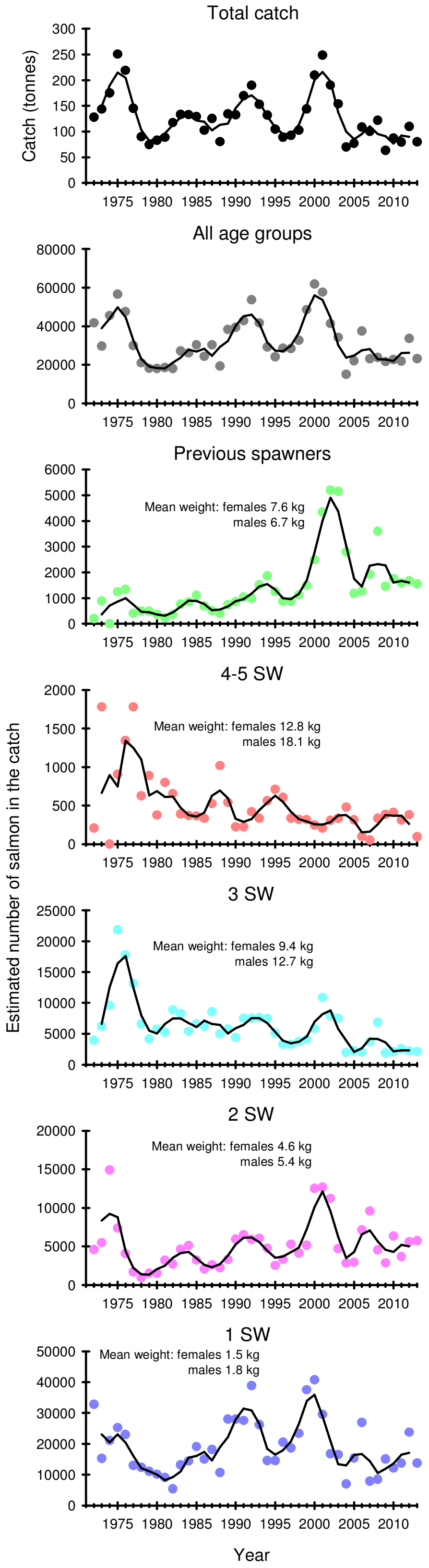


Figure 5. Estimated numbers of captured salmon in different age groups, and the total catch in tonnes.

2.2 TANA SALMON FISHERIES

The riverine salmon fisheries in Tana include a variety of fishing methods such as weir, gill net, seine and drift net, in addition to rod and line. The net fisheries are practiced by local people and it is permitted by fishing rights based on land owning, agriculture production or inherited rights. Fishing in the lower section is mixed-stock fishery throughout the season, whereas this is true for the upper section until the second half of July, when stocks from the tributaries have mostly ascended into their spawning rivers. In the upper section, fishing in August is directed to sub-stocks reproducing mainly in the main stem. According to the telemetry tagging experiments in the early 1990s, harvest rates in the river fisheries could reach the levels of more than 60 % (Erkinaro *et al.* 1999; Karppinen *et al.* 2004). A recent study in the large tributary, Utsjoki, even suggested exploitation rates of more than 80 % on MSW salmon. It should be emphasised, that by including the sea fishery, the effective exploitation rates for Tana salmon is even higher.

Tana salmon is further exploited in the sea fisheries along the coast of northern Norway. This coastal fishery has historically had yearly catches up to 700 tonnes, but regulations in the later years have brought the catch down to well under 200 tonnes. Earlier tagging experiments have indicated that around a third of this coastal catch might be Tana salmon and the total salmon production of the River Tana system has then been estimated to be up to 600 tonnes. Tagging of smolts from the River Tana in the 1970s indicated a fifty-fifty distribution of the catch between the coastal fisheries and the River Tana in terms of number of salmon. A recent genetic study assigning the coastal salmon catches to their population of origin has indicated that *c*. 15-17 % of the total salmon catch originating from the Tana river is caught in coastal fisheries (Svenning *et al*. 2014).

The catch statistics for the Tana River system have historically been divided into two separate parts, the Norwegian catch and the Finnish catch. The Norwegian catch statistics were calculated by the County Governor of Finnmark up until and including 2010. In 2011 the responsibility were transferred to the new local River Tana Fisheries Management Board. The Natural Resources Institute Finland (LUKE; formerly the Finnish Game and Fisheries Research Institute FGFRI) compile the catch on the Finnish side.

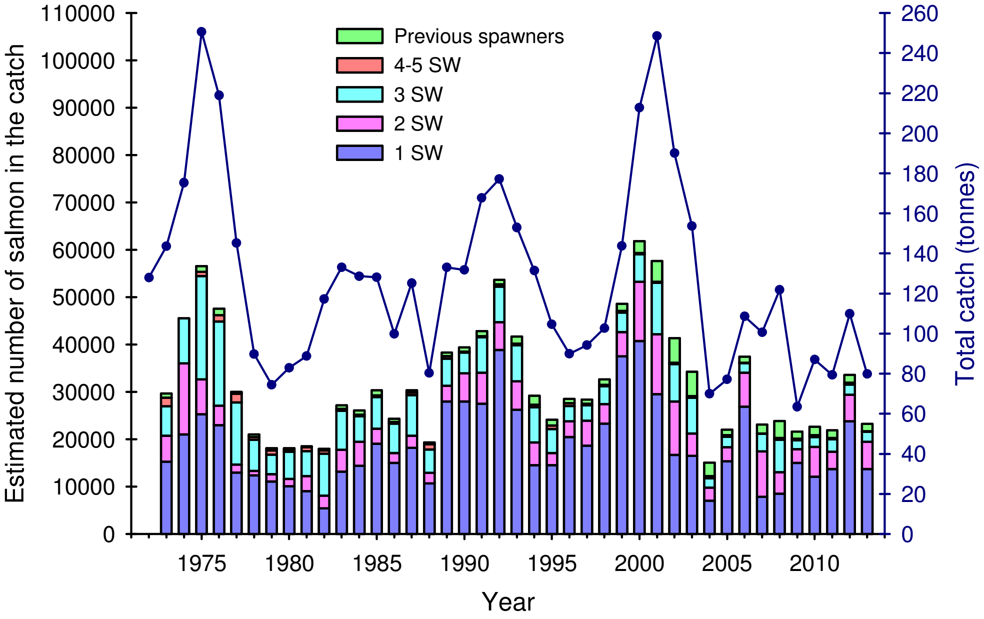


Figure 6. Total salmon catch in the River Tana system (both Norway and Finland) in 1972-2013 in terms of mass (line) and number of fish (bars). Bars are separated into different sea age groups.

Between 1972 and 2013, the annual salmon catch in the river have fluctuated between 63 and 250 t with an average of 130 t (Figure 6). Total number of salmon caught in the entire Tana system typically vary between 30 000 and 50 000, exceeding 60 000 fish in the best years and sinking to around 15 000 fish in the worst years.

The total salmon catch in the River Tana system has historically fluctuated in a seemingly periodic manner, with peaks every 8-9 years (Figure 6). This period length corresponds roughly with the average generation time of female spawners in the system. For example, good catches in the early 1990s resulted in good catches in the early 2000s. Worryingly, these periodic cycles seem to have broken down in the last years. The good catches in early 2000s did not result in high catches in 2006-2008, even though the catches of 1SW salmon in 2006, 2SW in 2007 and 3SW in 2008 were higher than the long-term averages. Effective salmon fishery of Tana River stocks in coastal areas and within the entire Tana River system in the early 2000s might therefore have resulted in too low spawning stocks. The average salmon catch in Tana over the last decade has been below the long-term average both in terms of salmon numbers and mass. Following the long-term fluctuations in the total catch, much higher catches were expected in 2009, 2010 and 2011 than what was observed.

Salmon catches have fluctuated in the same manner in Norway and in Finland (Figure 7). However, the relative development in catch level is very different between the two countries. Since 2004, the Norwegian catches have been much lower relative to the long-term average than the catches in Finland. This reflects a general trend of lower fishing intensity in Norway, especially in the lower Norwegian part of the Tana main stem. The extent of the Norwegian fishery is, thus, declining while the Finnish catches make up a larger proportion. During the 1970s and 1980s, the Norwegian catch was responsible for 60-70 % of the total catch. During the 1990s, this proportion gradually declined towards 50 %, and in the 2000s, the Finnish catch has made up over 50 % of the total (Figure 7).

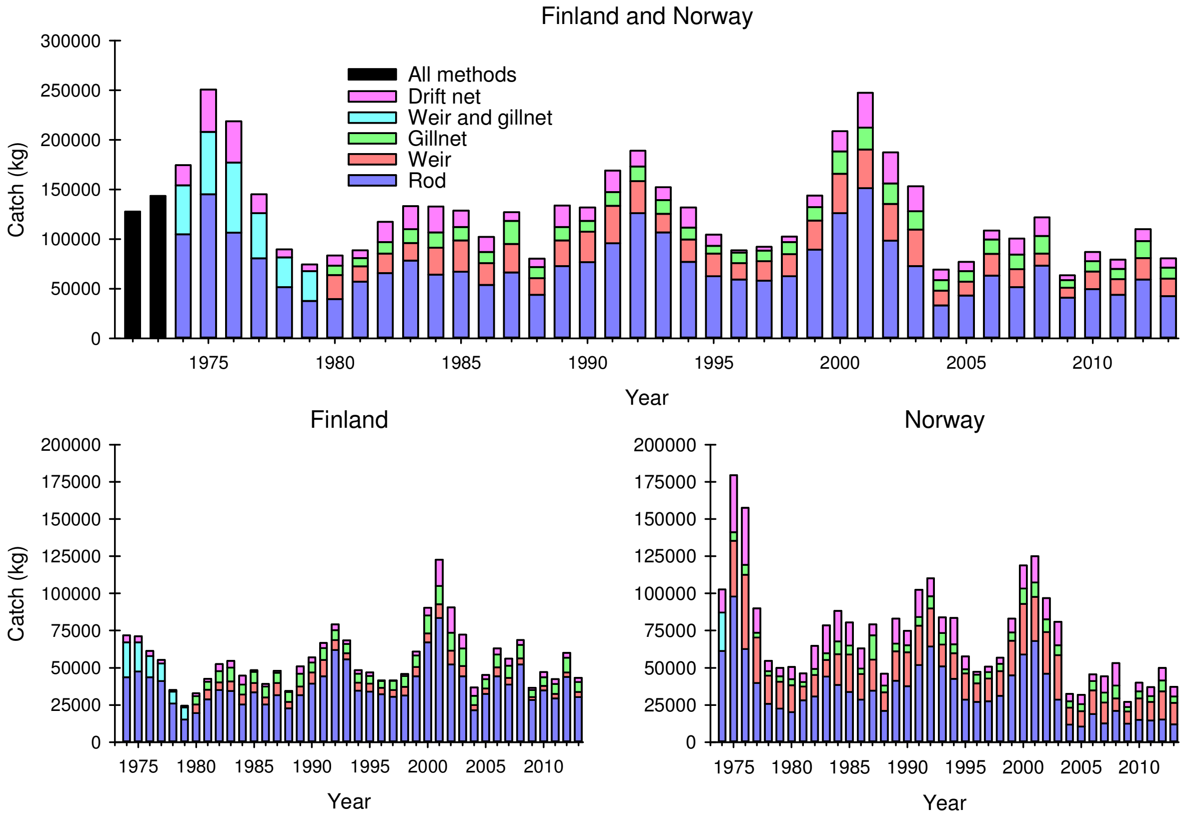


Figure 7. Total salmon catches in the Tana river system by countries and fishing methods.

Despite a large annual variation in the salmon catch estimates, the proportion of salmon caught with different fishing methods have remained relatively stable (Figure 8). The proportion of salmon caught with rod increased slightly from the 1970s until the early 2000s. There are, however, clear differences between the two countries. Around 75 % of the salmon caught in Finland have been taken with rod, while more than half (60-70 %) of the Norwegian catch is caught by nets. In Norway the proportion of rod catch has declined since the early 1990s, while in Finland it has increased since the early 2000s. In Norway the proportion of salmon caught with driftnets has increased since the mid-1990s.

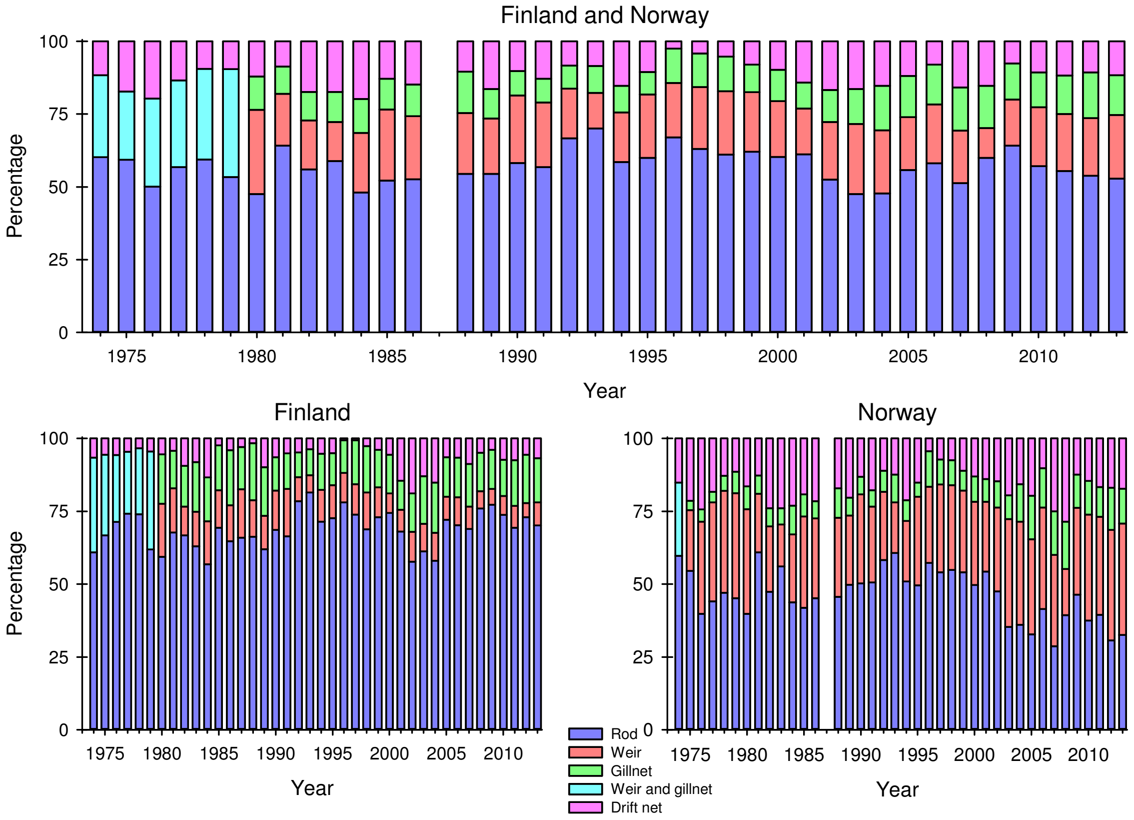


Figure 8. Percentage distribution of salmon catches in terms of mass for fishing gears in Norway and Finland.

In general, the proportion of rod-caught salmon in terms of numbers increased from the 1970s until the mid-1990s (Figure 9). After 1996, the proportion decreased steadily until 2004 followed by an increase until 2009. The proportion of salmon caught on gillnets has shown an increasing trend since mid-1980s. Large annual variations in the proportion of salmon caught on driftnet largely reflects annual variations in environmental conditions, especially the ice-break-up, following discharge and water level, which are determining the practical length of the drift net fishing season.

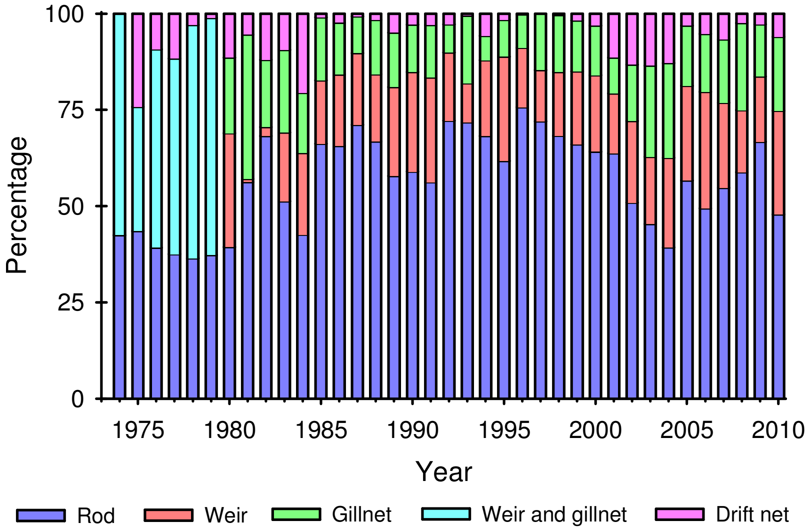


Figure 9. Percentage distribution of salmon catch (based on number of fish) between fishing methods in the River Tana system.

Based on scale reading, it is possible to estimate the relative abundance of different sea age-classes captured throughout the season. The time series dating back to 1973 demonstrates how the fishing exploits salmon of different sea age-classes (Figure 10 and Figure 11). Most virgin female spawners have been two (2SW) or three years (3SW) at sea, while most virgin males have spent only one year (1SW) at sea. There are also quite a few 1SW females, many of which belong to smaller tributaries, and also some large 4SW females. The largest males are 4SW and 5SW fish.

Both the number and mass of female and male salmon have fluctuated simultaneously (Figure 10 and Figure 11). The expected increase in salmon abundance in 2006-2009 did not occur, and in particular, the catches of females have been low in the later years. The catches of 1SW salmon in 2010 and 2011 were recruited mainly from the spawning stocks of 2004 and 2005, which were the lowest in the Tana salmon catch records since 1973, whereas the increase in 1SW catch in 2012 reflected the relatively good run of grilse in 2006 (Figure 10).

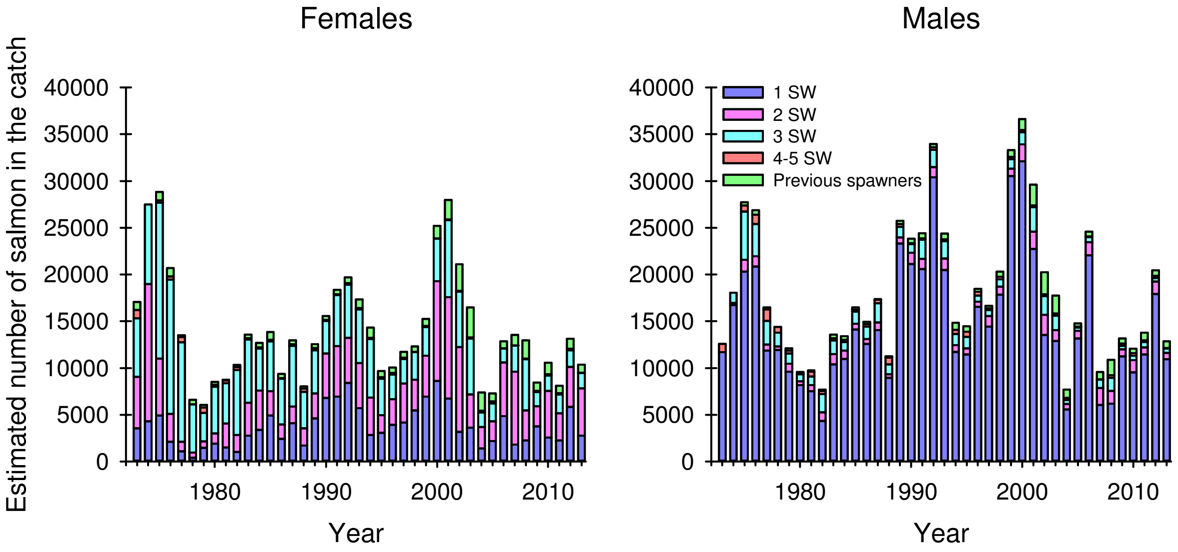


Figure 10. Estimated numbers of salmon in the River Tana catches for 1SW–4-5SW salmon and previous spawners.

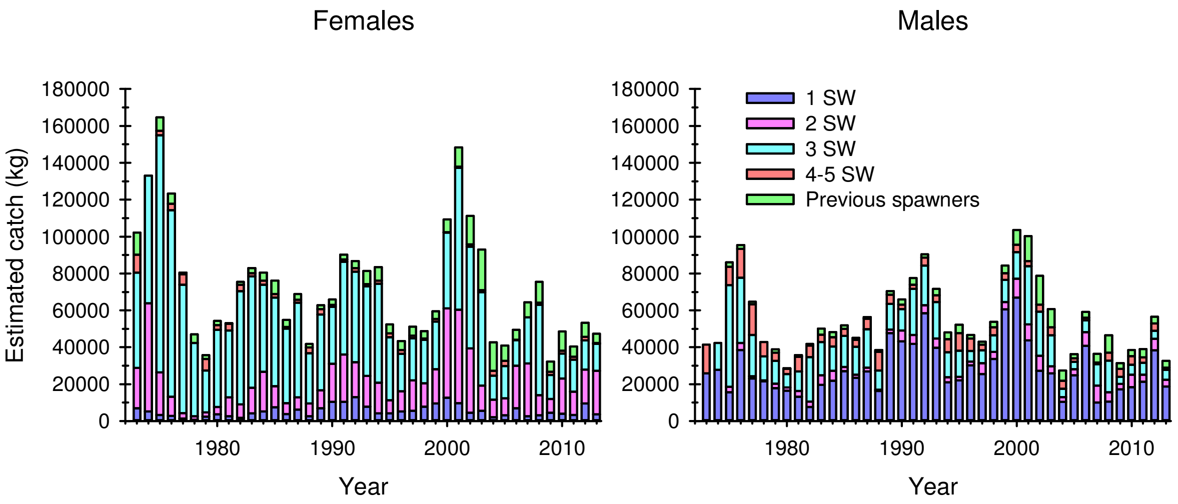


Figure 11. Estimated mass of salmon in the River Tana catches for 1SW–4-5SW salmon and previous spawners.

Female 2- and 3SW fish make an important contribution in the catches by mass because of their larger size compared to male-dominated 1SW fish. The estimated catches of large salmon have been low over the last 10 years except for the year 2008 (Figure 12).

The estimated number of salmon of different sea- age classes show a decreasing trend for especially large fish (3SW-4SW salmon, Figure 12), while the patterns for smaller salmon (1-2 SW) are less clear. There is a significant increasing trend for previous spawners. The long-term data show large annual variations, e.g. the numbers of 1SW salmon can vary 4-5 folds between the years of highest and lowest abundance.

The decreasing trend for larger salmon is evident both for females and males (Figure 12), but mostly for females. The numbers of female salmon in the catches all sea-ages combined has been below the long-term average during the last 10 years. During the last years the numbers of previous spawners have also declined from the record high figures to the level of long-term average. Between the years with high catches, there have always been periods of low catches. The duration of low catches has typically been 5-7 years.

The salmon catches in terms of numbers are fluctuating more or less simultaneously between the fishing gears used in the Tana system (Figure 13). The proportions of different sea ages of salmon are also fluctuating simultaneously between the fishing methods. Interestingly, in the last decade previous spawners have made up an extremely high proportion (up to 50 %) of the salmon caught with drift net. This high proportion of previous spawners also partly masks the worryingly low catch of virgin MSW spawners, especially the 3SW females.

The proportions of 3SW female salmon have declined significantly in the River Tana catches, reflecting the same phenomenon as the declining numbers of 3SW females in the overall catches (Figure 12), and their decreasing proportion in the total catch in the River Tana main stem (Figure 13). In addition, the same negative trend in the proportions of large females is evident in the August catches when most fish are already close to or at their spawning areas (Figure 14).

In certain Tana tributaries with a consistent long-term data set, previous spawners have shown an increasing contribution in the catches, and this is especially true for female salmon in the River Anárjohka/Inarijoki (Figure 15).

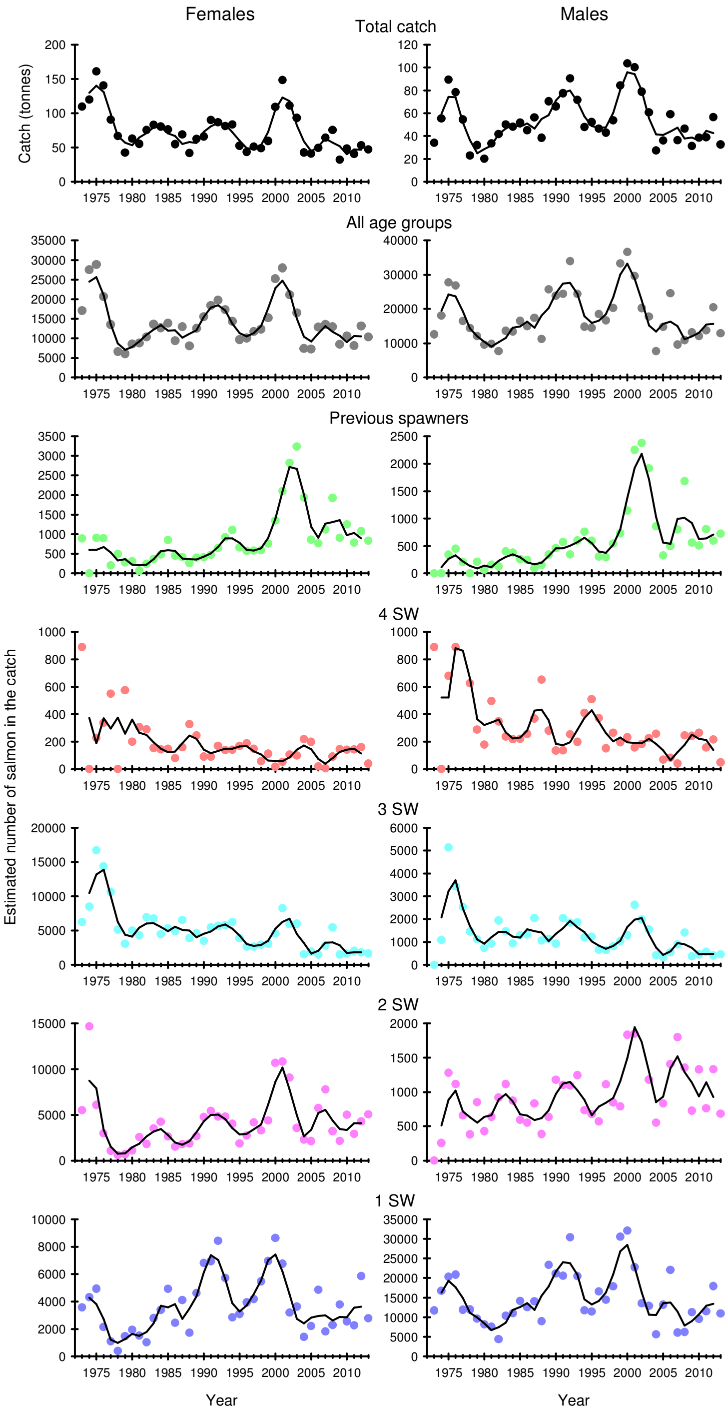


Figure 12. Estimated numbers of salmon of different sea-age-groups in catches of the River Tana system in 1973-2013.

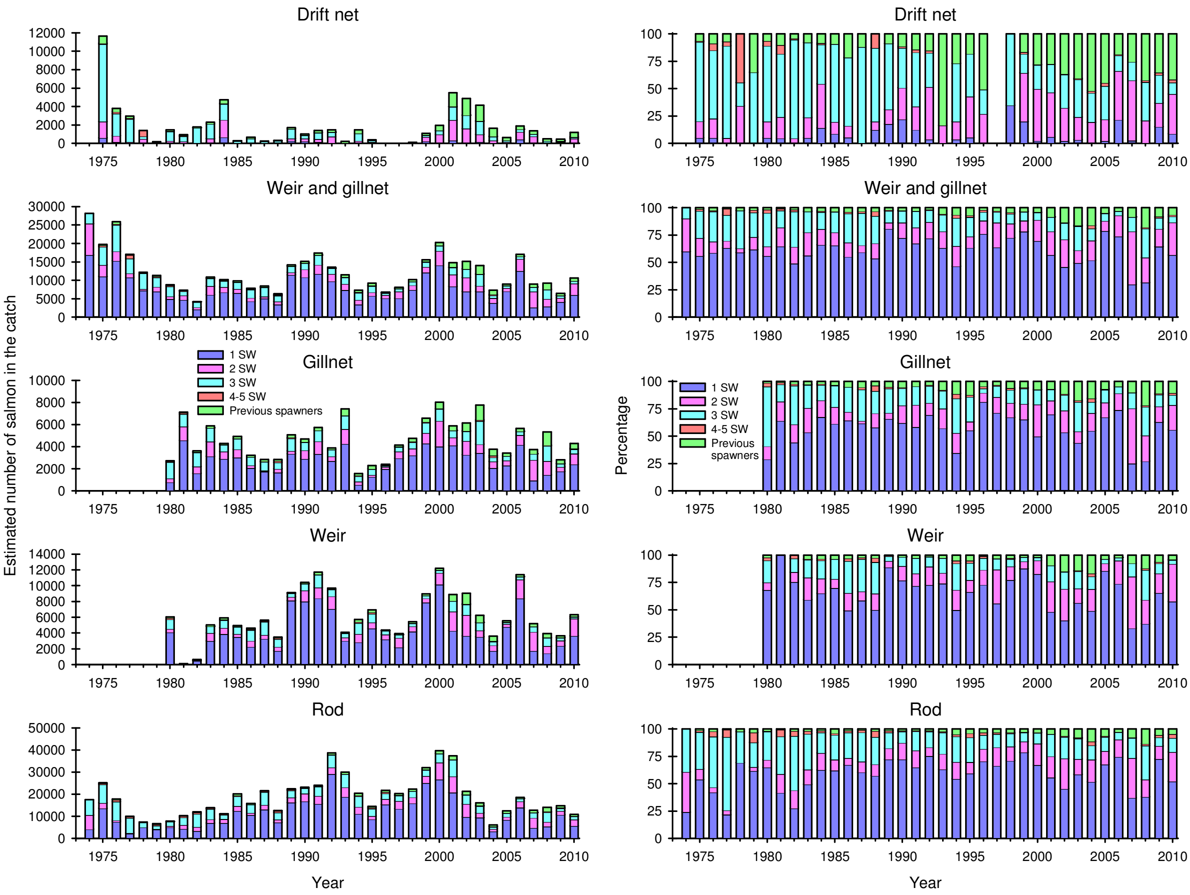


Figure 13. Numbers (figure on the left) and in percentages from the numbers (figure on the right) of salmon (1SW, 2SW, 3SW, 4-5SW, previous spawners) caught in the River Tana system with four different fishing methods.

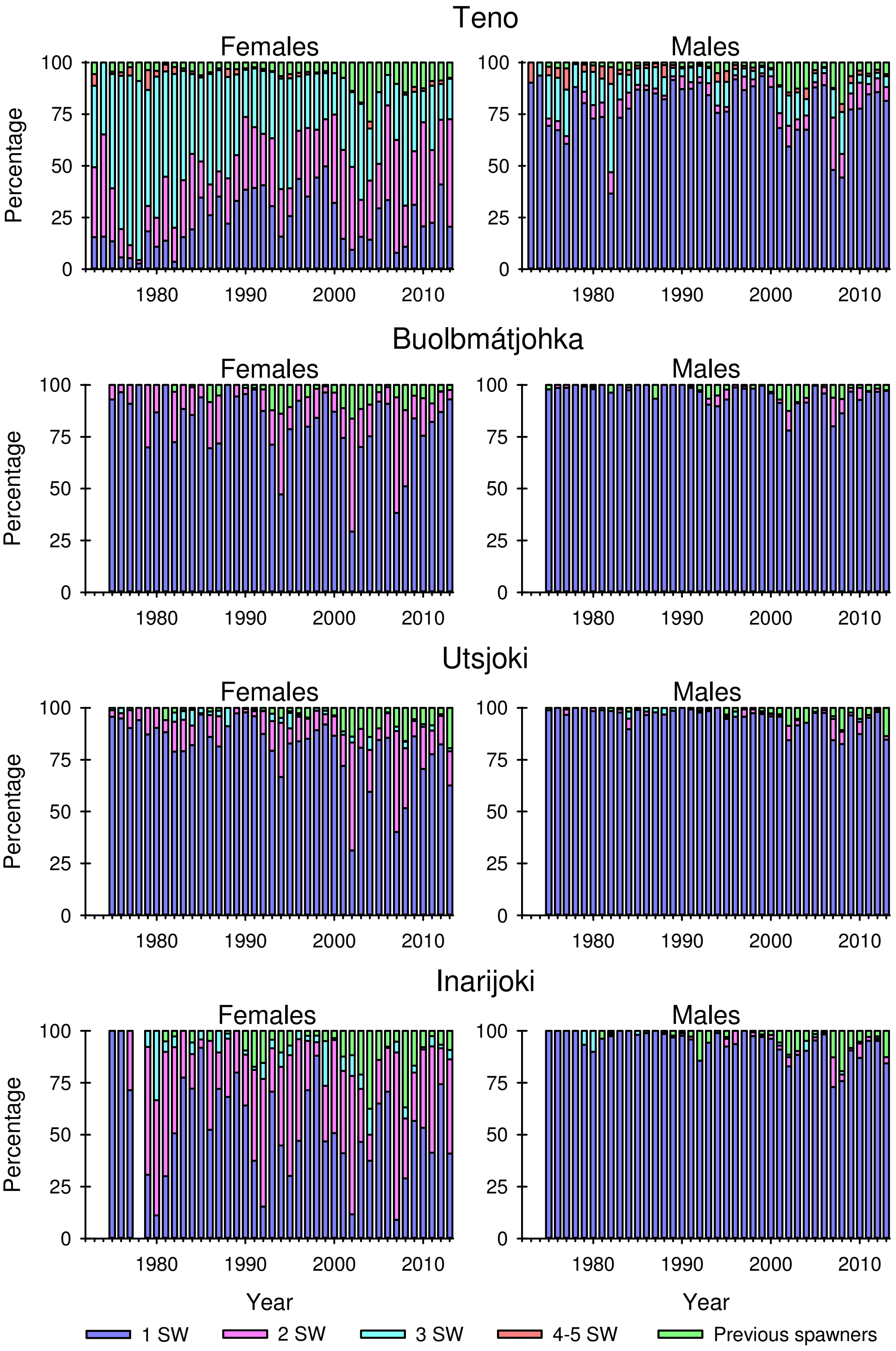


Figure 14. The proportions of various sea ages of salmon caught in Tana main stem and in three major tributaries.

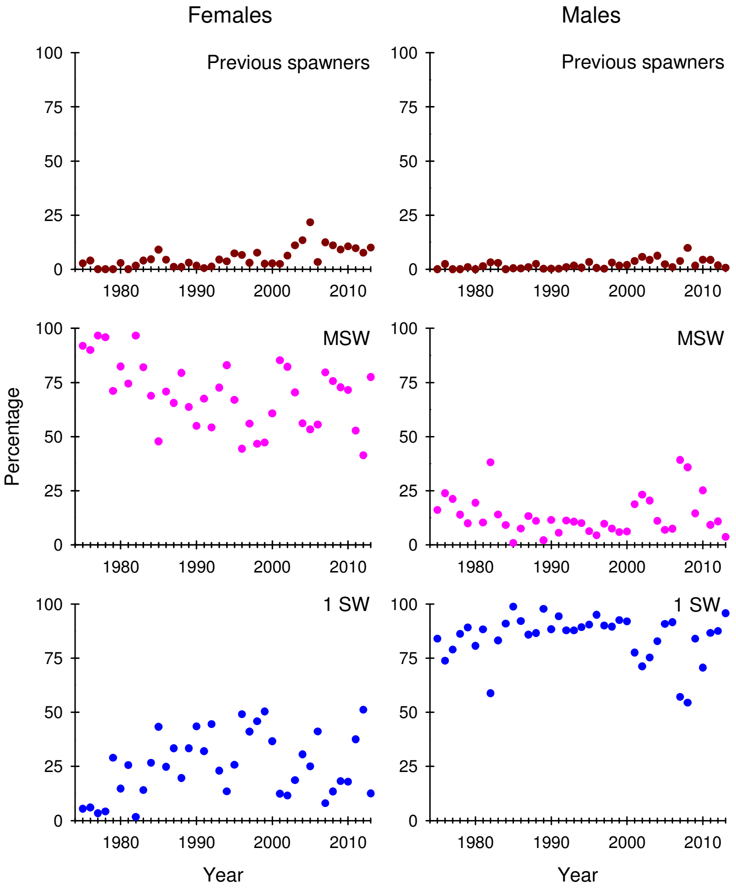


Figure 15. The proportion of female salmon in the spawning stocks (samples from August fishery) in the River Tana main stem.

From 1975 to 2013, the salmon catch of the tourist anglers have varied around 25 % of the total salmon catch in the River Tana system (Figure 16). Since 2005, the tourist catch proportion has increased to 30-40 % of the total catch. Between 1975 and 2013, the tourist catch have varied around 45 % of the total rod catch, and since 2005 this proportion have increased to more than 50 %.

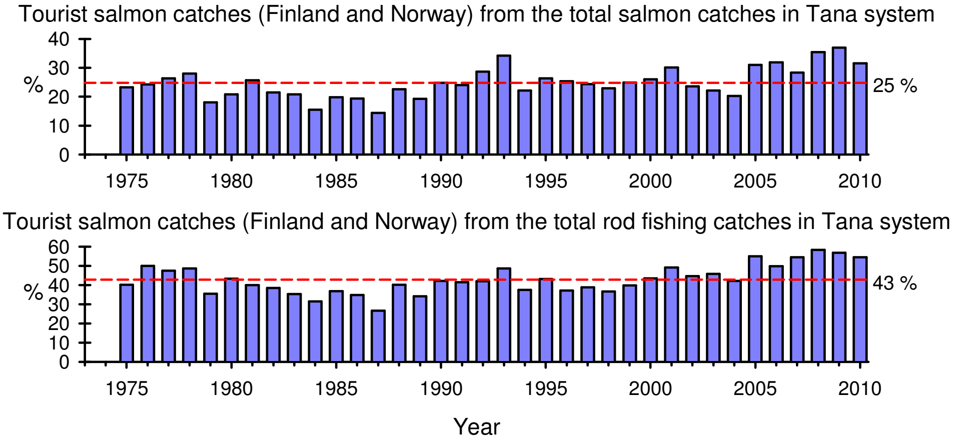


Figure 16. The proportion of tourist salmon catches (Finnish and Norwegian tourist catches together) from the total salmon catches and from the total catches caught with rod fishing methods.

The long-term data set on the Finnish tourist catches indicate an increase in the overall catch levels both in terms of numbers and weight (Figure 17). There is a declining trend of salmon larger than 7 kg, similar to the trend in the total Tana salmon catches. Large salmon have made up around 70 % of the total weight of catch in the 1970s and early 1980s, while in the latest years their proportion has been around 40 %.

The salmon catch of Finnish tourist fishermen further support the conclusion on a declining trend for the 3SW female salmon (Figure 18), but also show the increased proportion of previous spawners.

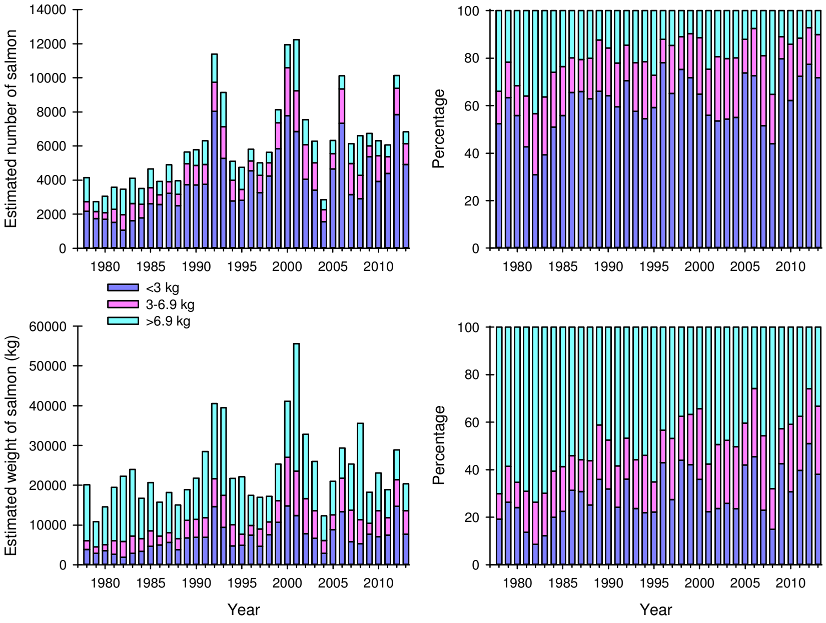


Figure 17. The salmon catches in terms of numbers and weight in three size categories for Finnish tourists in the River Tana and Anárjohka.

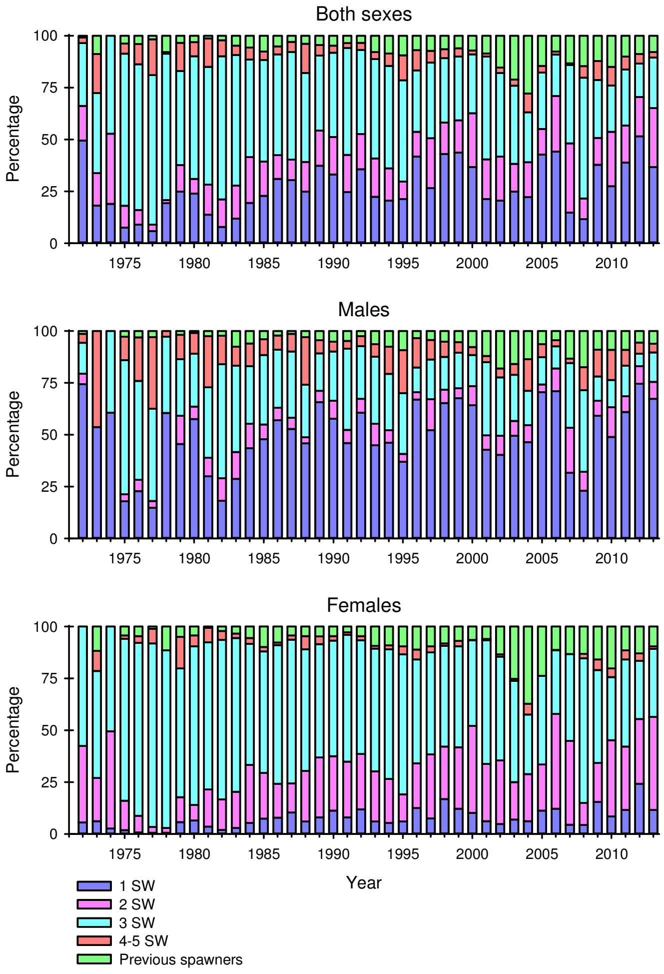


Figure 18. Proportions of different age groups in salmon catches (based on numbers) for Finnish tourist fishers in the Rivers Tana and Anárjohka/Inarijoki.

3 THREAT FACTORS

There are a multitude of human-derived factors that have the potential to affect salmon stocks in a negative way. The Scientific Advisory Committee for Atlantic Salmon Management in Norway has devised a system for evaluating and ranking such factors in terms of their influence and threat levels (Anon. 2014).

In this system, threat factors are ranked through a combination of the possible *influence* the threat factors can have on stocks in terms of reduced production and potential loss of stocks, and the *risk* that the factors might lead to additional and increasing losses in production and stocks. This leads to a two-dimensional system with an influence axis and a risk axis (Figure 19).

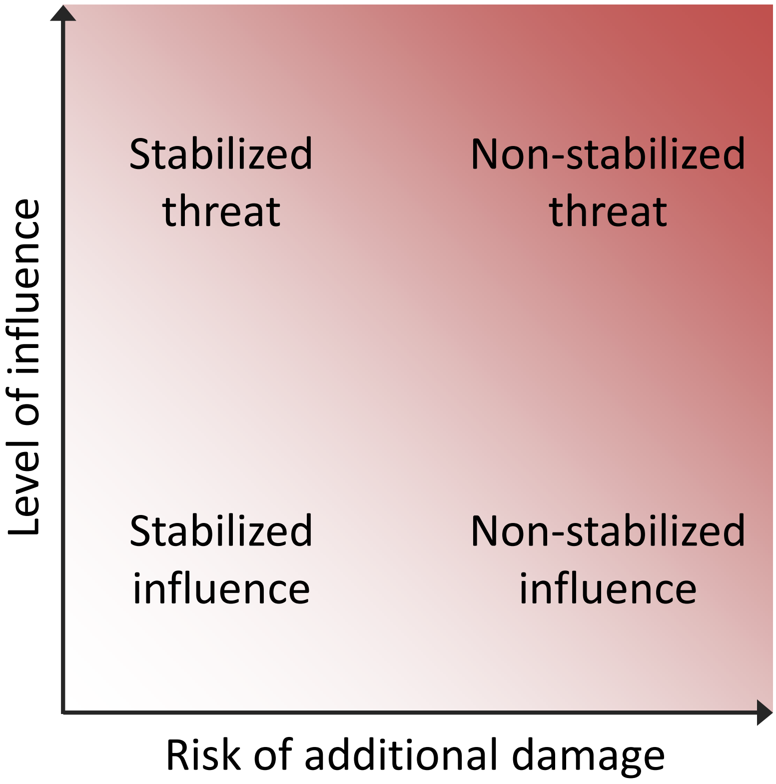


Figure 19. The two-dimensional system that was developed by the Scientific Advisory Committee for Atlantic Salmon Management in Norway to evaluate factors influencing and threatening Norwegian salmon stocks (figure from Anon. 2014).

Four different regions can be identified within the combination of the two axes (Figure 19):

1) **Non-stabilized threat**. A factor that affects stocks to the extent that they become critically threatened and even extinct. Mitigating measures are either lacking or not able to control or reduce the influence and extent of the threat factor.
2) **Stabilized threat**. A factor that can affect stocks to the extent that they become critically threatened and even extinct. Effective mitigating measures are available.
3) **Non-stabilized influence**. A factor that causes reductions in stock production (but not to the extent that stocks are threatened). Mitigating measures are either lacking or not able to control or significantly reduce the influence of the factor.
4) **Stabilized influence**. A factor that causes reductions in stock production (but not to the extent that stocks are threatened). Effective mitigating measures are available.

A total of 16 threat factors were identified and evaluated on a national level in Norway in terms of knowledge level, threat potential (for affecting stock size, production, stock structure and genetic integrity), extent of geographic distribution and the availability of mitigating measures (Anon. 2014). The national ranking of the factors is shown in Figure 20.

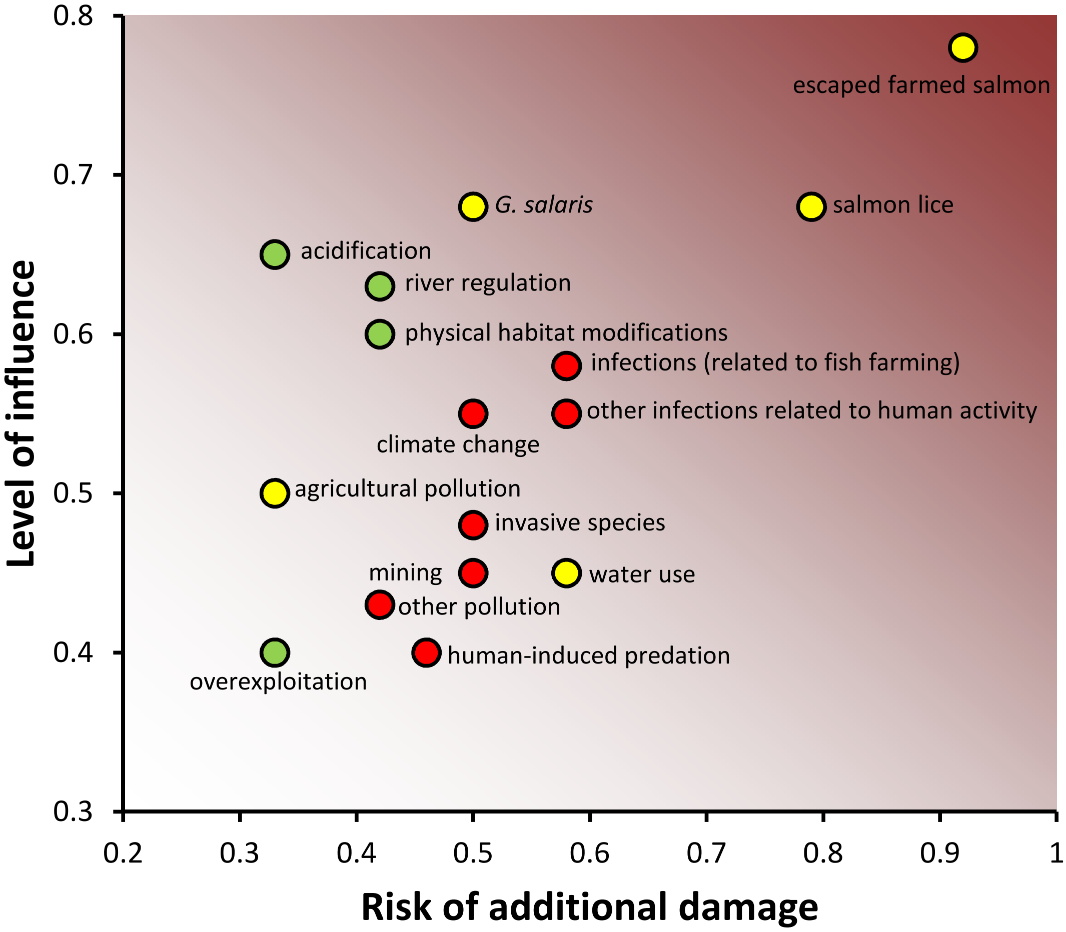


Figure 20. The **national** (Norwegian) ranking of different threat factors affecting salmon in an influence-/risk-diagram. The background colour illustrates level of severity (dark colour is most severe). Symbol colour designates level of knowledge and uncertainty, with green symbolizing an extensive knowledge level and little uncertainty about the development, yellow symbolizing a moderate level of knowledge and moderate uncertainty, and red symbolizing a low level of knowledge and high level of uncertainty about the development of the factor (figure from Anon. 2014).

3.1 REVIEW OF INDIVIDUAL HUMAN-CAUSED THREAT FACTORS

Please note that the national ranking shown in Figure 20 reflects the overall influence and risk of the factors in Norway. However, the influence/risk of individual factors differs locally among river systems, and in the following text we therefore evaluate the risk and pertinence of the individual threat factors from Figure 20 within the Tana river system. We make the evaluation over two different axes: (1) the current level of influence in Tana, and (2) the risk of (additional) damage in the future.

3.1.1 RIVER REGULATION (HYDROPOWER)

Currently, no parts of the Tana river system have been regulated for hydropower purposes, and no plans exist for such developments in the future. We have therefore placed this factor low both on the current influence axis and the risk of future damage axis.

3.1.2 WATER USE

Water from the river system can potentially be used for a variety of purposes, e.g. hatcheries, freshwater fish farming, industry and agriculture (irrigation). The extent of such water use in Tana is insignificant today, and the risk of future development is currently viewed as small.

3.1.3 ACIDIFICATION

Acidification is a threat factor that historically has eradicated several salmon stocks in areas exposed to acid rain. It is also a factor that can be countered effectively with liming, and several eradicated Norwegian salmon stocks have been reestablished through the national liming program. Water chemistry within the Tana river system indicate that acidification currently is not influencing Tana salmon stocks negatively. Therefore, we place this factor low on the current influence axis and with a low risk of increased future damage.

3.1.4 PHYSICAL HABITAT MODIFICATIONS

Physical habitat modifications include habitat changes such as channelization, embankments and river sills. Embankments can potentially have both negative and positive effects, while channelization and sills usually have negative effects. We have numerous embankments within the Tana river system, while channelization primarily is a habitat modification that might affect smaller streams within the system. The current level of influence from physical habitat modifications is likely small to moderate. Due to the strong restrictions on implementing habitat modifications, we assign a small risk of additional future damage from habitat modifications.

3.1.5 AGRICULTURAL POLLUTION

Agricultural activity can increase the nutrient salt load of the river system and contribute to erosion. The former can influence salmon production both positively and negatively, depending on river productivity and hydrology. The latter effect is negative as it can cause an increased input of fine-particulate matter into rivers, and this fine-particulate matter might reduce habitat quality and have clogging effects in spawning redds. There is widespread agricultural activity in the Tana river system, but the effect of this activity is likely small. We therefore place this factor low on both the influence and the risk axis.

3.1.6 MINING ACTIVITY

Mining activity commonly causes increased metal concentration, increased particle input and spill of production chemicals. All of these will have negative effects. In particular, an increased metal load will reduce the smolts ability to adapt to saltwater and thereby cause significantly decreased smolt survival. Increased particle load and spill of production chemicals will reduce egg and juvenile survival. We are severely missing knowledge about critical levels of different metals and chemicals, but experience from other river systems indicate that mining can severely decrease salmon production. Currently, mining activity is at a very low level within the Tana river system, but this activity is expected to increase in the future. We therefore place this factor low on the current influence level, but high on the risk of future damage axis.

3.1.7 OTHER CAUSES OF POLLUTION

River systems receive contaminants in the form of metals, PCB and various pesticides both through local and long-range sources. The effects of these contaminants can vary from weak reductions in reproduction, by way of chronically increased mortality, to episodes of extensive mortality of adults and/or juveniles. The knowledge-level about contaminant effects in general is poor, and we have virtually no knowledge about this factor in Tana. The remoteness of large parts of the Tana river system and the low level of human activity in the area is an indication that this factor likely currently has a low influence and a low risk of future damage.

3.1.8 GYRODACTYLUS SALARIS

The parasite *G. salaris* has caused several Norwegian salmon stocks to be critically endangered (or even extinct) and for this reason it is critically important to avoid transmission of the parasite into the Tana river system. The parasite has not yet been found in Finnmark. The nearest Norwegian localities with *G. salaris* are the rivers Skibotnelva and Signaldalselva in Troms, both of which will be treated with rotenone in the coming year. The parasite is found in Finland and Sweden in several rivers flowing into the Baltic Sea. A nearby example is the large River Tornionjoki/Torneälv. The parasite has been introduced with fish farming into the Inari/Enare lake which forms the source of the River Paatsjoki/Pasvik. Some of the headwaters of both these systems are situated very close to the source areas of the Tana river.

The parasite causes very high juvenile mortality, to the extent that salmon stocks become critically endangered and even extinct. Rotenone treatment is the current main approach to eradicating the parasite, but this treatment is, in practice, untenable in the Tana river system. This makes preventative measures highly important.

The parasite is currently not found in Tana, so this threat factor is placed low on the current influence axis. It is, however, set very high on the risk of future damage axis, due both to the profound negative effects and the extreme difficulties involved in eradicating the parasite from Tana if it ever is transmitted.

3.1.9 SALMON LICE

It is likely, given the current level of knowledge about the possible effects of salmon lice on anadromous salmonids, that increased levels of salmon lice caused by aquaculture have caused increased sea mortality and, thereby, decreased the number of salmon returning to rivers from the sea. On a national level in Norway, salmon lice is currently ranked as the second-most important threat factor for salmon (Figure 20). With the currently observed salmon lice levels in Finnmark (Taranger *et al*. 2014) we are likely approaching a moderate effect level of salmon lice in the area. The risk of future damage is high, as there will be a continuous pressure to increase the aquaculture production biomass in Finnmark in the coming years. Effects from climate change might further increase negative salmon lice effects on salmon.

3.1.10 INFECTIONS RELATED TO FISH FARMING

The immense scale and volume of fish in aquaculture comes with a proliferation of infectious agents, and the potential influences of these agents on wild salmon are largely unknown. The impact of this threat factor is likely small in Finnmark with the current level of aquaculture, but the risk of future damage is deemed moderately high due to planned increases of the aquaculture production biomass along the coast of Finnmark.

3.1.11 OTHER INFECTIONS (NOT RELATED TO FISH FARMING)

There are other infective agents (virus, bacteria, fungi and parasites) that are not related to aquaculture but still can be related to human activity. For instance, there are fish diseases that occur under very particular environmental conditions such as high summer water temperatures and low water levels (both of which can be related to climate change or river regulation). Proliferative kidney disease (PKD) is an example of such a disease, and PKD has been associated with significant juvenile mortality (Forseth *et al*. 2007). It is unlikely that this threat factor is affecting Tana salmon negatively today, but increasing summer water temperatures in Tana in the future means that the risk of future damage is set at a moderate level.

3.1.12 CLIMATE CHANGE

Climate change potentially affects salmon stocks on a multitude of levels, from changes in discharge, water temperature and water chemistry within rivers to large-scale changes in oceanic ecosystems (Anon. 2011a). With the current level of knowledge, climate change as a threat factor is placed low on the influence axis for Tana and moderate on the risk of future damage axis. However, the risk of future damage might be moved upwards on the risk axis as correlations between climate and salmon growth and survival become better understood.

3.1.13 ESCAPED FARMED SALMON

Escaped farmed salmon can influence wild salmon populations on a number of levels, e.g. being vectors of infections, causing ecological effects such as competition and creating a chronic genetic pressure on stocks. The production levels of the aquaculture industry have increased tremendously since its infancy in the early 1970s, and today the natural production of wild salmon is vanishingly small compared to the production of farmed salmon. In 2010, 1 000 000 tonnes farmed salmon were produced in Norway, while the river catch of wild salmon in comparison were only around 430 tonnes, of which approximately 20 % were taken in the River Tana.

In Tana, registrations of farmed salmon have come from two sources: 1) the regular scale samples taken from fishermen during the summer, and 2) monitoring fishing close to the river mouth during the autumn (1990/91, 1996/97 and 2003/04). The proportion of farmed salmon in the catches during the summer has been very low, well below 1 %. In the autumns of 1990 and 1991, the proportions were at their highest with 43-47 % (Erkinaro *et al.* 2010). However, the numbers of fish caught in the samples were only 19 and 7, respectively. The proportions of farmed salmon in the other autumn investigations was 0-13 %, but still with low total numbers of fish (8-21).

After the formal ratification of the Tana fjord as a national salmon fjord in Norway in 2003, all aquaculture in the fjord has been closed.

With the current low levels of escaped salmon in Tana, we currently score escaped farmed salmon low on the influence axis. However, there is a significant and ongoing pressure to increase the production biomass of farmed salmon in Finnmark, and for this reason there is a high risk of future damage from this threat factor.

3.1.14 INVASIVE (OR INTRODUCED) SPECIES

An invasive (introduced) species is an animal (or plant) that is not native to a location. These species might have been introduced to a location either directly by humans (a primary introduction) or they might have moved to the location from another primary introduction by their own means (a secondary introduction). There are some invasive species in Tana: bullhead (*Cottus gobio*), pink salmon (*Oncorhynchus gorbuscha*) and rainbow trout (*Oncorhyunchus mykiss*). The rainbow trout are farmed escapees and we have, until now, no record of any natural reproduction of rainbow trout in the area. The probability of this happening will increase with the increasing biomass of rainbow trout along the Finnmark coast. The pink salmon originate from a massive introduction programme in Russia in the period 1956-1998. There are self-reproducing stocks of pink salmon now in Russian rivers (Zubchenko *et al*. 2005) and we have indications of pink salmon reproduction in Norwegian rivers in the Varanger area (R. Muladal, pers. comm.).

The bullhead (*Cottus gobio*) is a newly introduced fish species in the Tana river system. It was first observed in Utsjoki in 1979, and has increased its distribution in that tributary since. Ten years ago, the bullhead was first observed in the Tana main river at quite many places between the river mouth of Utsjoki and downstream to the Storfossen/Alaköngäs area. This new fish species has also been found already approximately 5-10 km upstream from the river Utsjoki in the River Tana in the Kordsam-Kaava area. The bullhead that have been detected during the annual juvenile salmon survey have been larger than 4 cm, indicating that they most probably have been migrating from the River Utsjoki and they might therefore not be from bullhead that have spawned in the River Tana.

There have been some studies of the potential interactions between bullheads and juvenile salmonids. Bullhead is found to be frequent in areas with low salmon density but not found in high abundance in areas with a high salmon density, but decisive answers about its impact on salmon are still lacking. Focus should be kept on the bullhead in the annual juvenile monitoring, especially to see if the observations from Storfossen/Alaköngäs and upstream of the River Utsjoki river mouth represent a new establishment. Most probably there will occur some competition between juvenile salmon and bullhead in the River Tana because there are not such kind of habitat segregation like lakes and pools which can be found in the River Utsjoki, where salmon and bullhead currently can live separately.

In the current evaluation, we place invasive species low on the current influence axis and at a moderate level on the risk of future damage axis.

3.1.15 OVEREXPLOITATION

A detailed definition of overexploitation is provided in chapter 5.4.

Salmon exploitation should be based on a sustainable surplus. However, the current stock status evaluation in Tana clearly demonstrates that the current exploitation of some stocks in Tana far exceeds the sustainable surplus. A significant proportion of the pre-fishery abundance of most Tana stocks is caught in fisheries and only a small proportion survives to spawning. This makes exploitation a major factor affecting the development of Tana salmon stocks and, accordingly, overexploitation is placed high on the current influence axis. However, the current negotiation process between Norway and Finland has a strong focus on establishing an adaptive target-based management regime in Tana that will bring exploitation down to a sustainable level. Due to this expectation, we place overexploitation low on the risk of additional damage axis. Overexploitation might be moved upwards on the risk axis if the negotiation process fails.

3.1.16 PREDATION

Predation on salmon by birds, mammals and other fish are natural mortality factors that always have affected salmon populations and are factors that salmon are adapted to. In this sense, it might seem counterintuitive to include predation as part of an evaluation of *human-caused* threat factors.

However, the occurrence of predators might be influenced by human activity, either directly by hunting/fishing the predator species or indirectly by hunting/fishing the alternative prey species of the predators. For instance, heavy exploitation of other fish species in the Tana river system might deplete alternative prey for fish predators such as pike, meaning that predation would become more focused on salmon. Depleting the number of sandeel in the Tana estuary might increase seal and goosanders predation on salmon and trout. Attempts to reduce pike predation by removing pike might result in reduced numbers of large pike. However, large pike are a major predator on small pike, while small pike can be a major predator on salmon juveniles and smolts. Reducing the number of pike might therefore, in the end, increase salmon predation.

The observed relative level of predation will also be affected by salmon stock status. The highest level of influence from predators will be observed when salmon stocks are highly depleted, while low levels of influence will occur with healthy salmon stocks.

As salmon stocks in Tana currently are depleted due to human exploitation and are expected to recover through the implementation of stock recovery plans, we set predation at a moderate to low level on the current influence axis and at a low level on the risk of future damage axis.

3.2 OCEAN CONDITIONS

There is little doubt that environmental conditions in the ocean have contributed to reduced survival and decreased number of grilse in Norway in the last decades. However, it is difficult to evaluate this factor as a *human-caused* threat factor.

3.3 OVERALL VIEW OF TANA SALMON THREAT FACTORS

The ranking of individual threat factors made specifically for Tana above can be visualized in an influence/risk-diagram (Figure 21).

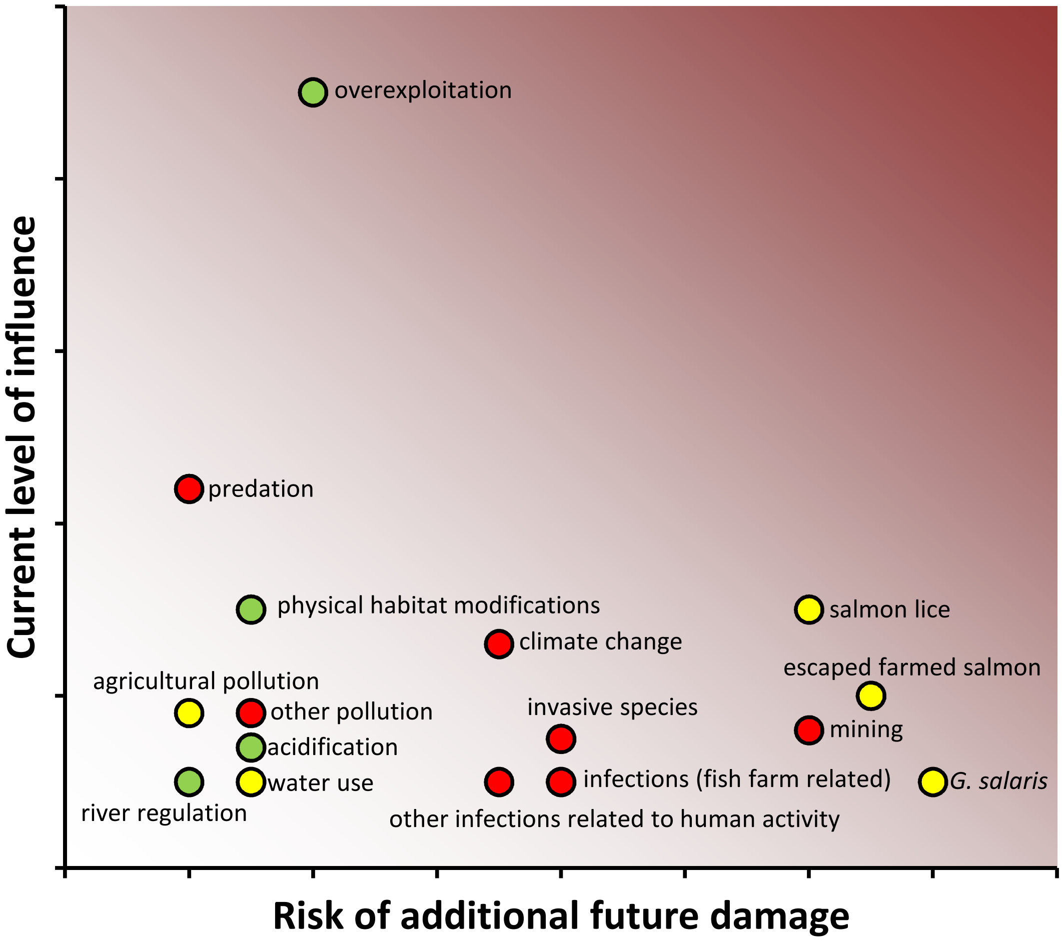


Figure 21. The ranking of different threat factors that affect Tana salmon in an influence-/risk-diagram. Symbol colour designates level of knowledge and uncertainty, with green symbolizing an extensive knowledge level and little uncertainty about the development, yellow symbolizing a moderate level of knowledge and moderate uncertainty, and red symbolizing a low level of knowledge and high level of uncertainty about the development of the factor.

4 THE ROAD TO RECOVERY: IMPLEMENTING RECOVERY PLANS TO REBUILD DEPLETED SALMON STOCKS

As noted in chapter 1.2.1, stock recovery plans should be developed for stocks that have been depleted below their conservation limits. The following text details a procedure for planning and implementing a stock recovery phase in Tana, given the complexity defined by the comprehensive main stem mixed-stock fishery. The structure follows the NASCO Precautionary Approach, with an emphasis on establishing reference points as management targets and pre-agreed management actions that are triggered when the stock status fail to meet the designated targets.

4.1 POSSIBLE FACTORS LIMITING SALMON PRODUCTION

As outlined in the previous chapter on threat factors, there are no (or only minor) negative effects on Tana salmon from human activities such as pollution, hydropower development or fish farming. The natural habitat of Tana salmon, both freshwater and at sea, seem to be in good condition, a sentiment underscored by the very positive stock development seen in neighbouring river systems. As a result of this, the only factor that is a source of high non-natural mortality for salmon in the Tana river system is human exploitation.

What, then, about the possible role of predation? Predators are a commonly raised local explanation of the current negative salmon stock situation in Tana. The natural role of predators in the Tana river system was thoroughly discussed in the previous Tana Group report (Anon. 2012) and it was concluded that it is highly improbable that predation has any role in depleting the Tana salmon stocks. That conclusion still stands.

4.2 RECOVERY ACTION

The identification of human exploitation as the main limiting factor affecting Tana salmon stocks greatly simplifies the recovery actions contained in the recovery plan. Due to this, the recommended recovery action becomes increasing the spawning escapement through the implementation of regulatory measures aimed at reducing the total accumulated exploitation rate experienced by the different stocks. An implementation procedure for this is detailed below.

4.3 STOCK RECOVERY IMPLEMENTATION PLAN

The implementation plan is outlined below as an eight-step procedure, detailing how to establish a recovery target (essentially “where we want to be”), current status (“where we are today”), how to keep track of the recovery development (a monitoring programme) and a road map, called a recovery trajectory, for moving from a depleted stock situation to a stock exceeding its reference point.

RP1 (Recovery Plan, step 1)

Specify stock-specific reference points/management targets (abundance criteria) that designate the levels each stock are expected to attain by the end of the stock recovery period.

A core objective of salmon fisheries management is to manage individual salmon stocks in order to optimise sustainable yield. Defining stock-specific targets for reproduction (e.g. in the form of egg deposition) is one way of achieving this. The spawning escapement of a salmon stock, i.e. the number of spawning females, is estimated by subtracting the number of adults lost through exploitation and natural mortality from the total run size. This escapement can then be converted into a total egg production for the stock and compared to a stock-specific threshold value for egg production defined by the stock carrying capacity. This latter egg production is the level that supports maximum sustainable yield for the stock.

A first step in establishing such management targets for different parts of the Tana river system were taken in the form of first-generation spawning targets through the work of Hindar *et al*. (2007). These first-generation targets have recently been revised (Falkegård et al. 2014). Furthermore, a project aiming to establish second-generation spawning targets that are based on local habitat mapping data have been started and this project should produce refined local-based targets within a few years.

RP2

Evaluate stock status relative to the abundance criteria in RP1.

Before a stock recovery plan can be initiated, we need to have an idea about where the different stocks are right now compared to the spawning targets that designate the point where we want the stocks to be in the future. Therefore, we need to do a stock-specific evaluation of current target attainment. In this way, the introduction of spawning targets have turned the management focus away from being a question about how many fish are caught into a question about having a sufficient number of spawning salmon. The most recent evaluation is provided in chapter 5.5.

In the status evaluation, spawning escapements (or spawning stock sizes) are estimated in terms of number of spawning females and this is compared to the spawning targets. Methods of approaching this issue are described in chapter 6.

RP3

Define and implement a monitoring programme based on a system of index stocks

There are four basic questions involved in management decision-making:

1) For each salmon stock, how many salmon should survive to spawn each year?
2) What is the pre-fishery abundance of each stock?
3) Given steps 1 and 2, how many salmon can be caught from each stock?
4) And following step 3, where should these salmon be caught?

A detailed and well-designed monitoring programme is essential when tackling these four questions. This programme must be designed around two parameters:

1) Exploitation rate estimates
2) Spawning stock size estimates

Exploitation rates are highly important. A dynamic regulation of the exploitation rate is the most important tool we have available when we try to match target attainment and stock recovery trajectories. The monitoring accordingly must be detailed enough to provide stock-specific exploitation estimates from different areas, for different life history groups and for different fishing gears.

Estimates of stock-specific spawning escapements are also a core part of the annual stock status evaluation. These estimates can either be direct spawner counts or data that can be used to infer spawning escapement indirectly.

The details of a monitoring programme specifically designed to give data on these two parameters is described in chapter 6 of this report.

RP4

Depending on current stock status, define a recovery trajectory for each stock.

The spawning target tells us at what level we want the stock to be at, while the stock target attainment evaluation tells us where we are currently positioned relative to the desired spawning target level. In case of a depleted stock, i.e. a spawning stock below the target, we will have to define a stock recovery plan with an associated stock recovery trajectory.

The initial construction of a recovery trajectory can depend on either of two questions: Either the decision is made based on time horizon (i.e. number of years that we want to spend in a stock recovery phase) or maximum acceptable reduction in exploitation rate.

The shape of the recovery trajectory depends on stock life history characteristics such as variation in smolt age, sea-age variation among spawning females and proportion of previous spawners.

As an example, consider a stock with a current target attainment of 20 % and an average generation length of 8 years. Figure 22 is then an example of a recovery trajectory that depends on a reduction in overall river exploitation rate of 25 % and, as a result, covers a time period of 25 years:

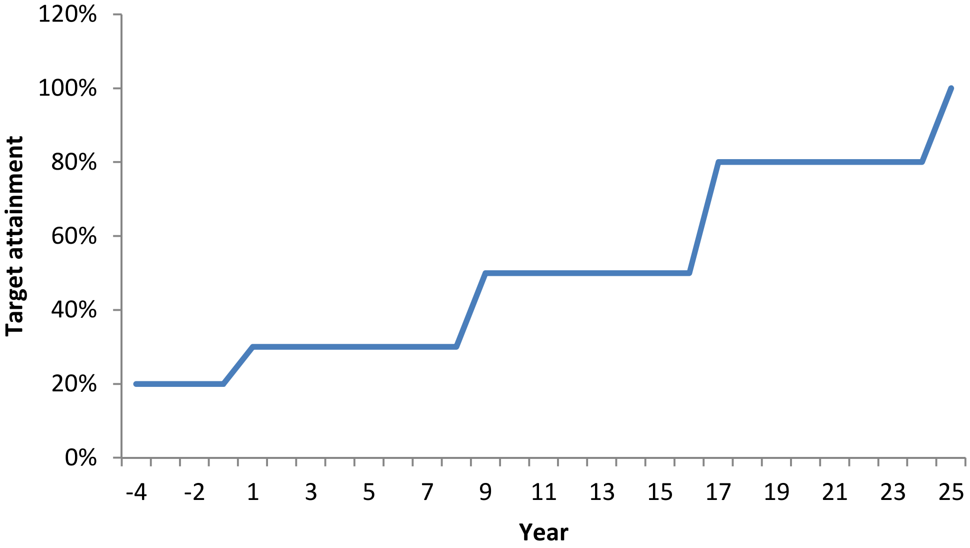


Figure 22. Constructed recovery trajectory for a river starting at 20 % target attainment, with a recovery period spanning 25 years.

RP5

Define a set of pre-agreed regulations that can, depending on different scenarios, be implemented for each stock.

Fishing regulations are the main management tool we have available when we try to make the different salmon stocks follow their respective recovery trajectories. The recovery trajectory provides us with a time horizon and a desired maximum level of exploitation. If we want the stock to follow the trajectory, the total exploitation rate experienced by the stock must be brought down to this level.

It is remarkably difficult to predict the exact outcome of a certain set of regulations on the exploitation rate. We can, however, estimate the exploitation rate after a season, thereby seeing the result of a regulation after it has been implemented. This has an important consequence for the starting years of the recovery period. We must expect the first years to be a trial period in which the following procedure should be followed:

1) An initial set of regulations is chosen on the basis that this set reasonably can be expected to bring the exploitation rate down to the maximum level given us by the recovery trajectory.
2) After the season, the resulting exploitation must be evaluated and compared with the expected maximum level.
3) If the new exploitation is too high, additional regulations must be implemented before the next season. If the new exploitation is too low, there might be a possibility to remove some of the initial regulations.
4) After the first few years, we should have arrived at a set of regulations that have the desired effect. These regulations should then be kept mostly unchanged for the rest of the recovery period.
5) There must be a continuous annual monitoring of the exploitation and target attainment. Some amendments in the regulations might be necessary from year to year depending on factors such as poor river or sea survival. For instance, if the forecast is that we are entering years with particularly poor sea survival, the proper response is to tighten the fisheries regulation so that the exploitation rate decreases and the probability of attaining the spawning target increases.

To be able to deal with the requirements of this dynamic process, we need to have a set of pre-defined and pre-agreed regulatory measures available that can be implemented depending on different scenarios.

RP6

Evaluate the current total (accumulated) exploitation rate experienced by each stock, and choose a new desired rate that will be the starting exploitation level in the recovery period.

Current monitoring data allows us to estimate both the pre-fishery abundance and the total (accumulated) exploitation rate of different stocks for the last few years (at least back to 2006). This can be used to select the new exploitation rate defined by the recovery trajectory:

1) Estimate target attainment and total exploitation rate.
2) Look at the first step in the recovery trajectory (first generation) and find which level of target attainment is specified there.
3) Calculate which exploitation rate would have given this new target attainment in the preceding years.

This new exploitation level should then be the starting point in the recovery period. A demonstration of this procedure is given in the stock recovery example further down.

RP7

Implement a subset of the pre-agreed regulations that is expected to bring total exploitation rates for each stock down to the level selected in RP6.

See RP5 for a description of the process involved in selecting regulatory measures and evaluating the resulting exploitation rate.

RP8

Do a post-season evaluation (using data from the monitoring programme) of the actual effect of implemented regulations on exploitation rates and target attainment in comparison with the expectations from RP4 and RP7.

This point must be repeated annually throughout the recovery period. This is where we make sure that there is a consistency between experienced exploitation rate, target attainment and recovery trajectory.

The monitoring programme must be designed so that we can assess the results of new regulations after a fishing season and then tweak the regulation before the next season (e.g. implement further restrictions from the above agreed-upon set of regulations to bring the exploitation further down, or, if we see that exploitation rates have gone down more than expected, remove some of the regulations). See description under RP5.

5 STOCK STATUS EVALUATION

This chapter aims to provide a comprehensive status update on salmon from 10 different parts of the Tana river system, in addition to a total status estimate for the whole river system. The status evaluation is based on (and extended from) the status evaluation in Anon. (2012) and work done by the Scientific Advisory Committee for Atlantic Salmon Management in Norway.

5.1 HOW TO EVALUATE STOCK STATUS?

The traditional approach to stock status evaluation has been through the use of catch statistics. Long time-series of catch data can quickly be put together and represents an illustration that initially looks easily interpretable. However, upon closer scrutiny, a number of problems arise with this approach.

First and foremost, it is very difficult to pinpoint the exact reason for fluctuations in catch statistics. Differences between years can arise from several sources in addition to yearly salmon stock changes. Such factors include e.g. differences in number of fishermen, fishing conditions and/or fisheries regulations. All of these extra factors will confound the catch statistics interpretation.

Secondly, it is problematic to relate the catch to any meaningful benchmark of how the stock is doing. The catch statistic provides an estimate of the number of caught fish, and thus is a useful way of describing how the fishermen are doing. It tells us very little, however, about how the stock is doing. How many salmon were left at the spawning grounds and how many should there have been? What was the exploitable surplus and how was that reflected in the catch? These are examples of questions that point to the need for a different approach.

The lack of a meaningful benchmark when using catch statistics (and other related and derived descriptive statistics) becomes a very obvious problem in processes where fisheries regulations are subject to change. It is not immediately apparent how to justify the need for change and the selection and evaluation of which changes to implement. The management regime itself commonly formulates only qualitative goals, and proposed regulations under this regime rarely have specific goals and lack a clear information basis that managers can use for evaluation.

Salmon as a species pose some very special management challenges with its spatially and temporally complex life cycles which span over vast areas and several years. This is especially true in the Tana River system, in which there are 20-30 genetically distinct stocks and a large variety of possible life history combinations. This stock complexity is further complicated by the presence of an extensive mixed-stock fishery both along the coast of Norway and in the Tana main stem.

5.2 SALMON PRODUCTION AND SPAWNING TARGETS

A major objective for salmon conservation and fisheries management is to develop a practical basis for managing individual salmon stocks and the environment in which they live in order to optimize sustainable yield. One way of achieving this, is to specify stock-specific targets for reproduction (e.g. egg deposition). For a salmon stock, the number of adults estimated to be lost through exploitation and natural mortality subtracted from the total run size, is called the spawning escapement. This escapement can be converted to a total egg production for the stock and then compared to a stock-specific threshold value for egg production. This threshold is the conservation limit (CL) (or Minimum Biologically Acceptable Limit) recommended by NASCO, and is the stock level that supports maximum yield and thus maximizes potential yield under the life-cycle characteristics applying to the stock. The CL is the threshold level below which stocks should not fall, and it is recommended that managers should aim to hold escapement at a higher (unspecified) level termed the management target.

The salmon production capacity in different parts of the Tana River system is limited, meaning that there exist a maximum number of salmon smolts that can be produced. This is usually referred to as the production potential. The factors that limit production are of two types, either (1) density-dependent or (2) density-independent.

Density-dependent factors vary in strength depending on the fish density. With increasing fish density, density-dependent factors such as competition become increasingly intensive. Density-dependence is most easily observed for juvenile salmon. As fish density increases, less food and space become available for each individual fish. This inevitably leads to some fish dying, with mortality increasing with the fish density. A river, accordingly, contains room for only a certain number of juveniles, and this number depends on the river area, abiotic factors such as habitat quality (e.g. the number of available hiding places) and biotic factors such as food availability.

When the spawning stock size is small, relatively few eggs are spawned and the density-dependent competition plays a relatively small role. With low stock levels, the number of smolts produced are proportionally dependent on the number of eggs that are spawned (left part of Figure 23). With increasing spawning stock size, the competition effect will gradually become more important. Thus, with increasing egg density, the increase in smolt production slows towards an asymptote (middle part of Figure 23). At high egg density levels, the river reaches its smolt production potential (right part of Figure 23).

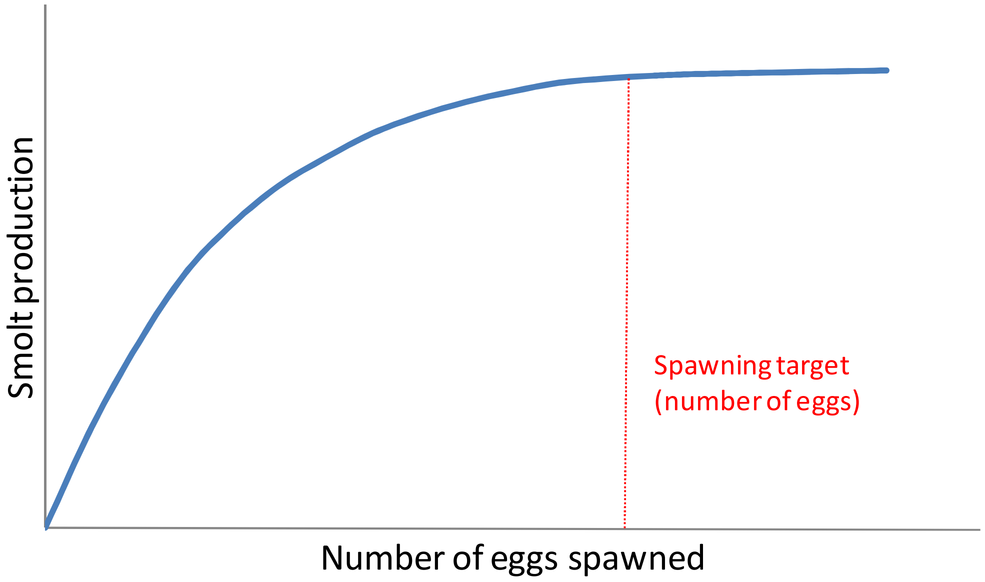


Figure 23. Simplified theoretical relationship between number of eggs spawned and number of smolts produced for a salmon stock.

The production potential varies greatly within different parts of the Tana River system. In some areas of the system, the habitat is predominantly of a good quality with lots of hiding places and rich food availability, and consequently the fish production potential is high. Other areas have predominantly poor habitat quality, with few hiding places available for juveniles and lower food availability, and consequently the fish production potential is low. Habitat factors such as water velocity, substratum composition and presence of other competitors (such as trout) are also affecting the production capacity.

Density-independent factors are not depending on fish density and occur more randomly. The occurrence of factors such as floods, drought, temperature and predation will result in fish dying. But the occurrence and intensity of these factors can vary greatly from year to year. In some years, the water level and temperature are favourable, resulting in high growth rates and low mortality. Under such conditions, juveniles might even smoltify and migrate to sea a year earlier than average. This will give a boost to the river smolt production, both because the river mortality is reduced by one year and because the remaining juveniles get better conditions because fish density is reduced. Other years can have extreme environmental conditions, e.g. severe droughts or rough spring floods with difficult ice conditions, which will be associated with a high mortality level for juvenile salmon and, accordingly, lowered smolt production.

Random spatial and temporal variation in environmental factors will lead to considerable fluctuations in production and observations both within and between areas of the river system. However, based on long time-series of stock-recruitment data between recruitment (number of eggs or number of spawning females) and production (number of smolts produced), it is possible to estimate the minimum number of spawning females that is needed to ensure that the resulting smolt production is at or near the production capacity of the river. In practice, a small buffer should be added to this minimum number, as a compensating insurance for random events that might cause increased mortality.

First-generation spawning targets have recently been established for the Tana river system (Table 2; Falkegård *et al*., 2014), based on the general methodology used in Norway (Hindar *et al*. 2007). The spawning targets are summarized in Table 2 with estimates both for different tributaries, main stem and the whole Tana river system.

Table 2. Spawning targets for the Tana river system (Falkegård *et al*., 2014).

River	*Revised target (eggs)*	*Female biomass w/fixed fecundity (1 800 eggs kg^{-1})*	*Female biomass w/stock-specific fecundity*	*Number of females w/stock-specific fec.*
Tana/Teno main stem	41 049 886	22 805	22 189	3 170
Máskejohka	3 155 148	1 753	1 521	380
Luovtejohka	-	-	-	-
Buolbmátjohka/Pulmankijoki	1 329 133	738	511	256
Lákšjohka	2 969 946	1 650	1 165	582
Veahčajohka/Vetsijoki	2 505 400	1 392	1 101	367
Ohcejohka/Utsjoki	4 979 107	2 766	2 059	938
Goahppelašjohka/Kuoppilasjoki	695 950	387	273	161
Borsejohka	0	0	0	0
Leavvajohka	499 203	277	208	77
Nuvvosjohka/Nuvvusjoki	0	0	0	0
Báišjohka	948 688	527	395	158
Njiljohka/Nilijoki	519 520	289	221	88
Váljohka	1 907 595	1 060	779	259
Áhkojohka/Akujoki	282 532	157	126	63
Lower Kárášjohka	2 013 178	1 118	1 046	174
Upper Kárášjohka	10 037 498	5 576	5 214	869
Geaimmejohka	250 824	139	105	42
Bávttajohka	1 735 823	964	926	154
Iešjohka	11 536 009	6 408	6 072	1 012
Anárjohka/Inarijoki	11 283 952	6 269	5 071	1 268
Garegasjohka/Karigasjoki	598 000	332	239	120
Iškorasjohka	213 000	118	99	33
Goššjohka	5 206 840	2 892	2 340	780
Skiehččanjohka/Kietsimäjoki	398 160	221	187	47
Tana/Teno (total)	104 274 286	57 838	51 846	10 998

A central point of the NASCO Precautionary Approach is that the management should, as far as possible, be stock-specific. This is a major challenge in the Tana River system with its high number of different stocks, for example due to the lack of data on the spatial boundaries of different stocks. Most of the spawning targets in Table 2 are tributary-specific and represent the closest approximation we currently have to a stock-specific evaluation. There is a need to focus on conservation of each discrete stock, as exchange of individuals among populations appears to be low, at least in the short term, so neighbouring populations do not easily compensate for local shortfalls in production elsewhere (Youngson *et al*. 2003). The main problem here is, of course, that current resource limitations make it impossible to obtain total coverage for assessments of any refinement on any geographical scale within the system, and in practice, compromise approaches have to be taken. Such compromises will however involve using inter-population numbers, and will probably not be able to catch population specific factors.

5.3 A PROCEDURE FOR TARGET-BASED STOCK EVALUATION

5.3.1 ESTIMATING TARGET ATTAINMENT

The introduction of spawning targets completely changes the management focus, turning it away from a question about how many fish are caught into a question about having a sufficient number of salmon survive to spawn. Obtaining an estimate of the spawning stock size (in terms of number of spawning females) and compare this to the spawning target accordingly becomes the main priority.

There are three alternative ways of estimating the spawning stock size of a stock:

1) **Direct counting of spawners**, e.g. through snorkelling. This approach is most useful in small tributaries of the Tana River system (Orell & Erkinaro 2007) where it has been shown to be fairly accurate, especially under good conditions with an experienced diving crew (Orell *et al.* 2011).
2) **Combine fish counting and catch statistics**. A count of ascending salmon, either through video (Orell *et al.* 2007) or acoustics (DIDSON/ARIS/Simsonar), will, when combined with catch statistics, provide an estimate of spawning stock size.
3) **Combine estimates of exploitation rate and catch statistics**. For most stocks we lack both spawner counts and fish counts. In these cases, it is necessary to rely directly on the catch statistic and use an estimate of the exploitation rate to calculate the spawning stock size. Because the exploitation rate has to be estimated, it is necessary to have access to monitoring data from comparable rivers in the area where the exploitation rate have been calculated (either through counting of spawners or through counting of ascending salmon).

Common for all three approaches is the use of simulation and probability distributions in all calculations. This includes both the spawning targets themselves and the exploitation rate estimate. The spawning targets are provided as single numbers in Table 2. These are the numbers that we believe the target most likely is. However, we also need a measure of uncertainty, and for that we use triangular probability distributions. A triangular probability distribution is a useful tool whenever precise knowledge about a factor is missing, but you have enough knowledge to state what the most likely level of a factor might be and also what the upper and lower bounds of the factor might be. So, for a spawning target of 2 eggs m^{-2}, the triangular distribution is defined with a modal value of 2, a lower egg density of 1.5 eggs m^{-2} and an upper egg density of 3 eggs m^{-2} (Figure 24).

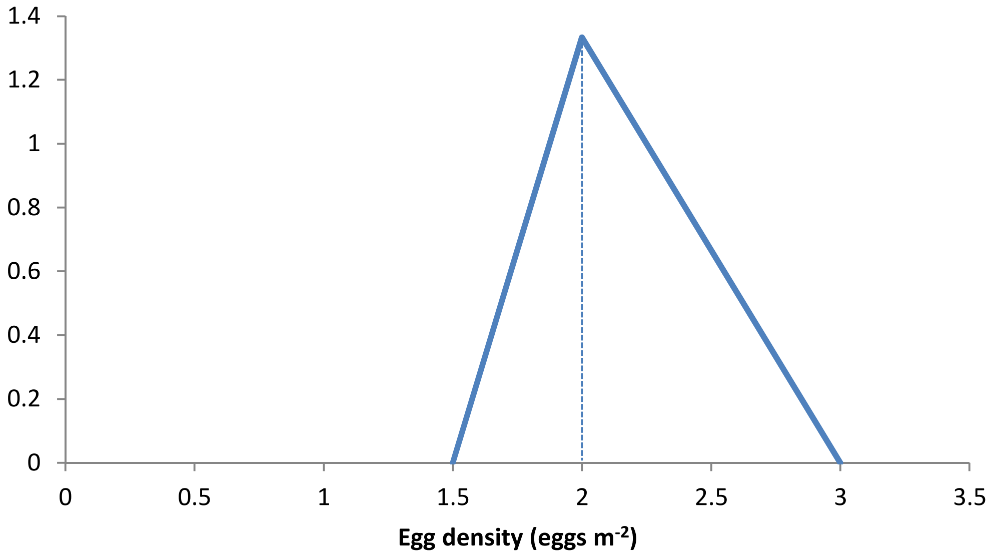


Figure 24. Triangular probability distribution for a spawning target based on the 2 eggs m^{-2} category.

5.3.2 MANAGEMENT TARGET DEFINITION

According to NASCOs Precautionary Approach, managers should define two stock-specific reference points that can be used to benchmark stock status in different river systems. The first of these points is the conservation limit, i.e. the minimum number of spawners required to maintain maximum sustainable yield. In Tana, we have defined these as the spawning targets.

The second reference point that must be defined is the management target. When looking at the concept of management target, i.e. the target that the management steers towards in Tana, we have to acknowledge that we will have to manage the stocks through two distinct periods. First, most stocks in Tana will have to go through a stock recovery period, followed by a stable sustainable period. From a management perspective, these two periods have differing management target priorities and the management target definitions must differ accordingly.

5.3.2.1 MANAGEMENT TARGET DEFINITION FOR THE STOCK-REBUILDING PERIOD

An important part of the stock rebuilding period is to define a recovery trajectory. The shape of this trajectory depends on the change in exploitation rate experienced by a stock, and it is this stock recovery exploitation rate that effectively becomes the target during the stock recovery period. Accordingly, we define the stock recovery management target as:

The estimated stock-specific total exploitation rate derived from the stock recovery trajectory.

The stock recovery trajectories are constructed based on certain levels of reduction in the exploitation rate experienced by the different stocks. These new exploitation rates then become the management targets that are used during the stock recoveries. Exploitation advice for stocks currently under recovery should then be based on a comparison of experienced exploitation rate and the exploitation rate defined by the recovery plan.

Please note, however, that no recovery plans have been implemented in Tana yet and we therefore base status evaluations in this report on the management target definition given below.

5.3.2.2 MANAGEMENT TARGET DEFINITION FOR LONG-TERM SUSTAINABILITY

The role of the management target in the long-term sustainable period following the stock-rebuilding period will be to ensure that stocks are kept above the conservation limit. This management target thus should represent the stock level that ensures long-term viability of the stock, and can be defined as follows:

The average probability that a stock has reached its spawning target must exceed 75 % over the last 4 years.

This definition is essentially saying that we need to be at least 75 % certain that the spawning target actually is exceeded by the actual spawning stock size. The same definition is used by the Scientific Advisory Committee for Atlantic Salmon Management in Norway in its evaluation of all Norwegian salmon stocks. Extended failure to meet the management target should directly lead to the implementation of a stock recovery plan.

As exemplified in Figure 24, the spawning target is based on a probability distribution that is defined by what we think is the most likely value for the target, and what we believe are the minimum and maximum level that a target in a particular river can be. Figure 25 provides an example of this, using numbers from the total Tana evaluation, with the target converted from egg density into female biomass. For Tana in total, we believe it is most likely that the total spawning target is 52 491 kg, with a lower limit of 38 766 kg and an upper limit of 78 343 kg (blue-coloured triangle).

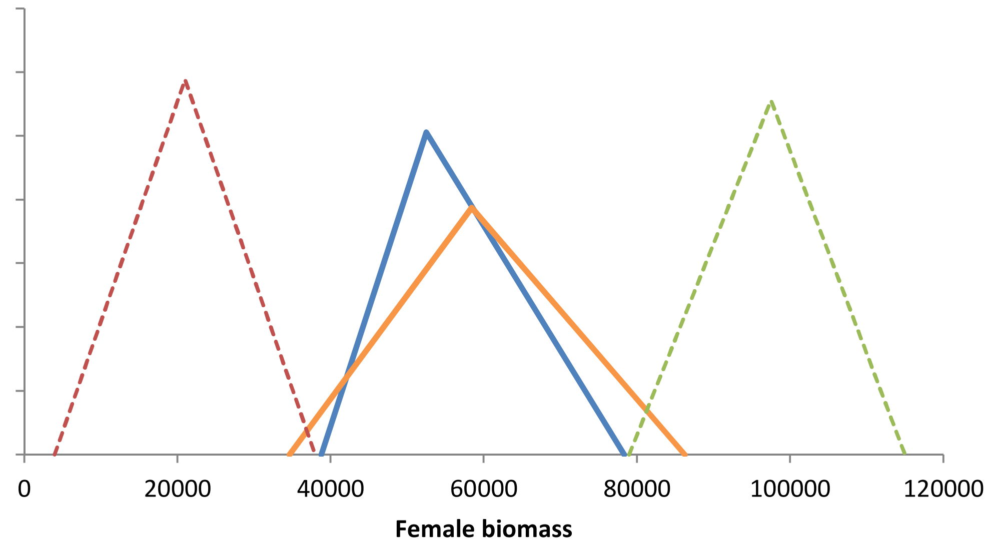


Figure 25. The triangular probability distribution describing the Tana (total) spawning target (blue line) and the triangular probability distributions of three exemplified spawning stock sizes: (1) an estimate completely below the target, representing a 0 % probability that the target was reached (red dotted line), (2) an estimate completely above the target, representing a 100 % probability that the target was reached (green dotted line), and (3) an estimate located within the target distribution (orange line), representing in this example a 57 % chance that the target was reached.

We also rely on probability distributions when estimating the spawning stock size, e.g. by estimating the exploitation rate with a central, most likely value together with lower and upper limits. Some possible spawning stock estimates are shown, together with the spawning target, in Figure 25. So, given these estimates for the target and the spawning stock, how certain can we be that the target actually was reached in this particular example? It is obvious from Figure 25 that there are some spawning stock distributions where we can be 100 % sure, either that the spawning stock was below all possible values of the spawning target (0 %

probability, dotted red line in Figure 25) or that the spawning stock was above all possible values of the spawning target (100 % probability, dotted green line in Figure 25).

The most complex situation happens when we have overlap between the spawning stock estimate and the spawning target, as exemplified in Figure 25 with the orange line. There are some parts of the orange line that is completely below the spawning target distribution. If these spawning stock sizes were true, then the target was definitely not reached. Likewise, there are spawning stock values above the upper limit of the target. If these were true, then the spawning target was definitely reached.

For all spawning stock values located within the range of the spawning target, there is a possibility that the target exceed the spawning stock. For instance, a spawning stock of 60 000 kg in Figure 25 would have over 20 000 kg of spawning target on the downside, and close to 20 000 kg of spawning target on the upside. The entire range of potential spawning targets on the upside in this case represents a possibility that the target was not reached. This is the reason we cannot simply look at the target attainment values. We need a measure of how likely it is that the target actually was reached, given the uncertainty we have about estimating the spawning target and the spawning stock.

In the example with the orange line in Figure 25, the probability that the target was reached was 57 %. This particular value is below the average value specified in the management target, signifying that the spawning stock in this particular year was not big enough for us to have enough confidence that the spawning target actually was reached.

There are ways of increasing the probability that the spawning target was reached. The most obvious way, of course, is to decrease the exploitation and thereby increase the spawning stock size.

Another possibility is to decrease the uncertainty of spawning stock and target estimates through monitoring and research. An example of the effect of a lack of knowledge is the wide uncertainty ranges used for the exploitation rate estimates in areas without fish counting. This uncertainty becomes much smaller with the implementation of fish counting, e.g. illustrated by comparing the solid red line with the dotted red line in Figure 26. The dotted line is the spawning stock estimate from Figure 25, while the solid red line shows the resulting spawning stock distribution when better monitoring data are available. The resulting probability of reaching the spawning target becomes 64 %.

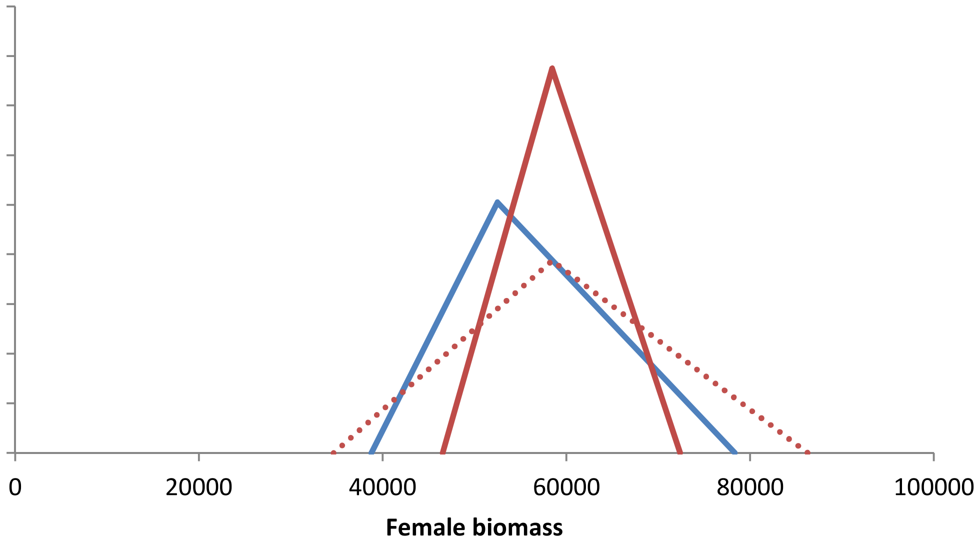


Figure 26. The triangular probability distribution describing the Tana (total) spawning target (blue line) and the triangular probability distribution describing the exemplified spawning stock from Figure 25 (dotted red line). The solid red line indicates the possible shape of the estimated spawning stock distribution if better monitoring data had been available.

5.3.3 PRE-FISHERY ABUNDANCE AND CATCH ALLOCATION

The estimation of spawning stock size and exploitation rates can further be used to evaluate the relative efficiency of different fisheries exploiting a salmon stock and estimate pre-fishery abundance.

During their spawning migration from open ocean feeding areas towards their natal areas in the Tana river system, Tana salmon experience extensive exploitation in a sequence of areas. The first area of the sequence is the outer coast of northern Norway. The second area is the Tana fjord, while the third area of exploitation is the Tana main stem. Finally, salmon are further exploited in their respective home tributaries.

The fishery in each area is defined by its own set of regulations, and accordingly the fishery in each area is characterized by its own exploitation rate. Due to stock differences in run timing and size composition, the vulnerability of each stock to exploitation in an area will differ, and this is one important factor to keep in mind when designing research and monitoring studies.

Most of the exploitation on different stocks in Tana takes place in areas with mixed-stock fisheries. This is the case along the coast, in the Tana fjord and the Tana main stem, leaving only the tributaries themselves as areas of single-stock fisheries. A mixed-stock fishery represents a major impediment when the exploitation rate on different stocks is to be evaluated, as the level of exploitation on each stock participating in a mixed-stock fishery is not apparent without specific knowledge gained e.g. through genetic stock identification of catch samples or some large-scale tagging program.

Tagging studies (a total of 29 000 salmon tagged on 23 tagging stations distributed north to south on the coast of Norway in the period 1935-1982) have shown that the salmon caught in the coastal fisheries belong to a large number of stocks covering a substantial area. The recaptures from this study allow for the construction of a distribution key for the coastal catch statistics (Anon. 2011b). Further refinement of the key comes from a recent project (EU Kolarctic ENPI CBC KO197) that stock identified a large number of salmon caught along the coast of northern Norway in 2011 and 2012. The resulting key can be used to estimate the exploitation of Tana salmon in different regions along the North Norwegian coastline.

The management of Norwegian coastal fisheries is separated into different regions (Figure 27). The regions can be classified as either outer coastal regions or fjord regions. The most extensive mixed-stock fishery occurs in the outer coastal regions, where tagging studies have demonstrated that salmon from several fjord regions are exploited. Comparatively, fjord fisheries exploit mostly stocks belonging to rivers in the fjords themselves.

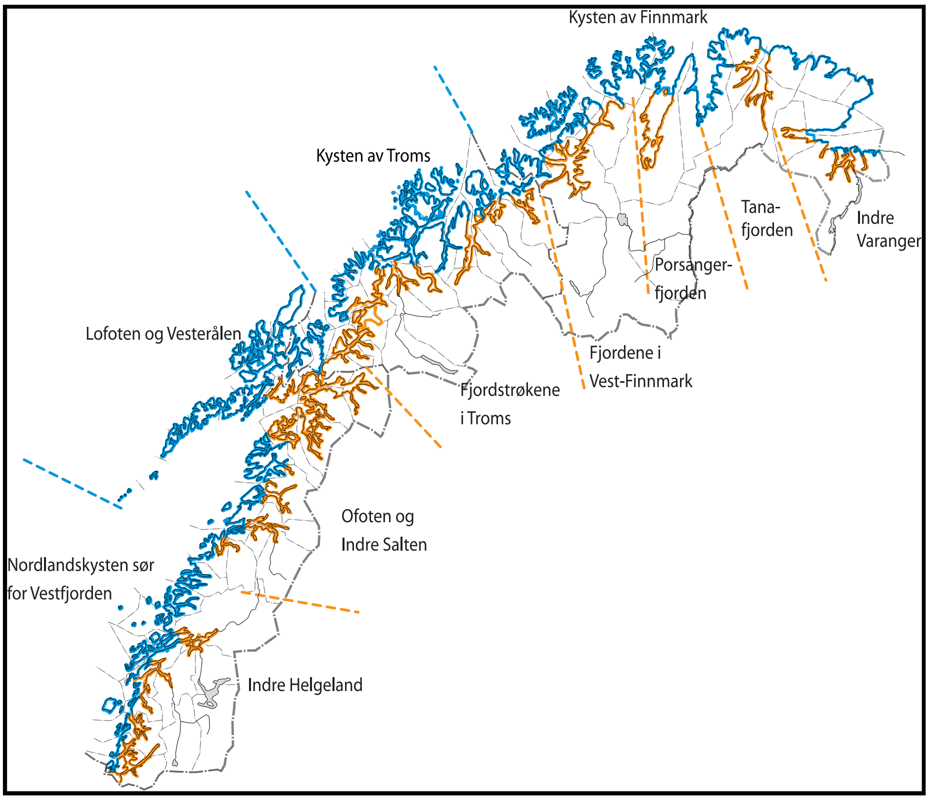


Figure 27. Management regions defined in the salmon management for northern Norway. The outer coastal regions are coloured blue, while the inner fjord regions are orange.

Steps for estimating the Tana catch from the coastal catch statistics:

1) Using the distribution key, 10 % of the catch from the outer coastal area of Troms and 33 % of the outer coastal catch of Finnmark is estimated to belong to the Tana fjord region. The redistributed catch from the outer coastal regions are added to the reported catch in the Tana fjord.
2) There are two salmon rivers in the Tana fjord: Tana and Laggo. The estimated total catch from the Tana fjord is separated into either Tana or Laggo based on the relative abundance of salmon in the two rivers (estimated from the river catch) and each rivers size composition (fish larger than 1.5 kg are positively selected in the coastal fisheries). The resulting number represents the total fishing mortality of Tana salmon in the coastal fisheries.
3) The estimated total coastal catch of Tana salmon is further separated into different Tana stocks (Figure 3) based on the relative abundance and size composition of each stock (inferred from the main stem catch, see below).

Through the GenMix project, genetic stock identification has been done on a large number of salmon caught in the Tana main stem from the years 2006-2008 and 2011-2012. Using the stock-identified data, an estimate can be made of the percentage contribution of each Tana stock in the total main stem catch. These percentages can then be used to estimate the total main stem catch of each stock.

After the mixed-stock fisheries catch have been distributed into different Tana stocks, it becomes possible to estimate the total exploitation, overexploitation, and maximum sustainable exploitation for each stock.

5.4 OVEREXPLOITATION

Human exploitation has for a long time now been the most important cause of mortality for adult salmon during their spawning migration. Historically, an increasing number of examples have shown us that it is possible to draw too heavily on salmon stocks through exploitation. However, history also teaches us that it is possible to have a sustainable and at the same time extensive fishery for salmon. The only caution in this comes from the problems that potentially can arise from fisheries induced evolution; a topic that should receive more attention in Tana.

Exploitation is, simultaneously, both a management target and an impact factor for the salmon stocks. The management should aim for stocks that fulfil their production potential, a situation that provides the best possible foundation for a rich fishery that favours local communities, rights holders and visiting anglers. Through the salmon fishery, fish are removed that would otherwise be a part of the spawning stock. It is inherently assumed here that this removal should be sustainable, i.e. that the fishing takes place on a stock surplus. This means that a stock exploitation evaluation should depend heavily on estimates of management target attainment, as management targets (such as the spawning targets that have been developed for some Tana tributaries) defines a lower acceptable limit for stocks. From this, it follows that a full-recruited stock is *overexploited* when fishing reduces the stock below the target (Figure 28).

Overexploitation can therefore be defined as **the extent of a reduction in spawning stock below the target that can be attributed to exploitation**. In a situation when the pre-fishery abundance of a stock is smaller than the spawning target (i.e. no exploitable surplus exists), the percentage overexploitation can be calculated as:

$$\frac{catch}{spawning\ target} \times 100$$

When the pre-fishery abundance is higher than the spawning target, the overexploitation is calculated as:

$$\frac{spawning\ target - spawning\ stock}{spawning\ target} \times 100$$

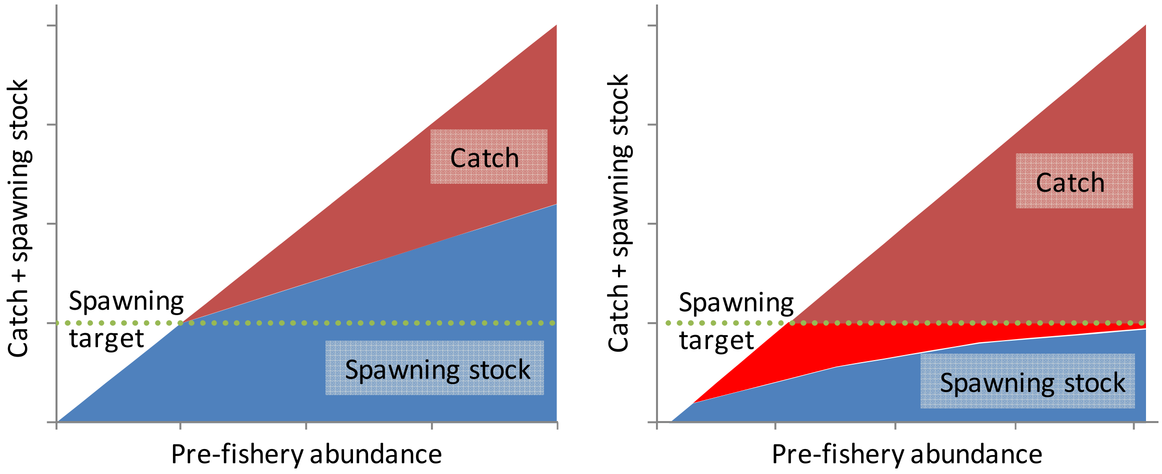


Figure 28. The left figure shows a situation *without* overexploitation, as the spawning stock is not reduced below the spawning target because of exploitation. The right figure shows a situation *with* overexploitation, as the spawning stock is reduced by exploitation below the spawning target. The stipled green line represents the spawning target. The bright red part of the right figure (between the blue spawning stock and the dark red catch) depicts the part of the catch that represents overexploitation. Please observe that it is only the part of the catch that is between the spawning target and spawning stock that is characterized as overexploitation, the catch above the spawning target is not included. Figure from Anon. (2010).

A direct consequence of a reduction in spawning stock through overexploitation is reduced smolt production and, consequently, fewer returning adult salmon. There are, however, also other possible negative effects of overexploitation. Exploitation, by its nature, inevitably causes a significant proportion of the adult salmon to die before spawning, and this mortality leads to a high selection pressure that can cause genetic changes in the population (Hard *et al.* 2008). Changes can be seen in the salmon life history, for example reducing the proportion of large salmon, shifting the run timing towards later river entry, or change survival, growth and habitat use so that the production potential of the stock becomes reduced. These are examples of unwanted changes that can be difficult to reverse. We have very little knowledge about what level of exploitation can cause such evolutionary changes in salmon stocks, but simulations indicate that exploitation at the level of maximum sustainable yield (F_{msy}) has a low probability of causing evolutionary changes (Hutchings 2009).

In practical terms, sustainable yield is not a fixed quantity. This is a major challenge for salmon management, as stocks must be kept at a sustainable level despite uncertainties in how environmental factors affect salmon stocks at any given time. First of all, salmon survival, both freshwater and oceanic, is very variable both in space and time, making it inherently difficult to estimate run size before the fishing season. Making management decisions therefore becomes difficult. Secondly, there is uncertainty in how different environmental conditions affect salmon survival, and this uncertainty becomes increasingly difficult to cope with as the climate itself appears to be changing. Thirdly, there is substantial uncertainty about the relationships between management actions, exploitation efficiencies and the resulting spawning stock sizes.

The exploitable surplus will, therefore, vary both with the size of previous spawning stocks (relative to the spawning target) and within the limits set by other influencing factors both in the river and at sea. Environmental factors in the river and size of the spawning stock ultimately decide the smolt production, which, together with sea survival, decides the pre-fishery abundance of adult salmon. The extent to which different stocks can be exploited will therefore have to be calculated individually from stock to stock and year to year, depending on the characteristics of each stock and the available knowledge of environmental factors in river and at sea.

A very simplified model can give a hint about which exploitation levels, given different levels of sea survival and smolt production, a salmon stock can sustain before it falls below its spawning target (Figure 29). A basic premise of the model is the relationship between smolt production and spawning stock from the spawning target model of Hindar *et al.* (2007). With sea survival at a medium level (5 %), a total exploitation of over 50 % can be sustained even if smolt production is somewhat reduced (>75 %). At higher sea survival (>10 %), a total exploitation of up to 80-90 % can be sustained. The maximum sustainable exploitation rapidly declines with both low sea survival and low smolt production (a situation that equals poor target attainment).

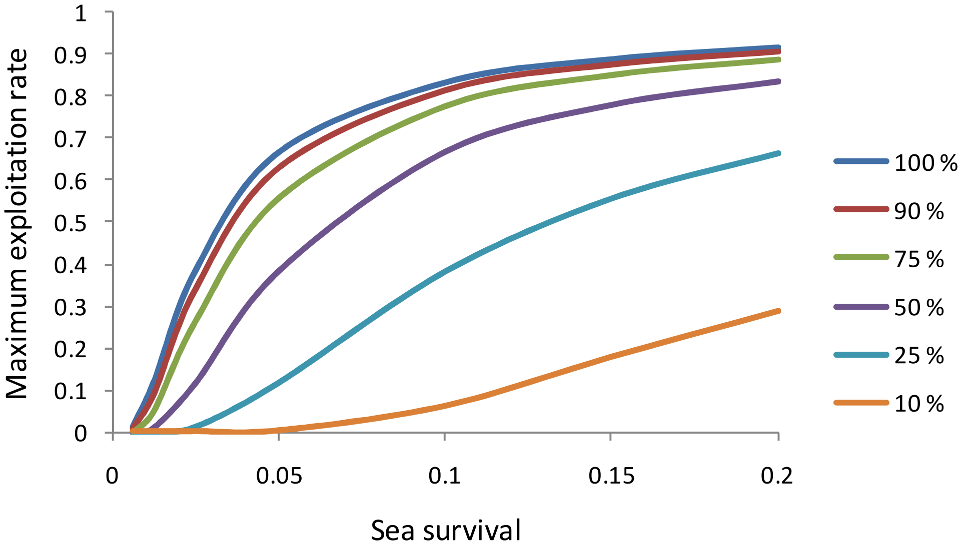


Figure 29. Maximum sustainable exploitation rate in a river under different levels of sea survival and six different smolt production scenarios (from 10 to 100 % of the river capacity). Maximum exploitation is the rate at which the resulting spawning stock falls below the spawning target. The different lines (10-100 % smolt production) corresponds to reduced smolt production that can be caused by earlier spawning below the spawning target and/or impact factors that reduce juvenile/smolt survival. The model is based on the relationship between smolt production and spawning stock from Hindar *et al.* (2007). Figure from Anon. (2010).

The estimated maximum exploitation in Figure 29 is based on the stock recruitment (hockey stick model) and smolt production from the spawning target models of Hindar *et al.* (2007). The reproductive rate of a stock is at its maximum when the spawning stock gets close to zero, and this maximum rate can be described by the slope of a stock recruitment curve close to the starting point of the curve. A review of different stock recruitment curves indicate that this slope is relatively consistent among different fish species, with a slope of 3-5 commonly observed for salmon (Myers *et al.* 1999). In the absence of other affecting factors, a maximum reproductive rate of 3-5 translates to a maximum sustainable exploitation rate of 65-80 %, slightly lower than the estimates from Figure 29.

The estimated maximum exploitation rates are total exploitation of female salmon, accumulated for both coastal and river fisheries. Within Norway, estimates of total exploitation vary substantially from region to region. In southern Norway, the estimated total exploitation is around 50 %, in middle Norway around 40 % and in northern Norway 70-80 %. The observed level of exploitation in northern Norway is very close to the modelled maximum in a situation with good sea survival and little to no reduction in smolt production (Figure 29). The current management regime therefore has very little buffer against changes in environmental conditions in northern areas (including Tana).

The model of maximum sustainable exploitation can be used to simulate the level of negative effects that exploitation can have on spawning target attainment (Figure 30). The maximum sustainable exploitation rate sinks rapidly both with low sea survival and reduced smolt production, illustrating the potential importance of other impact factors for fisheries interests. Noteworthy also in Figure 30 is that there is a very small difference between an exploitation rate that produces a large negative effect and exploitation with no effect, even in a situation with relatively high sea survival and good smolt production. This greatly underlines the importance of managing with a safety margin.

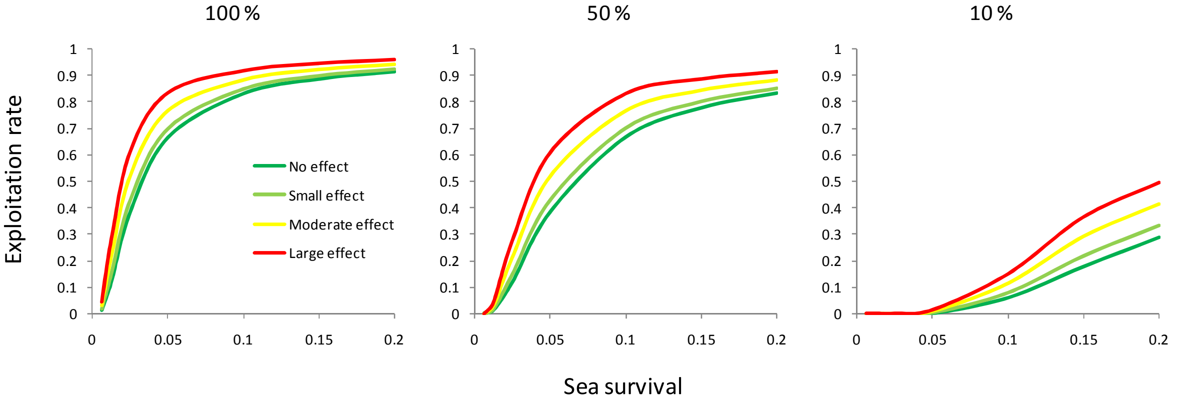


Figure 30. The exploitation rate that leads to no (spawning stock at or above spawning target), small (spawning stock >90 % of target), moderate (70-90 %) or large (<70 %) negative effects on spawning target attainment at different levels of sea survival and smolt production. Three different scenarios for smolt production: 100 % (left), 50 % (middle) and 10 % (right). Reduced smolt production can be caused by spawning stock below spawning target and/or impact factors that reduce juvenile/smolt survival. Figure from Anon. (2010).

Both Figure 29 and Figure 30 demonstrate how the maximum sustainable exploitation rate sinks rapidly with lowered sea survival. This is a vulnerable and difficult situation for the fisheries management, and points to the need for establishing accurate monitoring indicators that can provide early estimates of annual sea survival and can be used to trigger season-specific fisheries regulations in situations with a low pre-fishery abundance. Stocks inevitably become more vulnerable towards fisheries selection when impact factors create lowered survival (both in river and sea). The monitoring must, accordingly, be designed so that it intercepts important demographic factors and life history traits. Examples of important factors are fish size, migration timing, stock-specific exploitation rates, growth (size at age) and ability to reproduce (Kuparinen & Merilä 2007).

5.5 STOCK-SPECIFIC STATUS EVALUATION

The first generation spawning targets that were assigned in Tana covered only a limited subset of the Tana stocks (Hindar *et al*. 2007). There were methodological problems with some of these original spawning targets. The model used to estimate first generation spawning targets in Norwegian rivers assumes that a standardized GIS-based method has been used to calculate area. This assumption was violated for some parts of the system, namely the Tana main stem, Anárjohka, Utsjoki and the pooled "*Other tributaries*" (Hindar *et al*. 2007). This effectively meant that only six Norwegian tributaries, until recently, had a valid spawning target that could be used for the stock status evaluation presented in the previous status evaluation report from the Group. Of these six tributaries, one, Leavvajohka, had to be omitted from the status evaluation due to very few active fishermen and, consequently, low catch reports.

The first-generation targets in Tana were recently revised (Falkegård *et al*. 2014). However, time constraints have meant that we currently have been unable to extend the status evaluation to all stocks in the Tana river system. We have now, however, at least been able to extend the previous focus on only five Norwegian tributaries into a more comprehensive set covering both countries. The stock status in the present report is therefore evaluated for 11 areas; the five Norwegian tributaries from the earlier evaluations, three Finnish tributaries, the joint tributary Anárjohka/Inarijoki, Tana main stem, and the Tana system as a whole:

- Tana main stem
- Máskejohka (in the lower part of the Tana main stem)
- Lákšjohka (middle part)
- Veahčajohka/Vetsijoki (middle part)
- Ohcejohka/Utsjoki (middle part)
- Válljohka (upper part)

- Áhkojohka/Akujoki (upper part)
- Iešjohka (headwater)
- Kárášjohka (headwater)
- Anárjohka/Inarijoki (headwater)
- Tana total (an evaluation covering all Tana stocks)

All evaluations are now based on a standardized probabilistic approach which, ultimately, provides us with a measure of how likely it is that the respective spawning targets have been reached. This aspect is a necessity to be able to evaluate the management target of the stocks.

Please observe that there are different exploitation estimates in the following text. The exploitation rate estimates used to simulate spawning target attainment are based on number of salmon in three different size groups (<3 kg, 3-7 kg and >7 kg), while the exploitation estimates used in the stock allocation of salmon from the coastal and Tana main stem mixed-stock fisheries are based on total weight. Exploitation estimates for Utsjoki are based on video counts of ascending adult salmon and the estimated catch. There is no fishing in Akujoki, and the spawning target attainment there is evaluated by direct spawner counts by snorkelling.

Note also that the status evaluation is presented with two alternative levels of fecundity. The spawning targets for Tana is defined in terms of number of eggs, and then a measure of relative fecundity (eggs kg^{-1}) is used to convert eggs into the female biomass needed to deposit the number of eggs specified by the target. In the original first-generation spawning targets for Tana, a fixed relative fecundity of 1 800 eggs kg^{-1} was used for all stocks (Hindar *et al*. 2007). However, fecundity data from Tana show significant sea-age dependent differences in egg number for Tana. For this reason, we constructed stock-specific fecundities for Tana, defined from the sea-age composition of females in each stock. The former fixed fecundity is included in the present report only to ease comparison with earlier status evaluations, while the latter stock-specific fecundities will be used in future evaluations and is the only fecundity used to construct recovery plans for the stocks.

5.5.1 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.

5.5.1.1 STATUS ASSESSMENT

The revised 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 805kg (17 104-34 208 kg) when using a fixed fecundity of 1 800 eggs kg^{-1}, and 22 189 kg (16 642-33 284 kg) when using a stock-specific fecundity of 1 850 eggs kg^{-1}.

There is no fish counting of salmon in the Tana main stem so target evaluation must be based on a combination of an estimated exploitation rate and catch statistics (see chapter 5.3.1). The following exploitation estimate was used throughout the period 2006-2014: **55 % (40 %-75 %)**.

The estimated catch of Tana MS salmon within the main stem varied from 28 193 kg in 2009 to 55 203 kg in 2008.

Based on a fixed fecundity level of 1 800 eggs kg^{-1}, percentage target attainment varied from 51 % (2009) to 99 % (2008) in the period 2006-2014 (Figure 31). The average attainment over the last four years was 83 %. The highest probability of reaching the spawning target was seen in 2008 (45 %), followed by 2012 (30 %), 2006 (26 %) and 2007 (26 %). The management target (last 4 year average probability of reaching the spawning target) was 25 %.

With a stock-specific fecundity level of 1 850 eggs kg^{-1}, target attainment reached 100 % in 2008, followed by 90 % in 2012, 87 % in 2006 and 86 % in 2007. The average attainment over the last four years was 85 %. The highest probability of reaching the spawning target was 48 % in 2008, and the management target (last 4 year average probability of reaching the spawning target) with the stock-specific fecundity was 28 %.

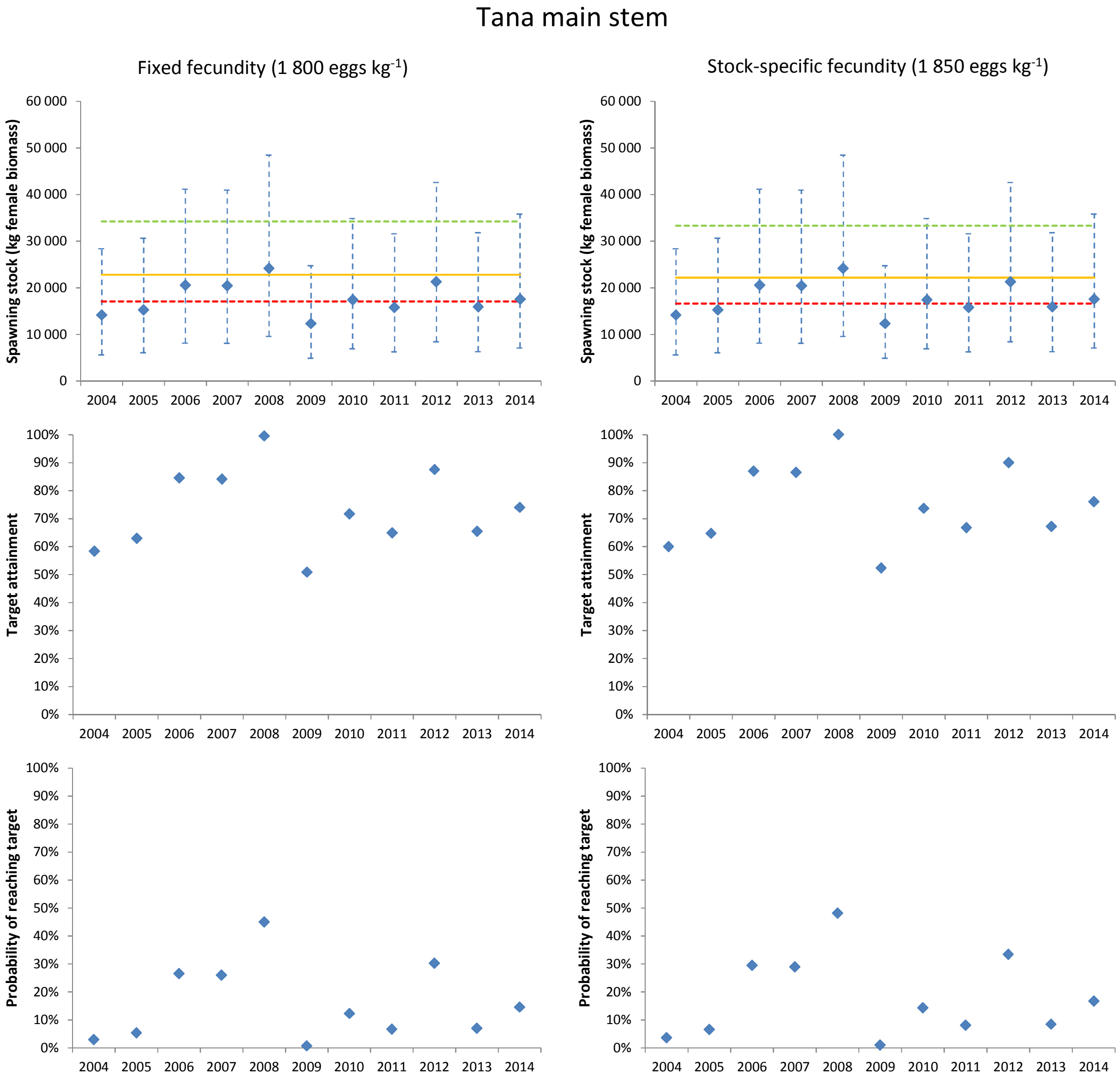


Figure 31. The estimated spawning stock (upper row), percent target attainment (middle row) and probability of reaching the target (bottom row) in the period 2006-2014 in the Tana main stem. The left column is based on a fixed fecundity of 1 800 eggs kg^{-1}, the right column is based on a stock-specific fecundity of 1 850 eggs kg^{-1}.

5.5.1.2 EXPLOITATION

The estimated total exploitation rate (based on weight) of Tana MS salmon was 63 % in the years 2006-2014 (Figure 32), with 16 % of the pre-fishery abundance caught in coastal fisheries and 47 % in main stem fisheries. The average estimated total pre-fishery abundance was 91 037 kg and the average total catch was 57 348 kg in the period 2006-2014.

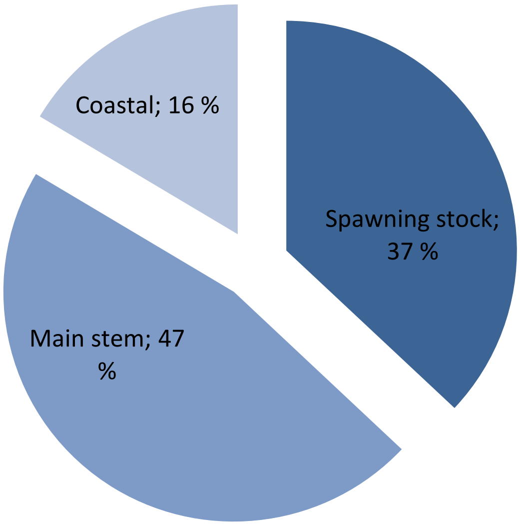


Figure 32. The total amount of salmon belonging to the Tana main stem stock in the years 2006-2014, distributed into surviving spawning stock and salmon caught in fisheries in either coastal or main stem fisheries. The percentages in the figure represent the proportion of the pre-fishery abundance that survives to spawning or are caught in coastal or main stem fisheries.

The estimated relative exploitation efficiencies (based on weight) in areas in the period 2006-2014 were:

- Coastal: 16 %
- Tana main stem: 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 divided by the estimated amount of salmon that have survived the coastal fisheries.

The average overexploitation was estimated at 22 %. This means that exploitation was responsible for reducing the spawning stock size by an amount of 22 % below the spawning target. The average maximum sustainable total exploitation rate in the period was 50 %.

5.5.1.3 STOCK RECOVERY

In the years 2006-2014, the average probability that the spawning target was reached in the Tana main stem was 32 %. A significant reduction in the total exploitation rate is therefore needed to improve status.

The average spawning stock size in the period 2006-2014 was 18 333 kg (7 296-36 884 kg). With the current exploitation estimates, we would need a spawning stock of approximately 26 500 kg to reach a 75 % probability of meeting the spawning target and over 45 000 kg to reach 100 % probability. In the years 2006-2014, we have, therefore, on average lacked a female biomass of approximately 8 000 kg in order to reach the 75 % probability level specified by the management target.

With a 20 % or a 30 % reduction in river exploitation, we would achieve 75 % probability of reaching the spawning target after 1 generation (7 years, Figure 33). With a 50 % reduction, we would achieve 75 % probability immediately.

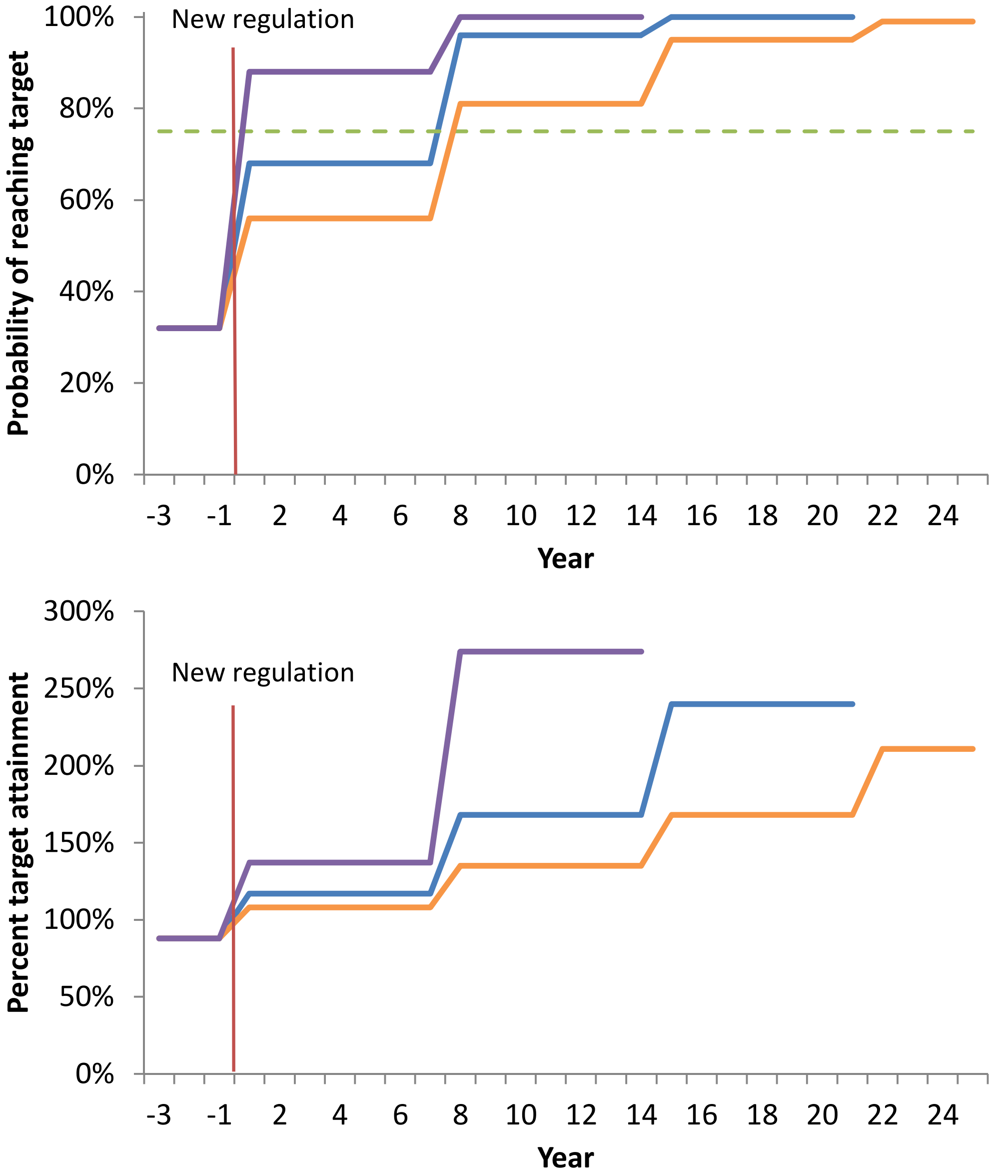


Figure 33. Stock recovery trajectories for Tana MS salmon, corresponding to three scenarios of reduced exploitation in the Tana main stem. (Orange) A 20 % reduction, (Blue) a 30 % reduction, and (Purple) a 50 % reduction. Upper panel depicts the development in probability of reaching the spawning target, bottom panel the development in percentage target attainment. The green dotted line represents the 75 % probability line.

5.5.2 MÁSKEJOHKA

Máskejohka is the lowermost major tributary in the Tana River system, entering the Tana approximately 15 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 all of these smaller tributaries, salmon distribution is upwards limited by waterfalls. The Máskejohka salmon stock has a good mixture of sea-age groups, mostly 1-3SW and a few 4SW.

5.5.2.1 STATUS ASSESSMENT

The revised 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 1 753 kg (1 268-2 305 kg) when using a fixed fecundity of 1 800 eggs kg^{-1}, and 1 521 kg (1 100-2 000 kg) when using a stock-specific fecundity of 2 075 eggs kg^{-1}.

There is no fish counting in Máskejohka so target evaluation must be based on a combination of an estimated exploitation rate and catch statistics (see chapter 5.3.1). The following exploitation estimates were used throughout the period 2004-2014:

- Salmon <3 kg: 50 % (40-60 %)
- Salmon 3-7 kg: 40 % (30-60 %)
- Salmon >7 kg: 30 % (20-50 %)

These are fairly high exploitation estimates, reflecting a relatively high number of visiting fishermen during the fishing season.

The catch in Máskejohka varied between 412 kg (2004) and 2 320 kg (2010) in the period 2004-2014. There were some localization problems with the Norwegian Tana catches in 2004 and 2005. This might have caused some underestimation of the Máskejohka-catch in these two particular years.

Based on a fixed fecundity level of 1 800 eggs kg^{-1}, percentage target attainment varied from 15 % (2004) to 98 % (2008) in the period 2004-2014 (Figure 34). The average attainment over the last four years was 64 %. The highest probability of reaching the spawning target was seen in 2008 (43 %), followed by 2010 (19 %) and 2012 (10 %). The management target (last 4 year average probability of reaching the spawning target) was 2 %.

With a stock-specific fecundity level of 2 075 eggs kg^{-1}, target attainment reached 100 % in 2008 and was close in 2010 (97 %) and 2012 (90 %). The average attainment over the last four years was 74 %. The highest probability of reaching the spawning target was 68 % in 2008, and the management target (last 4 year average probability of reaching the spawning target) with the stock-specific fecundity was 10 %.

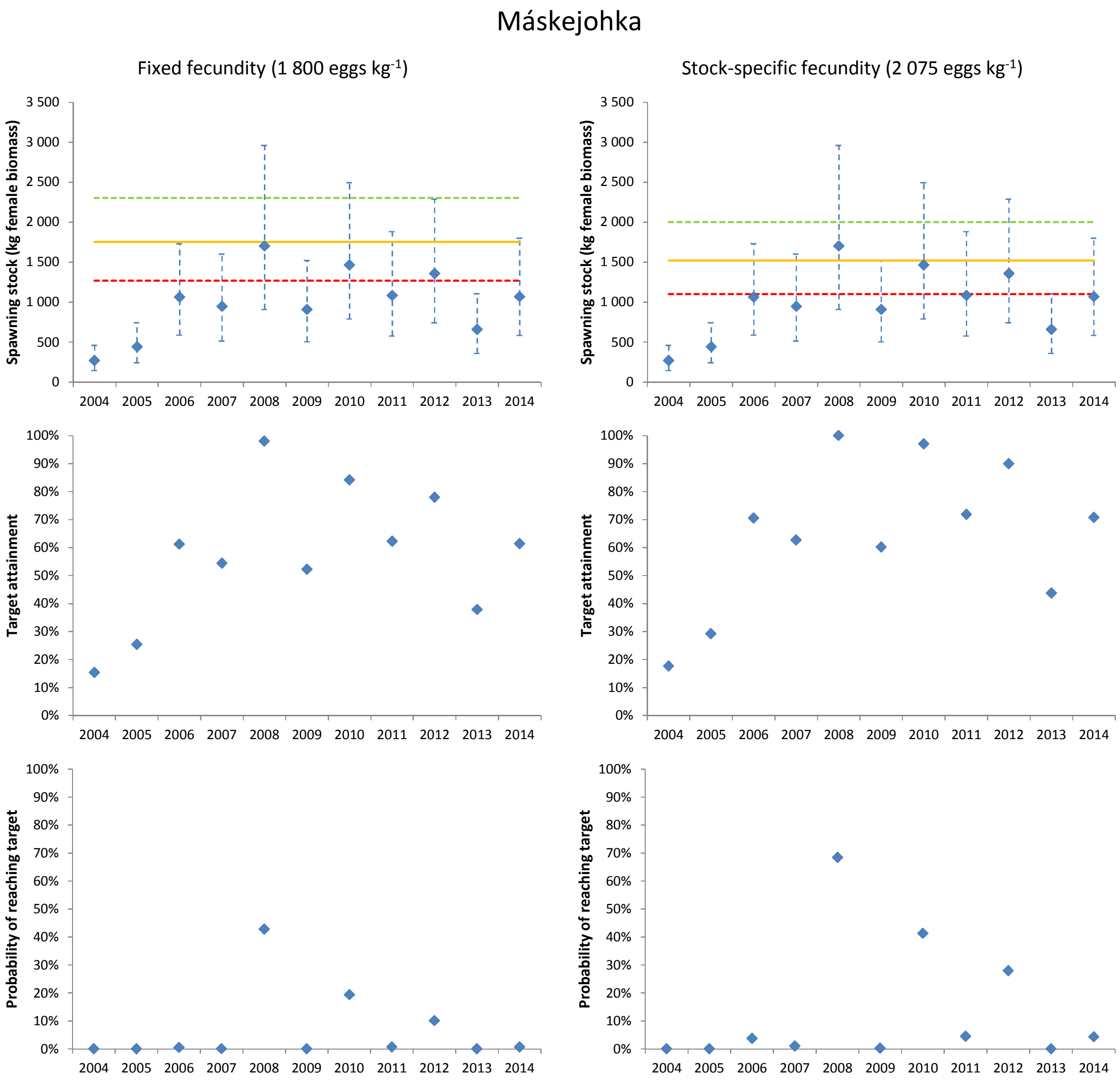


Figure 34. The estimated spawning stock (upper row), percent target attainment (middle row) and probability of reaching the target (bottom row) in the period 2004-2014 in the Norwegian tributary Máskejohka. The left column is based on a fixed fecundity of 1 800 eggs kg^{-1}, the right column is based on a stock-specific fecundity of 2 075 eggs kg^{-1}.

5.5.2.2 EXPLOITATION

The estimated total exploitation rate (based on weight) of Máskejohka salmon was 66 % in the years 2006-2014 (Figure 35), with 17 % of the pre-fishery abundance caught in coastal fisheries, 24 % in main stem fisheries and 26 % in Máskejohka itself . The average estimated total pre-fishery abundance was 6 142 kg and the average total catch was 4 263 kg in the period 2006-2014.

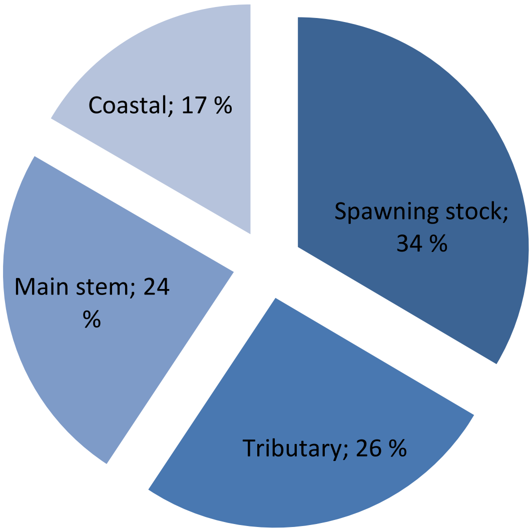


Figure 35. The total amount of salmon belonging to Máskejohka in 2006-2014, distributed into surviving spawning stock and salmon caught in fisheries in either coastal, main stem or within-tributary fisheries. The percentages in the figure represent the proportion of the pre-fishery abundance that survives to spawning or are caught in coastal, main stem or tributary fisheries.

Estimated relative exploitation efficiencies (based on weight) in areas in the period 2006-2014 were:

• Coastal:	17 %
• Tana main stem:	29 %
• Within Máskejohka:	43 %

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 divided by the estimated amount of salmon that have survived the coastal fisheries.

The average overexploitation was estimated at 30 %. This means that exploitation was responsible for reducing the spawning stock size by an amount of 30 % below the spawning target. The average maximum sustainable total exploitation rate in the period was 49 %.

5.5.2.3 STOCK RECOVERY

In the years 2006-2014, the average probability that the spawning target was reached in Máskejohka was 18 %. A significant reduction in the total exploitation rate is therefore needed to improve status in Máskejohka.

The average spawning stock size in the period 2006-2014 was 1 138 kg (618-1 931 kg). With the current exploitation estimates, we would need a spawning stock of approximately 1 800 kg to reach a 75 % probability of meeting the spawning target and approximately 2 400 kg to reach 100 % probability. In the years 2006-2014, we have, therefore, on average lacked a female biomass of approximately 650 kg in order to reach the 75 % probability level specified by the management target.

With a 20 % reduction in river exploitation, we would achieve 75 % probability of reaching the spawning target after 1 generation (7 years, Figure 36). With a 30 or 50 % reduction, we would achieve 75 % probability immediately.

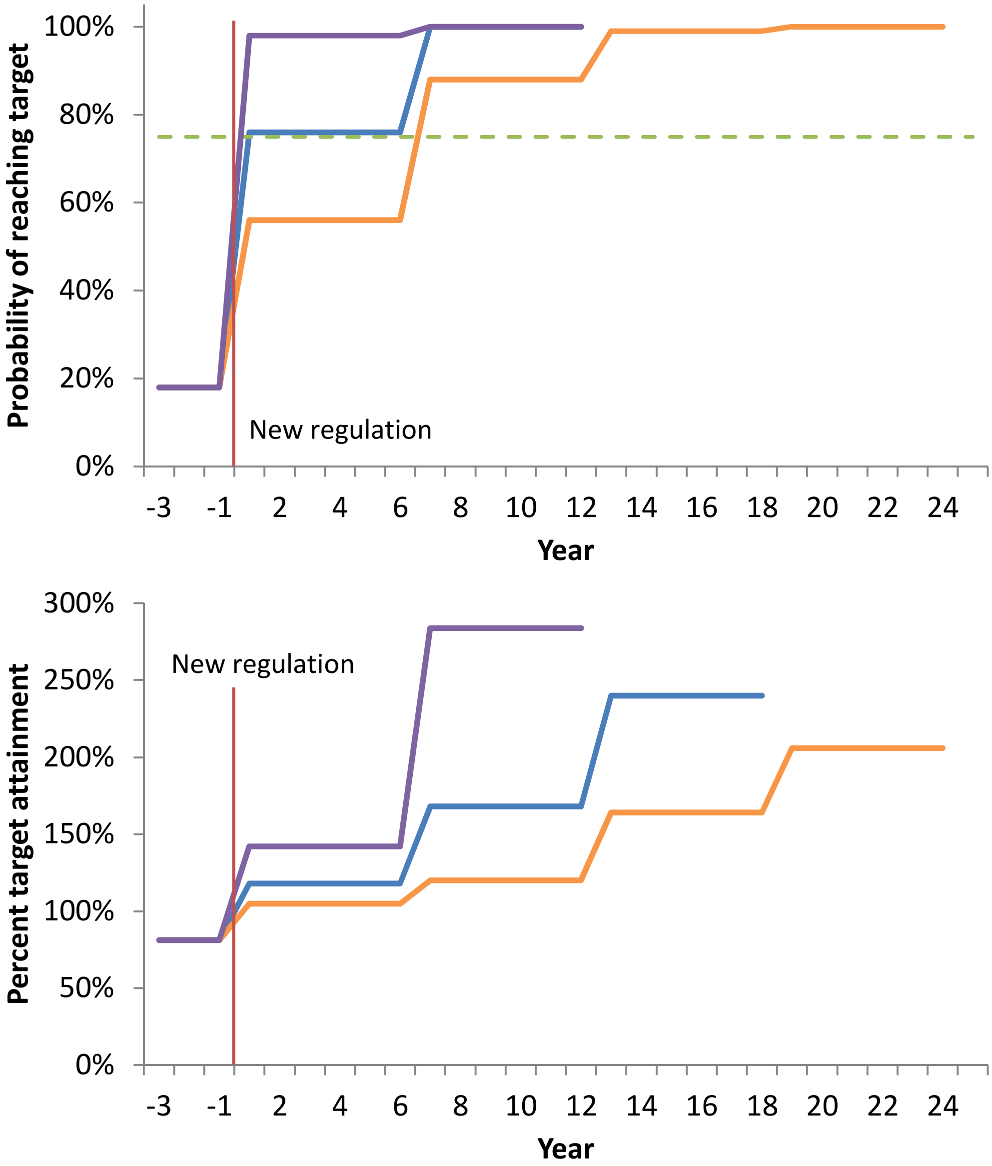


Figure 36. Stock recovery trajectories for Máskejohka, corresponding to three scenarios of reduced river exploitation (Tana main stem + Máskejohka). (Orange) A 20 % reduction, (Blue) a 30 % reduction, and (Purple) a 50 % reduction. Upper panel depicts the development in probability of reaching the spawning target, bottom panel the development in percentage target attainment. The green dotted line represents the 75 % probability line.

5.5.3 LÁKŠJOHKA

Lákšjohka is a small- to medium-sized tributary that enters the Tana just over 60 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 quickly 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.

5.5.3.1 STATUS ASSESSMENT

The catch in Lákšjohka varied from 152 kg (2004) to 700 kg (2006) in the period 2004-2013. In 2014, a total catch of 247 kg was reported, of which 148 kg was released alive and 99 kg killed. There were some localization problems with the Norwegian Tana catches in 2004 and 2005. This likely caused an underestimation of the Lákšjohka-catch in these two particular years.

Ascending salmon in Lákšjohka have been counted with video since 2009. These counts provide a good estimate of the annual exploitation rate in the river. Total exploitation 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. The high proportion of released salmon in 2014 translates to an exploitation rate of only 6 %. The reductions in exploitation level observed in the years 2012-2014 in Lákšjohka are a result of two factors, firstly, that the number of visiting fishermen has decreased substantially, and secondly, that the proportion of released salmon has increased, especially in 2014.

The revised 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 1 650 kg (1 224-2 475 kg) when using a fixed fecundity of 1 800 eggs kg^{-1}, and 1 165 kg (864-1 747 kg) when using a stock-specific fecundity of 2 550 eggs kg^{-1}.

Based on a fixed fecundity level of 1 800 eggs kg^{-1}, percentage target attainment varied from 12 % (2004) to 58 % (2006 and 2014) in the period 2004-2014 (Figure 37). The average attainment over the last four years was 39 %. The probability of reaching the spawning target was 0 % for all years, and, accordingly, the management target (last 4 year average probability of reaching the spawning target) was also 0 %.

When using a stock-specific fecundity level of 2 550 eggs kg^{-1}, the percentage target attainment varied from 18 % in 2004 to 82 % in 2006 and 2014. The average attainment over the last four years was 55 %. The probability of reaching the spawning target was 0 % for most years of the period 2004-2014. The exceptions were 2006 (16 %) and 2014 (10 %). The management target (last 4 year average probability of reaching the spawning target) was 0 %.

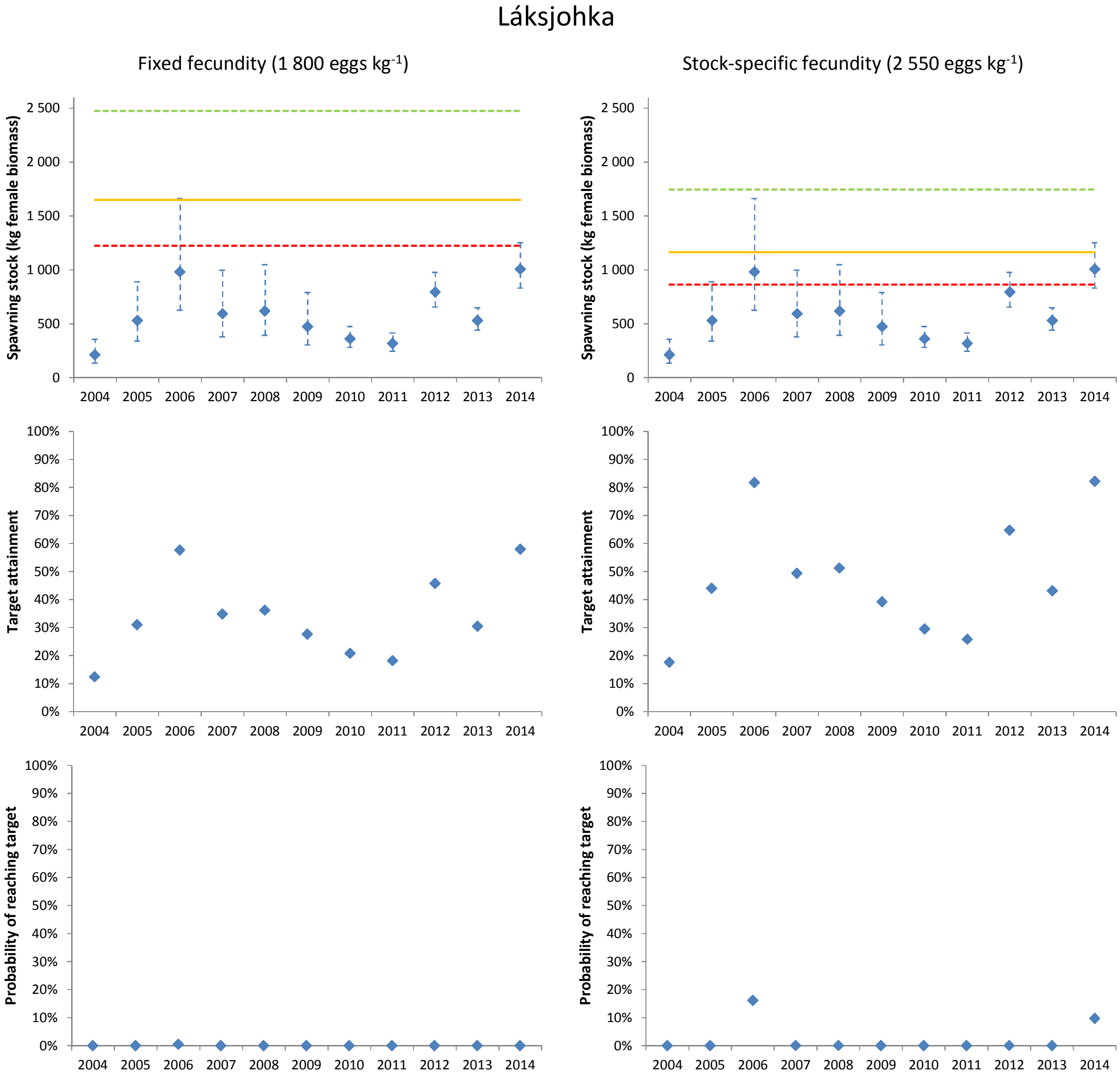


Figure 37. The estimated spawning stock (upper row), percent target attainment (middle row) and probability of reaching the target (bottom row) in the period 2004-2014 in the Norwegian tributary Lákšjohka. The left column is based on a fixed fecundity level of 1 800 eggs kg^{-1}, the right column is based on a stock-specific fecundity of 2 550 eggs kg^{-1}.

5.5.3.2 EXPLOITATION

The estimated total exploitation rate (based on weight) of Lákšjohka salmon was 61 % in the years 2006-2014 (Figure 38), with 11 % of the pre-fishery abundance caught in coastal fisheries, 37 % in main stem fisheries and 14 % in Lákšjohka itself. The average estimated total pre-fishery abundance was 2 477 kg and the average total catch was 1 516 kg in the period 2006-2014.

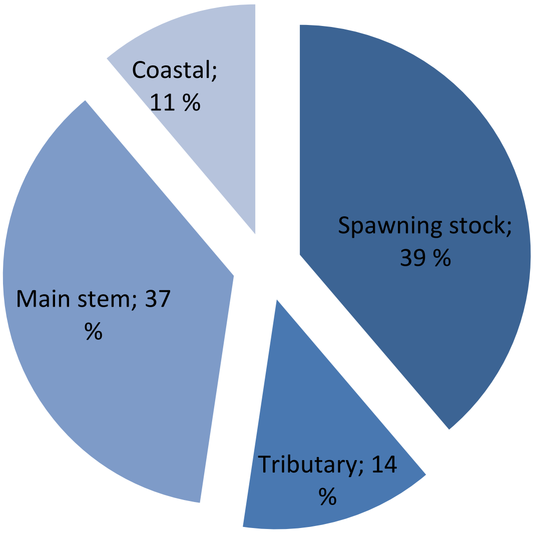


Figure 38. The total amount of salmon belonging to Lákšjohka in 2006-2014, distributed into surviving spawning stock and salmon caught in fisheries in either coastal, main stem or within-tributary fisheries. The percentages in the figure represent the proportion of the pre-fishery abundance that survives to spawning or are caught in coastal, main stem or tributary fisheries.

The estimated relative exploitation efficiencies (based on weight) in areas in the period 2006-2014 were:

Coastal:	11 %
Tana main stem:	41 %
Within Lákšjohka:	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 divided by the estimated amount of salmon that have survived the coastal fisheries.

The average overexploitation was estimated at 48 %. This means that exploitation was responsible for reducing the spawning stock size by an amount of 48 % below the spawning target. The average maximum sustainable total exploitation rate in the period was 19 %.

5.5.3.3 STOCK RECOVERY

In the years 2006-2014, the average probability that the spawning target was reached in Lákšjohka was 0 %. A significant reduction in the total exploitation rate is therefore needed to improve status in Lákšjohka.

The average spawning stock size in the period 2006-2014 was 631 kg (462-919 kg). With the current exploitation estimates, we would need a spawning stock of approximately 1 350 kg to reach a 75 % probability of meeting the spawning target and approximately 1 750 kg to reach 100 % probability. In the years 2006-2014, we have, therefore, on average lacked a female biomass of approximately 700 kg in order to reach the 75 % probability level specified by the management target.

With a 50 % reduction in river exploitation, we would achieve 75 % probability of reaching the spawning target after 1 generation (6 years, Figure 39). With a 30 % reduction, we would achieve 75 % probability after 2 generations (12 years). With a 20 % reduction, we would meet the management target by the end of the third generation (18 years).

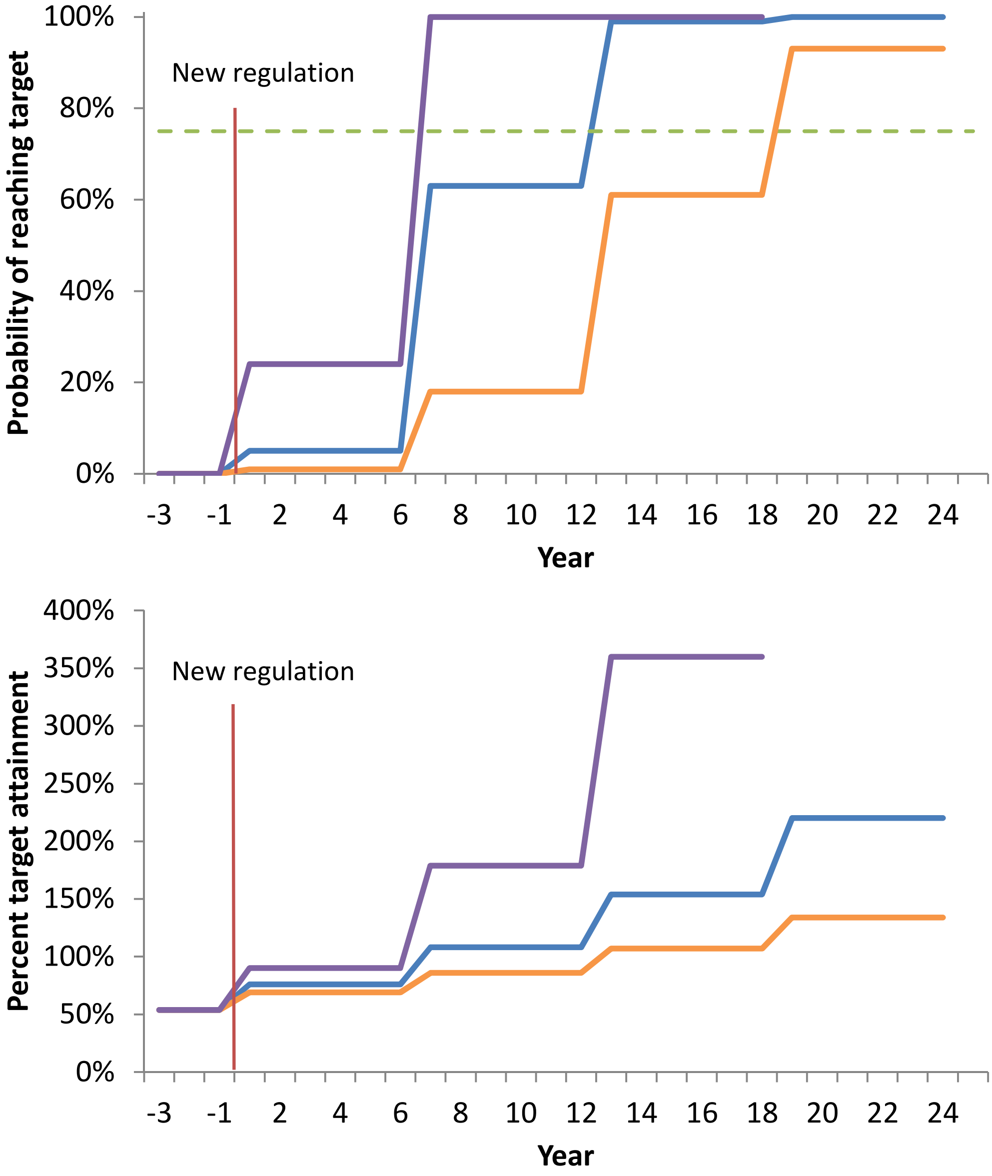


Figure 39. Stock recovery trajectories for Lákšjohka, corresponding to three scenarios of reduced river exploitation (Tana main stem + Lákšjohka). (Orange) A 20 % reduction, (Blue) a 30 % reduction, and (Purple) a 50 % reduction. Upper panel depicts the development in probability of reaching the spawning target, bottom panel the development in percentage target attainment. The green dotted line represents the 75 % probability line.

5.5.4 VEAHČAJOHKA/VETSIJOKI

Vetsijoki is a middle-sized river flowing into the Tana main stem approximately 92 km from the Tana estuary. It is one of the most important salmon tributaries flowing to the Tana from the Finnish side, with a significant 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.

5.5.4.1 STATUS ASSESSMENT

The catch in Vetsijoki varied from 200 kg (2004) to 1 885 kg (2001) in the period 1998-2014.

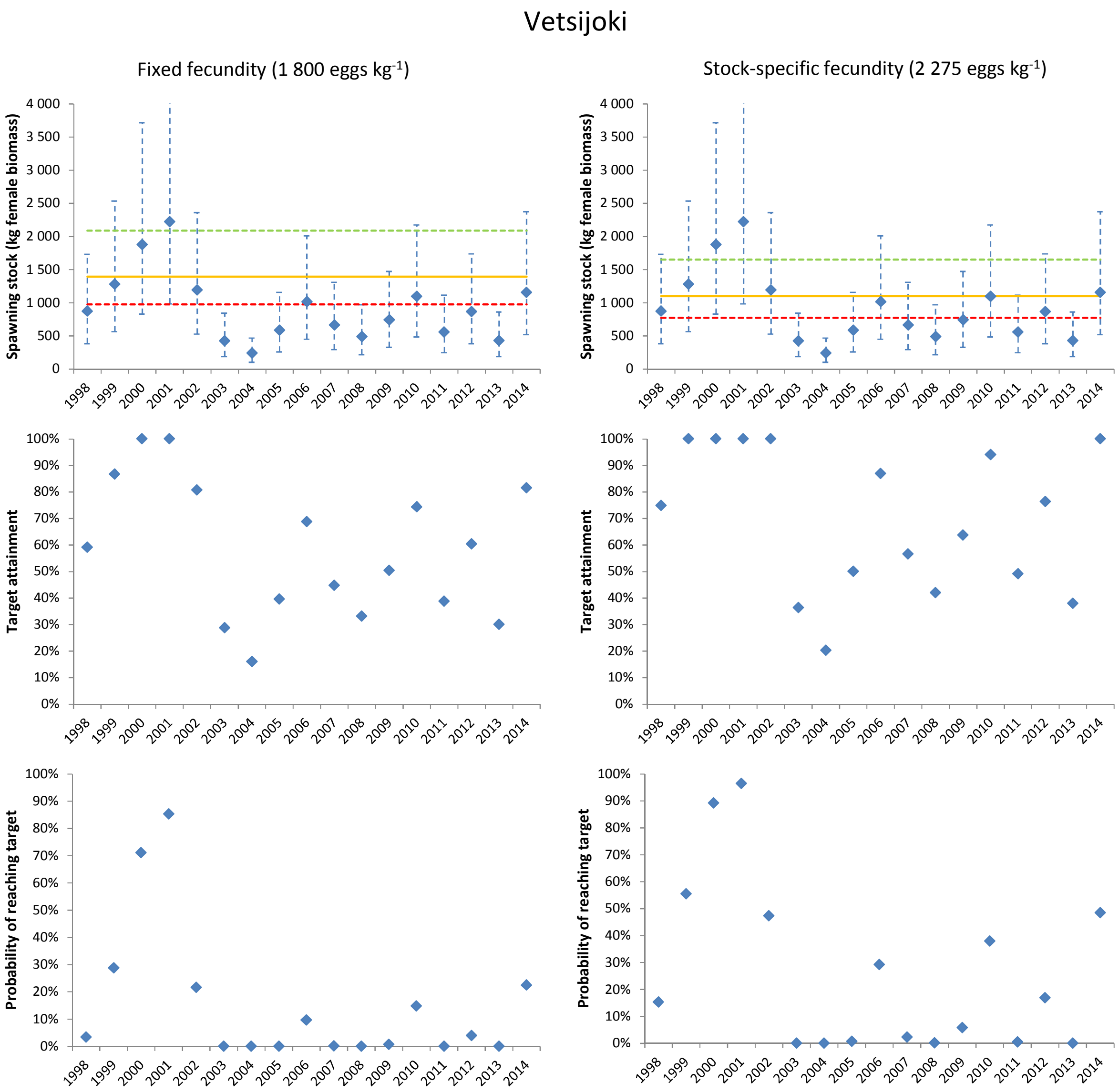
There is no fish monitoring in Vetsijoki, so the target evaluation must be based on an estimated exploitation rate in combination with catch statistics. The following exploitation estimate (based on number of fish) was used for the period 1998-2014: **30 % (20-50 %)**.

This exploitation estimate corresponds to a level defined as low exploitation for small Norwegian rivers (Anon. 2011b) and can therefore be viewed as a fairly conservative estimate. This exploitation estimate also corresponds to the exploitation rate most commonly observed in the neighbouring Utsjoki river.

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 1 392 kg (975-2 088 kg) when using a fixed fecundity of 1 800 eggs kg^{-1}, and 1 101 kg (771-1 652 kg) when using a stock-specific fecundity of 2 275 eggs kg^{-1}.

Based on a fixed fecundity level of 1 800 eggs kg^{-1}, percentage target attainment varied from 16 % (2004) to 100 % (2000-2001) in the period 1998-2014 (Figure 40). The average attainment over the last four years was 60 %. The probability of reaching the spawning target was 85 % in the best year (2001). In the last four years, the probability has varied from 0 to 22 %, and the management target (last 4 year average probability of reaching the spawning target) becomes 4 %.

Target attainment increases when using a stock-specific fecundity level of 2 275 eggs kg^{-1}, varying from 20 % in 2004 to 100 % in 1999-2002 and 2014. The average attainment over the last four years was 76 %. The highest probability of reaching the spawning target was 96 % in 2001, while in the last four years the probability has varied from 0 to 48 %. The management target (last 4 year average probability of reaching the spawning target) then becomes 17 %.



Vetsijoki

Fixed fecundity (1 800 eggs kg^{-1})

Stock-specific fecundity (2 275 eggs kg^{-1})

Figure 40. The estimated spawning stock (upper row), percent target attainment (middle row) and probability of reaching the target (bottom row) in the period 1998-2014 in the Finnish tributary Vetsijoki. The left column is based on a fixed fecundity of 1 800 eggs kg^{-1}, the right column is based on a stock-specific fecundity of 2 275 eggs kg^{-1}.

5.5.4.2 EXPLOITATION

The estimated total exploitation rate (based on weight) of Vetsijoki salmon was 72 % in the years 2006-2014 (Figure 41), with 15 % of the pre-fishery abundance caught in coastal fisheries, 44 % in main stem fisheries and 12 % in Vetsijoki itself. The average estimated total pre-fishery abundance was 5 396 kg and the average total catch was 3 883 kg in the period 2006-2014.

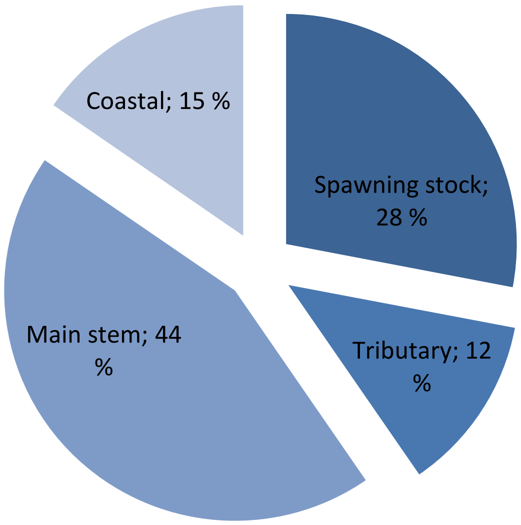


Figure 41. The total amount of salmon belonging to Vetsijoki in 2006-2014, distributed into surviving spawning stock and salmon caught in fisheries in either coastal, main stem or within-tributary fisheries. The percentages in the figure represent the proportion of the pre-fishery abundance that survives to spawning or are caught in coastal, main stem or tributary fisheries.

Estimated relative exploitation efficiencies (based on weight) in areas in the period 2006-2014 were:

Coastal:	15 %
Tana main stem:	52 %
Within Vetsijoki:	31 %

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 divided by the estimated amount of salmon that have survived the coastal fisheries.

The average overexploitation was estimated at 30 %. This means that exploitation was responsible for reducing the spawning stock size by an amount of 30 % below the spawning target. The average maximum sustainable total exploitation rate in the period was 58 %.

5.5.4.3 STOCK RECOVERY

In the years 2006-2014, the average probability that the spawning target was reached in Vetsijoki was 14 %. A significant reduction in the total exploitation rate is therefore needed to improve status.

The average spawning stock size in the period 2006-2014 was 778 kg (346-1 558 kg). With the current exploitation estimates, we would need a spawning stock of close to 1 300 kg to reach a 75 % probability of meeting the spawning target and approximately 2 050 kg to reach 100 % probability. In the years 2006-2014, we have, therefore, on average lacked a female biomass of approximately 500 kg in order to reach the 75 % probability level specified by the management target.

With a 50 % reduction in river exploitation, we would achieve 75 % probability of reaching the spawning target immediately (Figure 42). With a 20 or 30 % reduction, we would achieve 75 % probability after 1 generation (6 years).

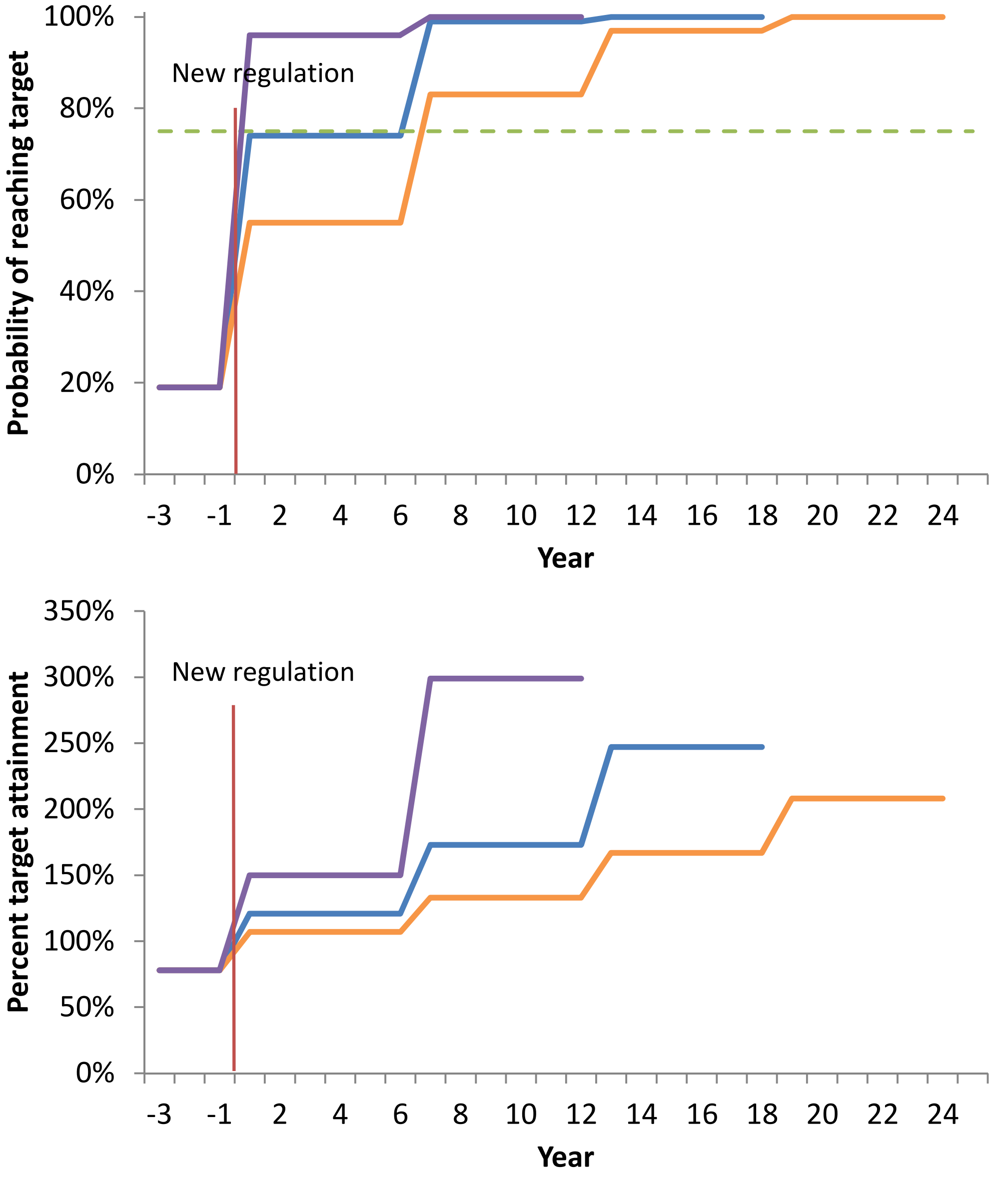


Figure 42. Stock recovery trajectories for Vetsijoki, corresponding to three scenarios of reduced river exploitation (Tana main stem + Vetsijoki). (Orange) A 20 % reduction, (Blue) a 30 % reduction, and (Purple) a 50 % reduction. Upper panel depicts the development in probability of reaching the spawning target, bottom panel the development in percentage target attainment. The green dotted line represents the 75 % probability line.

5.5.5 OHCEJOHKA/UTSJOKI + TRIBUTARIES

Ohcejohka/Utsjoki is one of the largest tributaries of the River Teno 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 106 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.

5.5.5.1 STATUS ASSESSMENT

The catch in the Utsjoki river system varied from 800 kg (2004) to 2 955 kg (2014) in the period 2002-2014.

There has been video monitoring in Utsjoki since 2002, and the video counts allow the use of accurate exploitation rate estimates in the status evaluation. The exploitation rate in the Utsjoki river system has varied from 20 % (2013) up to 60 % (2008).

The revised Utsjoki spawning target is 4 979 107 eggs (3 599 272-7 211 017 eggs). The female biomass needed to obtain this egg deposition is 2 766 kg (2 000-4 006 kg) when using a fixed fecundity of 1 800 eggs kg^{-1}, and 2 059 kg (1 486-2 972 kg) when using stock-specific fecundities for the stocks in the Utsjoki main stem, Kevojoki and Tsarsjoki.

Based on a fixed fecundity level of 1 800 eggs kg^{-1}, percentage target attainment varied from 25 % (2004) to 100 % (2006, 2012-2014) in the period 2002-2014 (Figure 43). The average attainment over the last four years was 117 %. The probability of reaching the spawning target was 94 % in the best year (2014). In the last four years, the probability has varied from 11 to 94 %, and the management target (last 4 year average probability of reaching the spawning target) becomes 75 %.

Target attainment increases when using stock-specific fecundity levels, varying from 34 % in 2004 to 100 % in 2006, 2011-2014. The average attainment over the last four years was 158 %. The highest probability of reaching the spawning target was 100 % in 2012 and 2014, while in the last four years the probability has varied from 64 to 100 % with a management target (last 4 year average probability of reaching the spawning target) of 99 %.

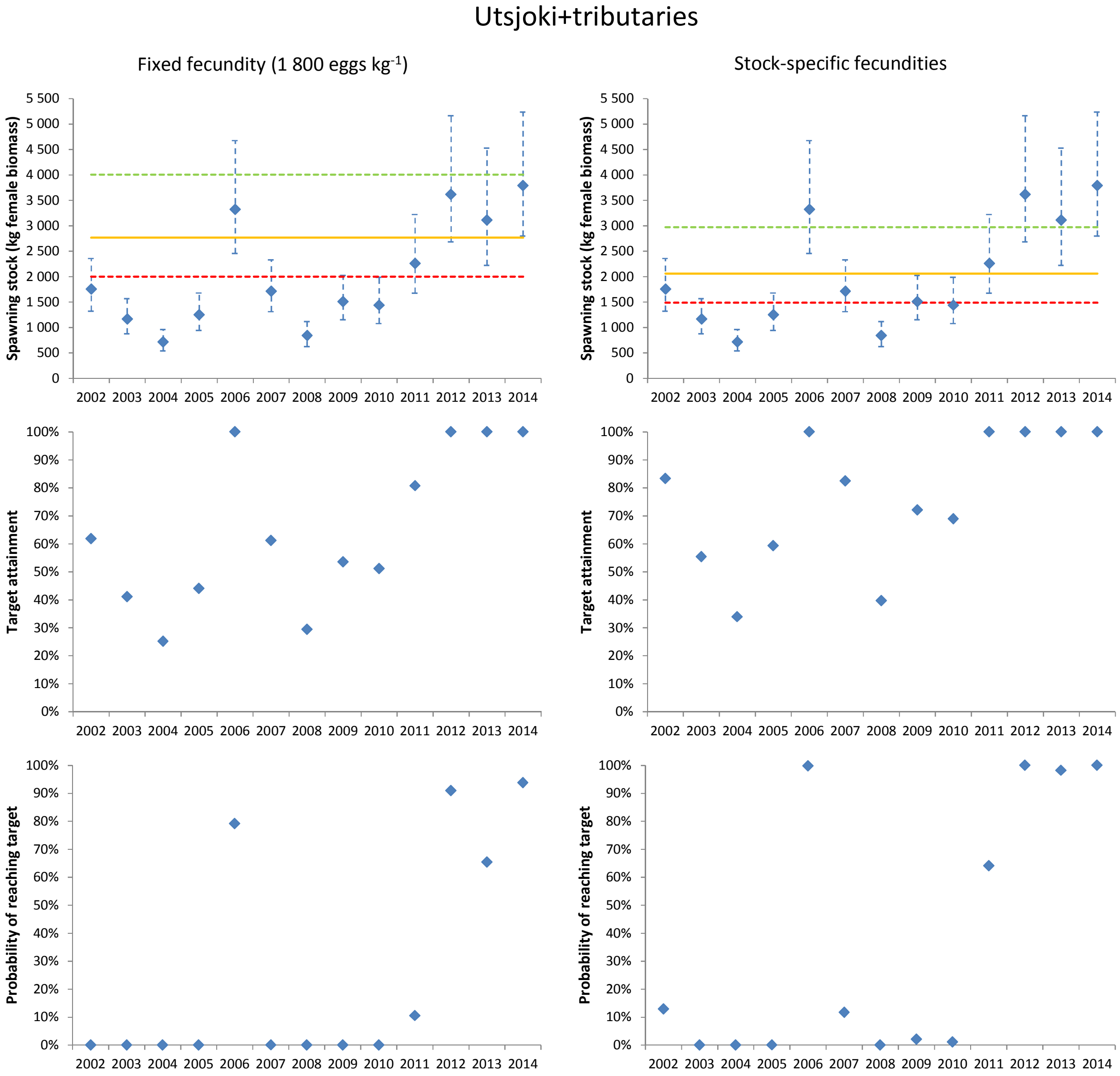


Figure 43. The estimated spawning stock (upper row), percent target attainment (middle row) and probability of reaching the target (bottom row) in the period 2002-2014 in the Finnish tributary Utsjoki (including tributaries). The left column is based on a fixed fecundity of 1 800 eggs kg^{-1}, the right column is based on stock-specific fecundities (2 225-2 625 eggs kg^{-1}).

5.5.5.2 EXPLOITATION

The estimated total exploitation rate (based on weight) of Utsjoki salmon was 63 % in the years 2006-2014 (Figure 44), with 16 % of the pre-fishery abundance caught in coastal fisheries, 29 % in main stem fisheries and 18 % in Utsjoki itself. The average estimated total pre-fishery abundance was 11 575 kg and the average total catch was 7 273 kg in the period 2006-2014.

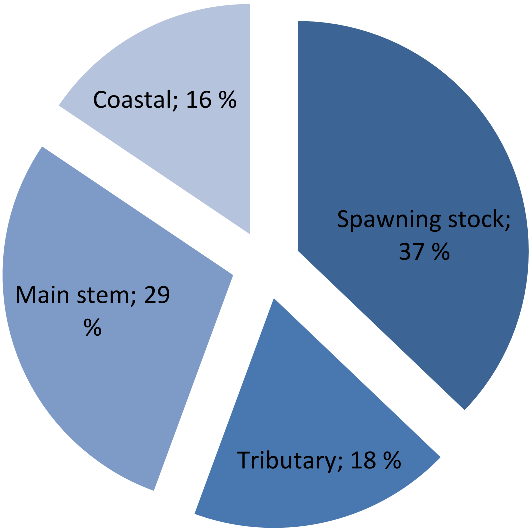


Figure 44. The total amount of salmon belonging to Utsjoki in 2006-2014, distributed into surviving spawning stock and salmon caught in fisheries in either coastal, main stem or within-tributary fisheries. The percentages in the figure represent the proportion of the pre-fishery abundance that survives to spawning or are caught in coastal, main stem or tributary fisheries.

Estimated relative exploitation efficiencies (based on weight) in areas in the period 2006-2014 were:

Coastal:	16 %
Tana main stem:	34 %
Within Utsjoki:	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 divided by the estimated amount of salmon that have survived the coastal fisheries.

The average overexploitation was estimated at 17 %. This means that exploitation was responsible for reducing the spawning stock size by an amount of 17 % below the spawning target. The average maximum sustainable total exploitation rate in the period was 63 %.

5.5.5.3 STOCK RECOVERY

In the years 2006-2014, the average probability that the spawning target was reached in Utsjoki was 77 %.

The average spawning stock size in the period 2006-2014 was 2 396 kg (1 777-3 364 kg). With the current exploitation estimates, we would need a spawning stock of over 2 350 kg in order to reach a 75 % probability of meeting the spawning target and over 3 100 kg in order to reach 100 % probability. In the years 2006-2014, we have, therefore, on average lacked no female biomass in order to reach the 75 % probability level specified by the management target.

This means, of course, that with all simulated reductions in river exploitation (20, 30 and 50 % reductions), a 75 % probability of reaching the spawning target would be attained immediately (Figure 45).

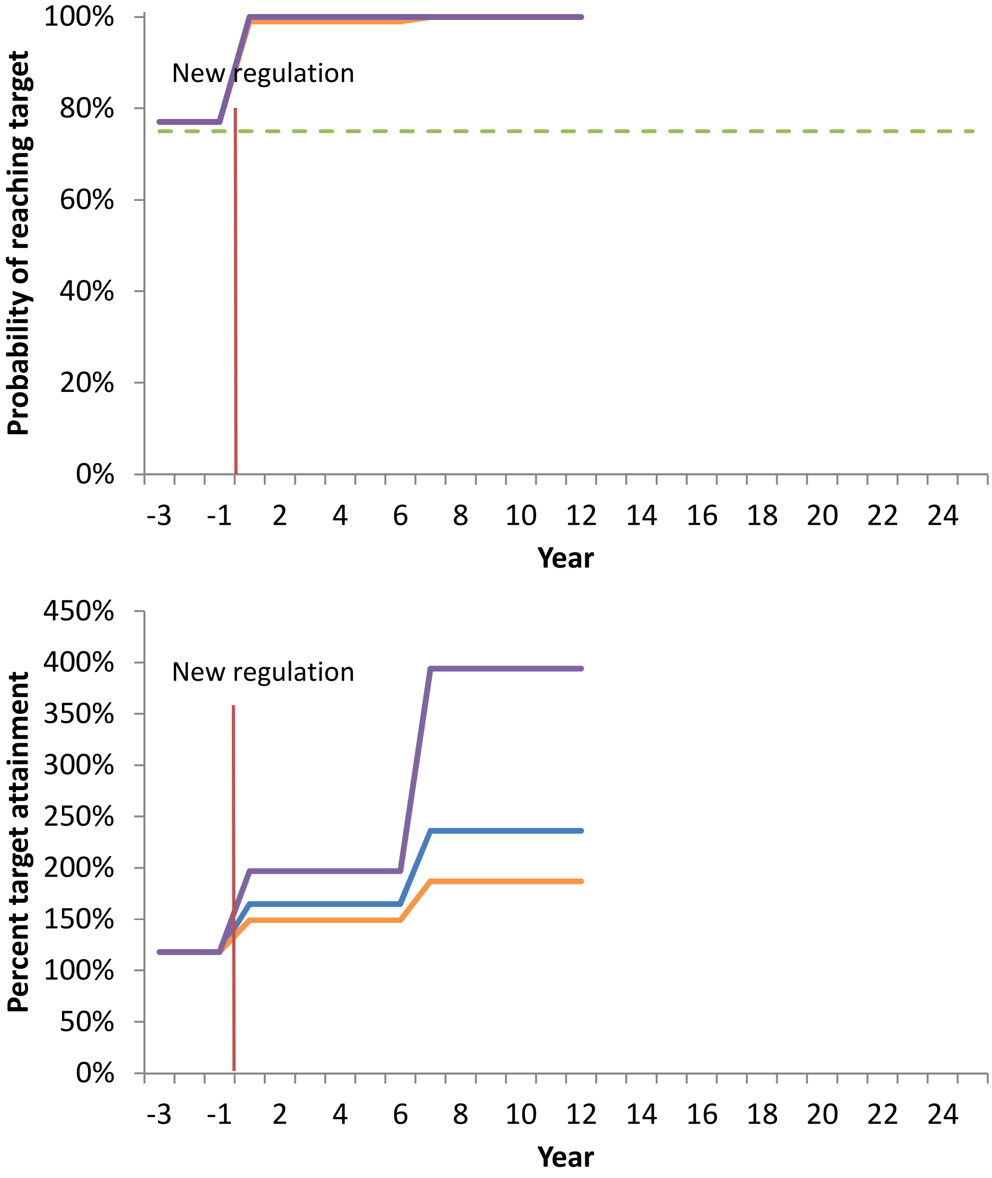


Figure 45. Stock recovery trajectories for Utsjoki, corresponding to three scenarios of reduced river exploitation (Tana main stem + Utsjoki). (Orange) A 20 % reduction, (Blue) a 30 % reduction, and (Purple) a 50 % reduction. Upper panel depicts the development in probability of reaching the spawning target, bottom panel the development in percentage target attainment. The green dotted line represents the 75 % probability line.

5.5.6 VÁLJOHKA

Váljohka is a small-sized river flowing into the Tana main stem over 170 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. The status of Ástejohka is presently unknown.

5.5.6.1 STATUS ASSESSMENT

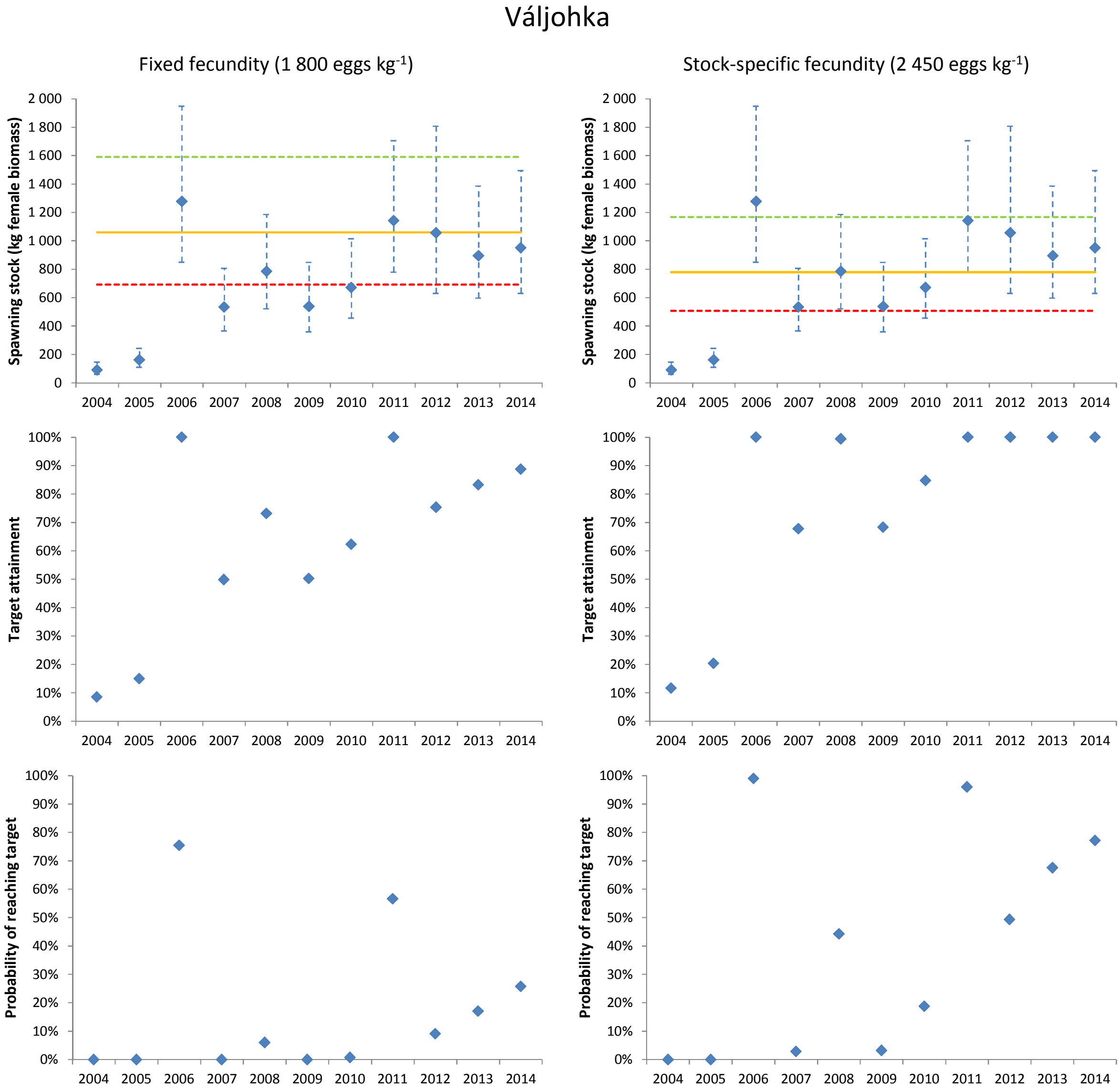
The catch in Váljohka varied from 20 kg (2004) to 365 kg (2012) in the period 2004-2014. There were considerable localization problems with the Norwegian Tana catches in 2004 and 2005. This likely caused some underestimation of the Váljohka-catch in these two particular years.

There is no annual fish counting in Váljohka, so the target evaluation must be based on an estimated exploitation rate in combination with catch statistics. The fishing activity in Váljohka is low with only a few licenses sold each year. The low number of licenses combined with low accessibility for fishermen indicates a low exploitation level. The lowermost kilometres of the river, the areas that are most commonly fished, were snorkelled in September 2014 (Johansen 2015) under medium water visibility conditions. This snorkelling count indicates an exploitation rate in 2014 of 14 %. This is likely too high, both considering the visibility and the extensive river areas that were uncounted. If we estimate that only 50 % of the spawning population were counted, the exploitation rate estimate becomes 7 %. If there are any unreported catches in Váljohka, and the extent of this unreported catch equals the reported catch, the exploitation rate estimate would approach 20 %. With this background, we use 10 % (probability range 7-20 %) as the exploitation estimate for most years in the period 2004-2014. The only exception was 2012. In this season, the number of licenses was significantly higher than in the preceding and subsequent years. We therefore increased the exploitation estimate to 15 % (10-25 %) in 2012.

The revised 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 1 060 kg (692-1 590 kg) when using a fixed fecundity of 1 800 eggs kg^{-1}, and 779 kg (508-1 168 kg) when using a stock-specific fecundity of 2 450 eggs kg^{-1}.

Based on a fixed fecundity level of 1 800 eggs kg^{-1}, the percentage target attainment in the period 2006-2014 varied from 9 % in 2004 to 100 % in 2006 and 2011 (Figure 46). The average attainment over the last four years was 101 %. The probability of reaching the spawning target varied from 0 % in 2004, 2005 and 2007, up to 75 % in 2006. The management target (last 4 year average probability of reaching the spawning target) with a fixed fecundity was 46 %.

Target attainment increases when using a stock-specific fecundity level of 2 450 eggs kg^{-1}, varying from 12 % in 2004 to 100 % in 2006 and 2011-2014. The average attainment over the last four years was 137 %. The probability of reaching the spawning target varied between 0 % in 2004-2005 and 99 % in 2006. The management target (last 4 year average probability of reaching the spawning target) when using a stock-specific fecundity level was 87 %.


Váljohka

Fixed fecundity (1 800 eggs kg-1)

Stock-specific fecundity (2 450 eggs kg-1)

Figure 46. The estimated spawning stock (upper row), percent target attainment (middle row) and probability of reaching the target (bottom row) in the period 2004-2013 in the Norwegian tributary Váljohka. The left column is based on a fixed fecundity of 1 800 eggs kg^{-1}, the right column is based on a stock-specific fecundity of 2 450 eggs kg^{-1}.

5.5.6.2 EXPLOITATION

The estimated total exploitation rate (based on weight) of Váljohka salmon was 55 % in the years 2006-2014 (Figure 47), with 15 % of the pre-fishery abundance caught in coastal fisheries, 35 % in main stem fisheries and 5 % in Váljohka itself. The average estimated total pre-fishery abundance was 3 552 kg and the average total catch was 1 971 kg in the period 2006-2014.

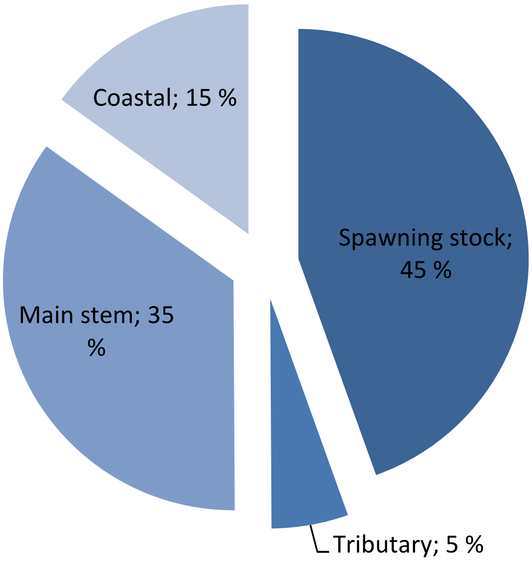


Figure 47. The total amount of salmon belonging to Váljohka in 2006-2014, distributed into surviving spawning stock and salmon caught in fisheries in either coastal, main stem or within-tributary fisheries. The percentages in the figure represent the proportion of the pre-fishery abundance that survives to spawning or are caught in coastal, main stem or tributary fisheries.

Estimated relative exploitation efficiencies (based on weight) in areas in the period 2006-2014 were:

Coastal:	15 %
Tana main stem:	41 %
Within Váljohka:	11 %

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 divided by the estimated amount of salmon that have survived the coastal fisheries.

The average overexploitation in the years 2006-2014 was estimated at 7 %. This means that exploitation was responsible for reducing the spawning stock size by an amount of 7 % below the spawning target. The average maximum sustainable total exploitation rate in the period was 61 %.

5.5.6.3 STOCK RECOVERY

In the years 2006-2014, the average probability that the spawning target was reached in Váljohka was 70 %. Only small changes are needed in order to exceed a management target of 75 %.

The average spawning stock size in the period 2006-2014 was 872 kg (576-1 355 kg). With the current exploitation estimates, we would need a spawning stock of slightly above 900 kg in order to reach a 75 % probability of meeting the spawning target and over 1 250 kg in order to reach 100 % probability. In the years 2006-2014, we have, therefore, on average lacked a female biomass of approximately 30 kg in order to reach the 75 % probability level specified by the management target.

Váljohka would achieve 75 % target attainment probability immediately following a new regulation, regardless of reduction in exploitation rate (Figure 48).

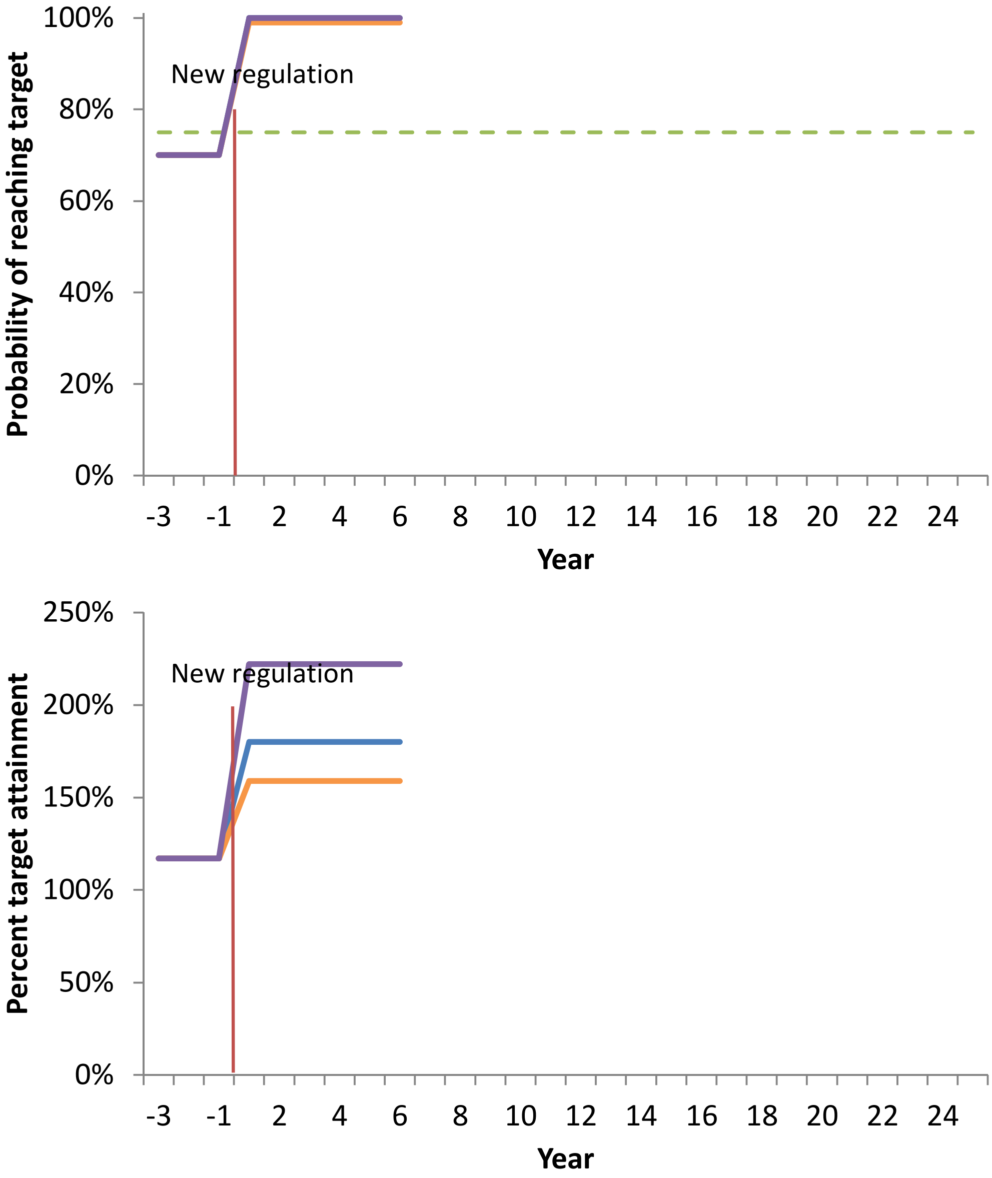


Figure 48. Stock recovery trajectories for Váljohka, corresponding to three scenarios of reduced river exploitation (Tana main stem + Váljohka). (Orange) A 20 % reduction, (Blue) a 30 % reduction, and (Purple) a 50 % reduction. Upper panel depicts the development in probability of reaching the spawning target, bottom panel the development in percentage target attainment. The green dotted line represents the 75 % probability line.

5.5.7 ÁHKOJOHKA/AKUJOKI

The river 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.

5.5.7.1 STATUS ASSESSMENT

The salmon fishery in Akujoki is very limited. However, spawning salmon in Akujoki have been counted annually in the autumn with snorkelling in the years 2003-2014. Field tests of these snorkelling counts have demonstrated that it is a reasonably accurate method, and we have used these counts directly as a basis for the target assessment of Akujoki.

The revised Akujoki spawning target is 282 532 eggs (211 899-423 798 eggs). The female biomass needed to obtain this egg deposition is 157 kg (118-235 kg) when using a fixed fecundity of 1 800 eggs kg^{-1}, and 126 kg (94-188 kg) when using a stock-specific fecundity of 2 250 eggs kg^{-1}.

Based on a fixed fecundity level of 1 800 eggs kg^{-1}, percentage target attainment varied from 27 % (2003) to 84 % (2014) in the period 2003-2014 (Figure 49). The average attainment over the last four years was 75 %. The probability of reaching the spawning target in the last 4 years varied from 0 to 12 %. The management target becomes 3 %.

Target attainment increases somewhat when using the stock-specific fecundity level, varying from 34 % in 2003 to 100 % in 2012 and 2014. The average attainment over the last four years was 94 %. The probability of reaching the spawning target in the last 4 years varied from 0 to 60 %. The management target then becomes 34 %.

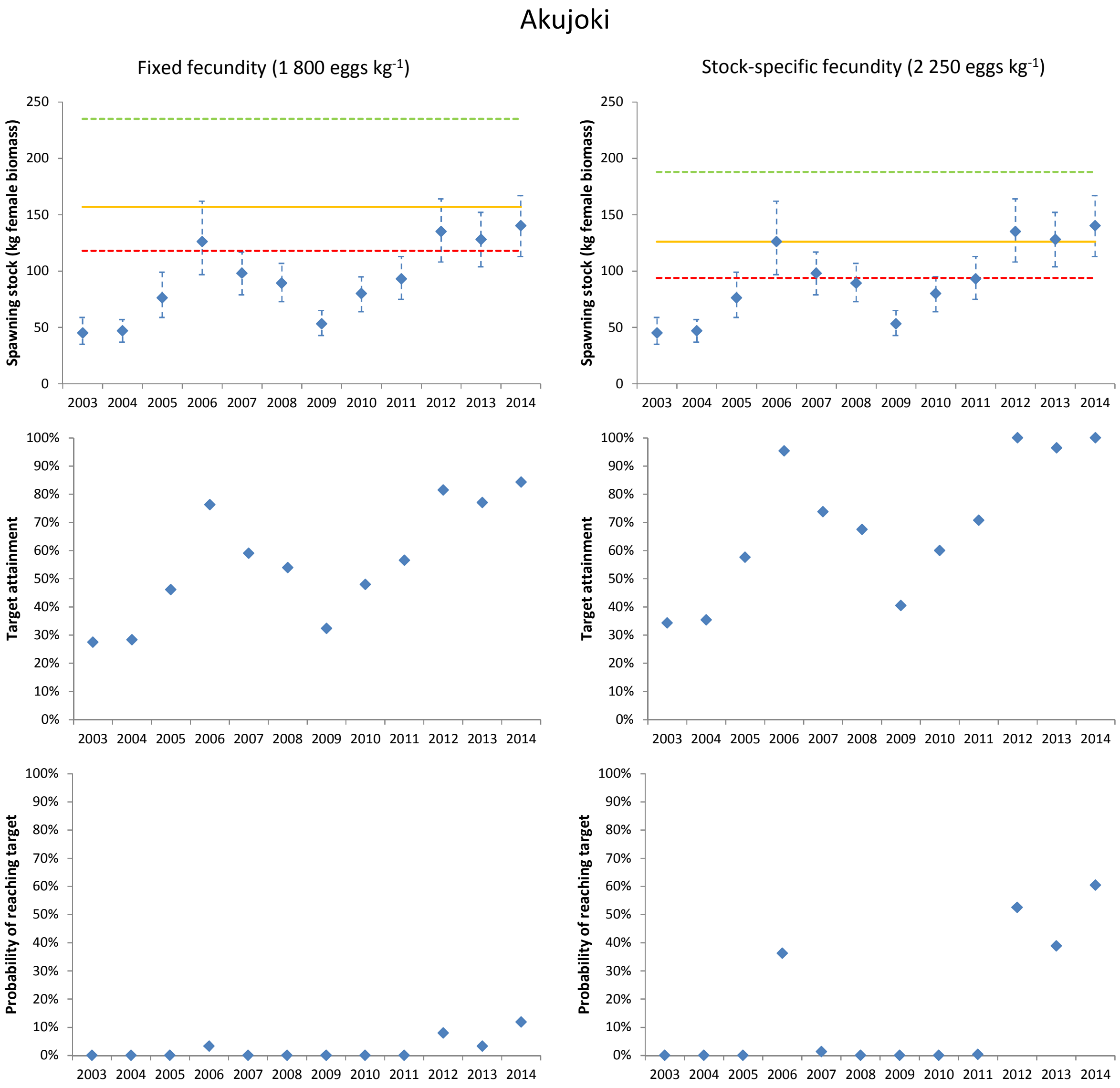


Figure 49. The estimated spawning stock (upper row), percent target attainment (middle row) and probability of reaching the target (bottom row) in the period 2003-2014 in the Finnish tributary Akujoki. The left column is based on a fixed fecundity of 1 800 eggs kg^{-1}, the right column is based on a stock-specific fecundity of 2 250 eggs kg^{-1}.

5.5.7.2 EXPLOITATION

Due to genetic similarities between salmon sampled in Akujoki and neighbouring areas, it is not possible to make an estimate of the coastal and main stem exploitation of Akujoki.

5.5.7.3 STOCK RECOVERY

In the years 2006-2014, the average probability that the spawning target was reached in Akujoki was 7 %. A reduction in the total exploitation rate experienced by Akujoki-salmon is therefore needed to improve the stock status.

The average spawning stock size in the period 2006-2014 was 105 kg (84-127 kg). With the current uncertainty level in the spawning stock estimates, we would need a spawning stock of over 150 kg in order to reach a 75 % probability of meeting the spawning target and over 200 kg in order to reach 100 % probability. In the years 2006-2013, we have, therefore, on average lacked a female biomass of approximately 45 kg in order to reach the 75 % probability level specified by the management target.

With all simulated reductions in river exploitation (20, 30 and 50 % reductions), we would achieve 75 % probability of reaching the spawning target immediately following a new regulation (Figure 50).

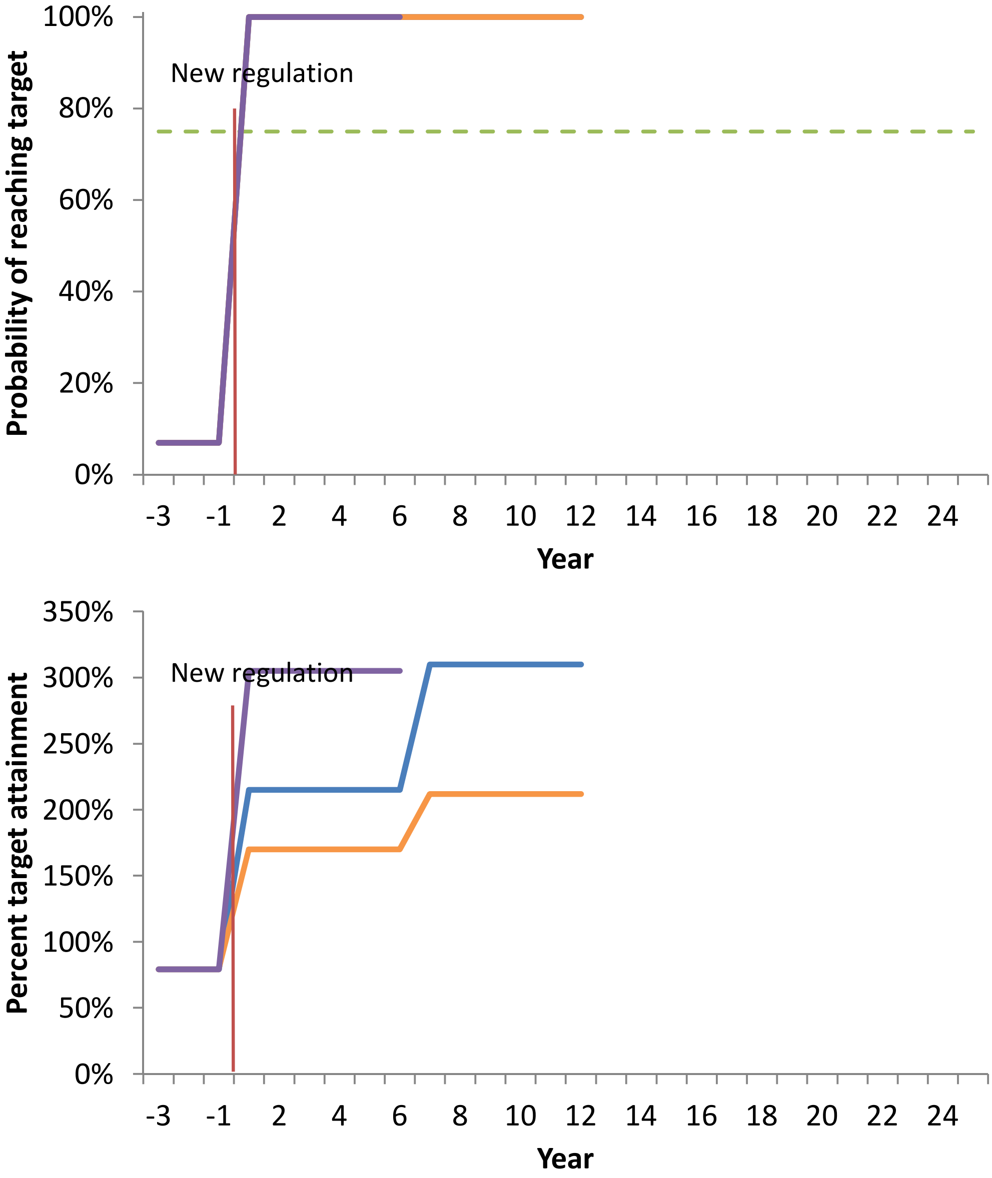


Figure 50. Stock recovery trajectories for Akujoki, corresponding to three scenarios of reduced river exploitation (Tana main stem + Akujoki). (Orange) A 20 % reduction, (Blue) a 30 % reduction, and (Purple) a 50 % reduction. Upper panel depicts the development in probability of reaching the spawning target, bottom panel the development in percentage target attainment. The green dotted line represents the 75 % probability line.

5.5.8 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 possible 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.

5.5.8.1 STATUS ASSESSMENT

The status assessment in this chapter is a combined evaluation for Kárášjohka and its tributaries Bávttajohka and Geaimmejohka.

The catch in Kárášjohka and its tributaries Bávttajohka and Geaimmejohka varied from 1 543 kg (2009) to 4 977 kg (2006) in the period 2004-2014. There were some localization problems with the Norwegian Tana catches in 2004 and 2005. This likely caused some imprecision in the estimate of the Kárášjohka-catch in these two particular years.

There was acoustic fish counting in 2010 and 2012 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, which then could be used to estimate the 2010 and 2012 exploitation rate in the upper part of Kárášjohka.

Based on the acoustic results, the following exploitation estimates (based on number of fish) were used to estimate spawning stock size in Kárášjohka in the years 2004-2014:

- Salmon <3 kg: 20 % (15-25 %) throughout the period
- Salmon 3-7 kg: 40 % (30-50 %) in 2004-2011 and 2013-2014; 35 % (30-45 %) in 2012
- Salmon >7 kg: 40 % (30-50 %) in 2004-2011 and 2013-2014; 35 % (30-45 %) in 2012

The revised spawning target of Kárášjohka and its tributaries Bávttajohka and Geaimmejohka is 14 034 595 eggs (10 527 992-21 055 983 eggs). The female biomass needed to obtain this egg deposition is 7 797 kg (5 849-11 698 kg) when using a fixed fecundity of 1 800 eggs kg^{-1}, and 7 290 kg (5 468-10 936 kg) when using stock-specific fecundities.

Based on a fixed fecundity level of 1 800 eggs kg^{-1}, percentage target attainment varied from 16 % (2009) to 60 % (2008) in the period 2004-2014 (Figure 51). Average attainment last four years was 45 %. The probability of reaching the spawning target was 0 % for all years, and, accordingly, the management target (last 4 year average probability of reaching the spawning target) was also 0 %.

Target attainment increases when using the stock-specific fecundity level, varying from 17 % in 2009 to 64 % in 2008. The average attainment over the last four years was 48 %. The probability of reaching the spawning target was 0 % most of the years in the period 2004-2014, with the exception of 1 % in 2008. The management target (last 4 year average probability of reaching the spawning target) was 0 %.

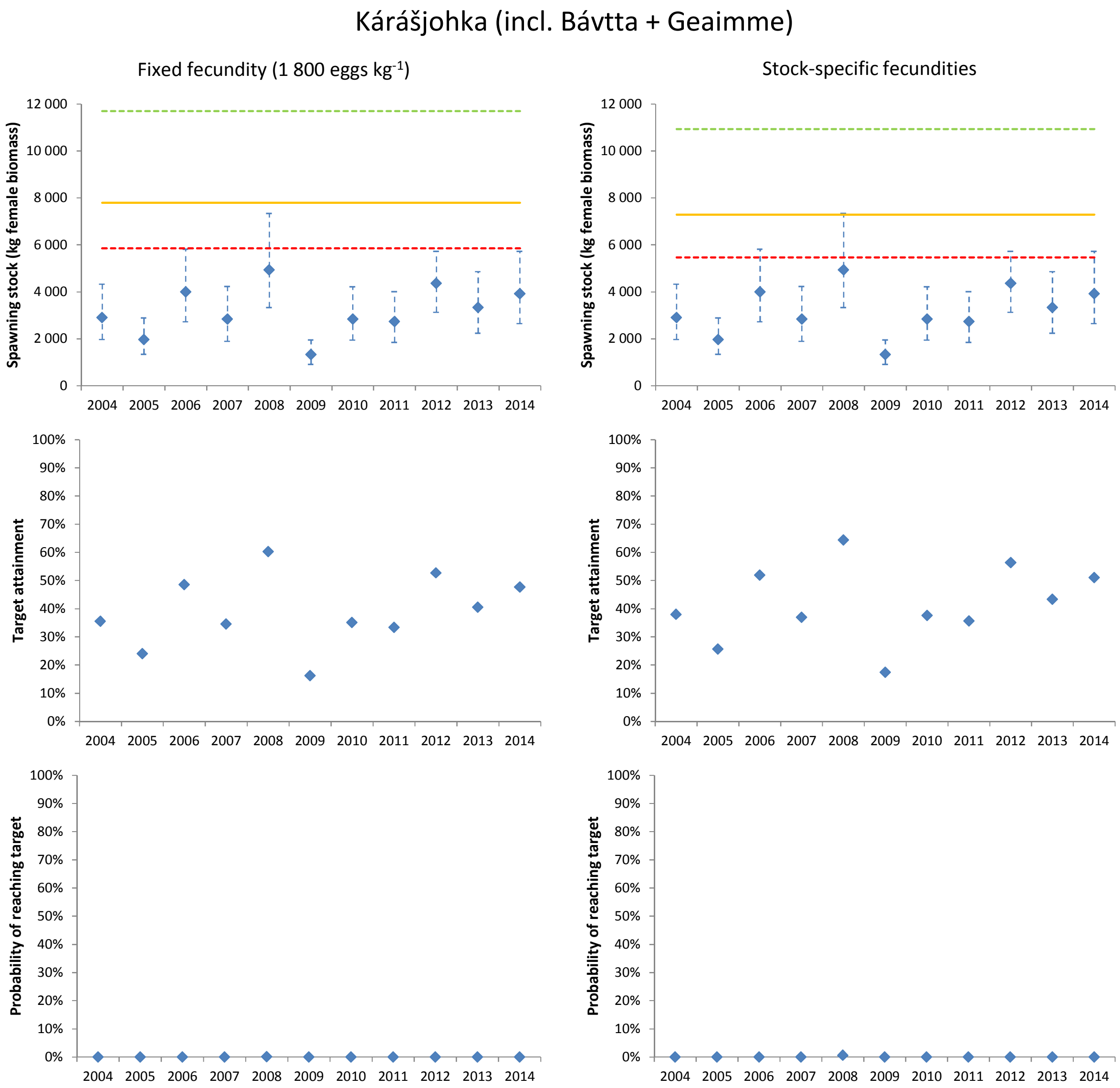


Figure 51. The estimated spawning stock (upper row), percent target attainment (middle row) and probability of reaching the target (bottom row) in the period 2004-2014 in the Norwegian tributary Kárášjohka (including the tributaries Bávttajohka and Geaimmejohka). The left column is based on a fixed fecundity of 1 800 eggs kg^{-1}, the right column is based on stock-specific fecundities (1 875-2 400 eggs kg^{-1}).

5.5.8.2 EXPLOITATION

The estimated total exploitation rate (based on weight) of Kárášjohka salmon was 67 % in the years 2006-2014 (Figure 52), with 16 % of the pre-fishery abundance caught in coastal fisheries, 35 % in main stem fisheries and 16 % in Kárášjohka itself. The average estimated total pre-fishery abundance was 22 144 kg and the average total catch was 14 855 kg in the period 2006-2014.

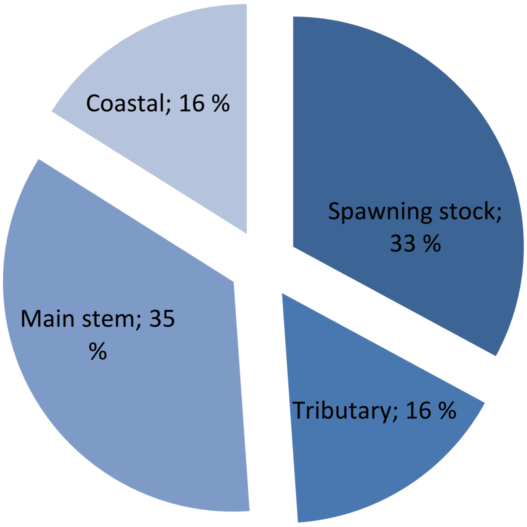


Figure 52. The total amount of salmon belonging to Kárášjohka (including Bávttajohka and Geaimmejohka) in 2006-2014, distributed into surviving spawning stock and salmon caught in fisheries in either coastal, main stem or within-tributary fisheries. The percentages in the figure represent the proportion 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 the period 2006-2014 were:

Coastal:	16 %
Tana main stem:	42 %
Within Kárášjohka:	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 divided by the estimated amount of salmon that have survived the coastal fisheries.

The average overexploitation was estimated at 40 %. This means that exploitation was responsible for reducing the spawning stock size by an amount of 40 % below the spawning target. The average maximum sustainable total exploitation rate in the period was 41 %.

5.5.8.3 STOCK RECOVERY

In the years 2006-2014, the average probability that the spawning target was reached in Kárášjohka (including the tributaries Bávttajohka and Geaimmejohka) was 0 %. A significant reduction in the total exploitation rate is therefore needed to improve status in the Kárášjohka river system.

The average spawning stock size in the period 2006-2014 was 3 364 kg (2 296-4 875 kg). With the current exploitation estimates, we would need a spawning stock of over 8 500 kg in order to attain a 75 % probability of reaching the spawning target and over 11 500 kg in order to attain 100 % probability. In the years 2006-2014, we have, therefore, on average lacked a female biomass of approximately 5 100 kg in order to reach the 75 % probability level specified by the management target.

With a 50 % reduction in river exploitation, we would achieve 75 % probability of reaching the spawning target after 1 generation (7 years, Figure 53). With a 30 % reduction, we would achieve 75 % probability after 2 generations (14 years). With a 20 % reduction, we would need 3 generations (21 years).

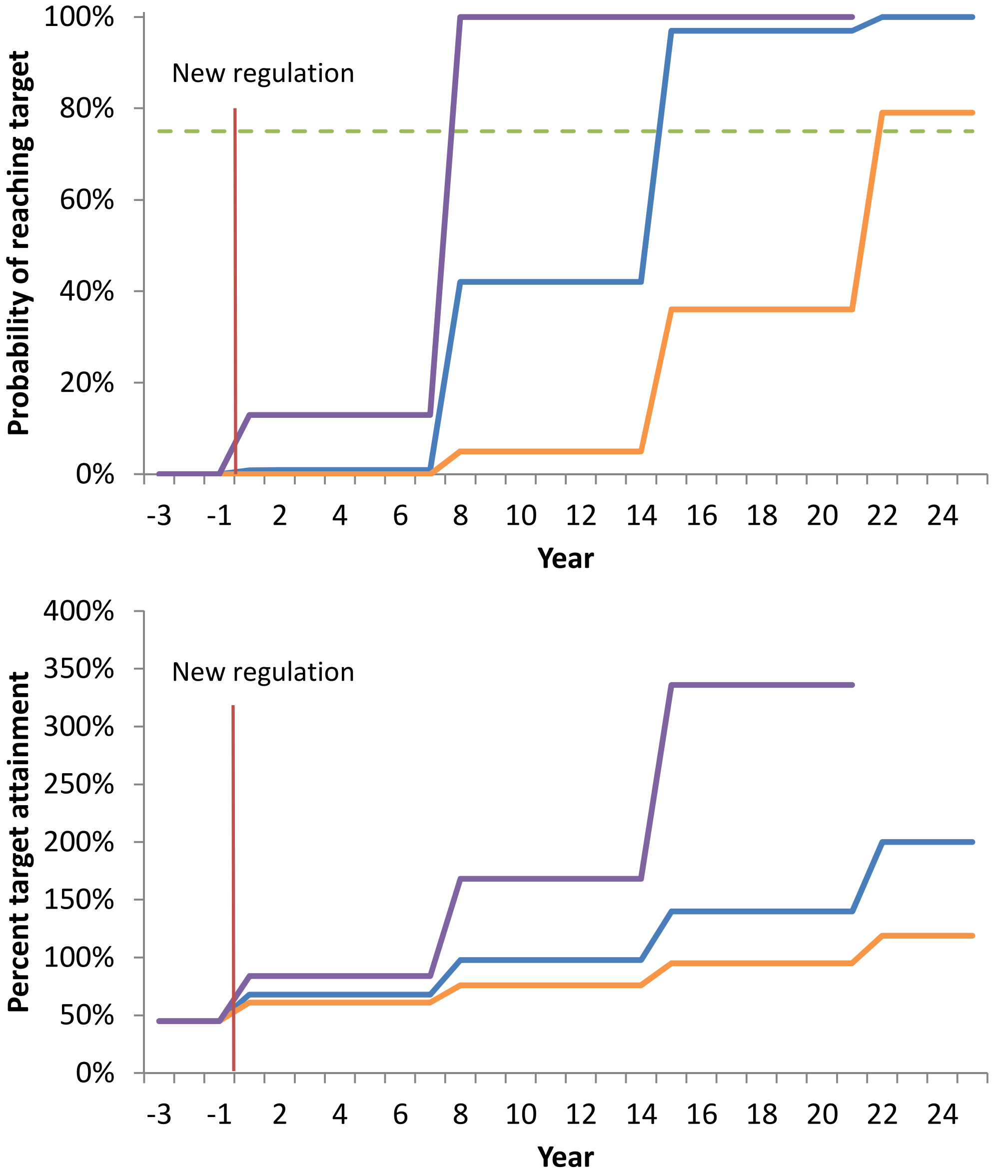


Figure 53. Stock recovery trajectories for Kárášjohka, corresponding to three scenarios of reduced river exploitation (Tana main stem + Kárášjohka). (Orange) A 20 % reduction, (Blue) a 30 % reduction, and (Purple) a 50 % reduction. Upper panel depicts the development in probability of reaching the spawning target, bottom panel the development in percentage target attainment. The green dotted line represents the 75 % probability line.

5.5.9 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 slowflowing pools. The only major obstacle for salmon is a waterfall approximately 75 km upstream. It is likely that salmon are able to pass this waterfall, at least at low water levels.

5.5.9.1 STATUS ASSESSMENT

The catch in Iešjohka varied from 995 kg (2009) to 3 498 kg (2008) in the period 2004-2014. There were some localization problems with the Norwegian Tana catches in 2004 and 2005. This likely caused some imprecision in the estimate of the Iešjohka-catch in these two particular years.

There is no fish monitoring in Iešjohka, so the target evaluation must be based on an estimated exploitation rate in combination with catch statistics. The following exploitation estimates (based on number of fish) were used in the period 2004-2014:

- Salmon <3 kg: 20 % (15-25 %)
- Salmon 3-7 kg: 40 % (30-50 %) in 2004-2011, 2013-2014; 35 % (30-45 %) in 2012
- Salmon >7 kg: 40 % (30-50 %) in 2004-2011, 2013-2014; 35 % (30-45 %) in 2012

These are equivalent to the estimates used in Kárášjohka, which were derived from acoustic fish counting in 2010 and 2012.

The revised 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 6 409 kg (4 515-9 613 kg) when using a fixed fecundity of 1 800 eggs kg^{-1}, and 6 072 kg (4 278-9 107 kg) when using a stock-specific fecundity of 1 900 eggs kg^{-1}.

Based on a fixed fecundity level of 1 800 eggs kg^{-1}, percentage target attainment varied from 13 % (2009) to 55 % (2008) in the period 2004-2014 (Figure 54). The average attainment over the last four years was 31 %. The probability of reaching the spawning target was 0 % for all years, and, accordingly, the management target (last 4 year average probability of reaching the spawning target) was also 0 %.

Target attainment increases somewhat when using the stock-specific fecundity level, varying from 14 % in 2009 to 58 % in 2008. The average attainment over the last four years was 33 %. The probability of reaching the spawning target was 0 % throughout the period 2004-2014. The same goes for the management target (last 4 year average probability of reaching the spawning target).

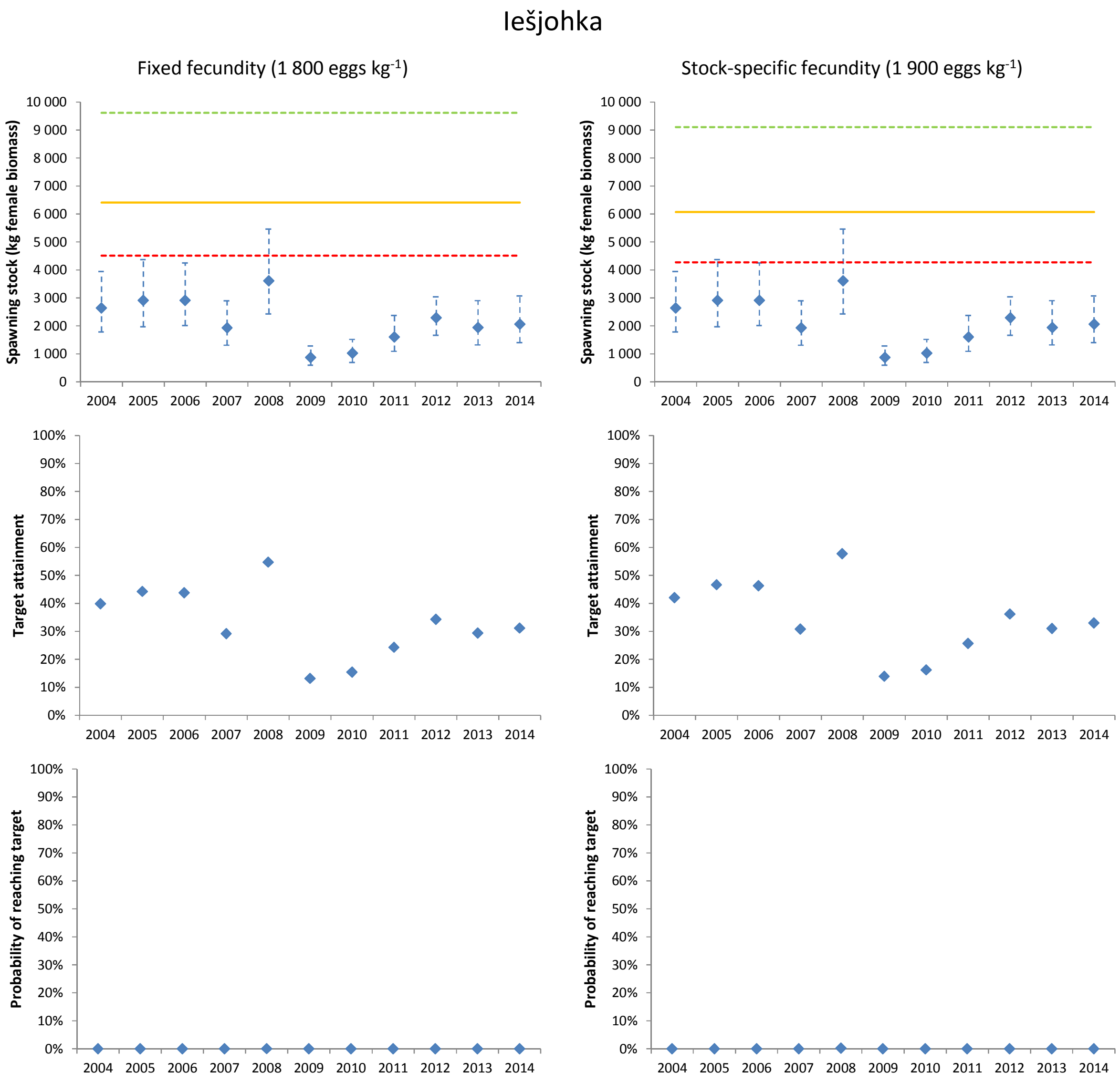


Figure 54. The estimated spawning stock (upper row), percent target attainment (middle row) and probability of reaching the target (bottom row) in the period 2004-2014 in the Norwegian tributary Iešjohka. The left column is based on a fixed fecundity of 1 800 eggs kg^{-1}, the right column is based on a stock-specific fecundity of 1 900 eggs kg^{-1}.

5.5.9.2 EXPLOITATION

The estimated total exploitation rate (based on weight) of Iešjohka salmon was 75 % in the years 2006-2014 (Figure 52), with 16 % of the pre-fishery abundance caught in coastal fisheries, 46 % in main stem fisheries and 13 % in Iešjohka itself. The average estimated total pre-fishery abundance was 15 742 kg and the average total catch was 11 847 kg in the period 2006-2014.

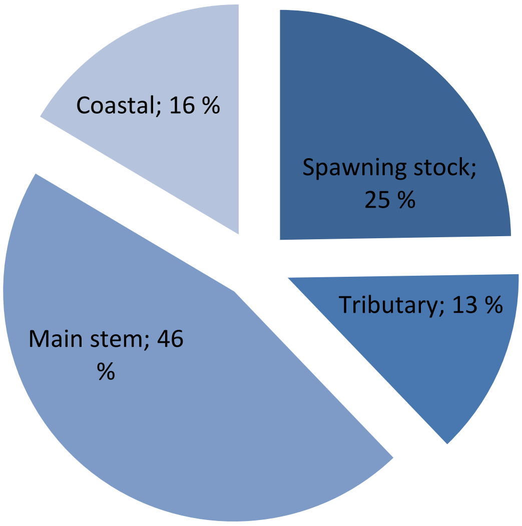


Figure 55. The total amount of salmon belonging to Iešjohka in 2006-2014, distributed into surviving spawning stock and salmon caught in fisheries in either coastal, main stem or within-tributary fisheries. The percentages in the figure represent the proportion of the pre-fishery abundance that survives to spawning or are caught in coastal, main stem or tributary fisheries.

Estimated relative exploitation efficiencies (based on weight) in areas in the period 2006-2014 were:

Coastal:	16 %
Tana main stem:	55 %
Within Iešjohka:	35 %

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 divided by the estimated amount of salmon that have survived the coastal fisheries.

The average overexploitation was estimated at 60 %. This means that exploitation was responsible for reducing the spawning stock size by an amount of 60 % below the spawning target. The average maximum sustainable total exploitation rate in the period was 33 %.

5.5.9.3 STOCK RECOVERY

In the years 2006-2014, the average probability that the spawning target was reached in Iešjohka was 0 %. A significant reduction in the total exploitation rate is therefore needed to improve status in this river.

The average spawning stock size in the period 2006-2014 was 2 028 kg (1 393-2 979 kg). With the current exploitation estimates, we would need a spawning stock of over 7 050 kg in order to reach a 75 % probability of meeting the spawning target and over 9 000 kg to reach 100 % probability. In the years 2006-2014, we have, therefore, on average lacked a female biomass of over 5 000 kg in order to reach the 75 % probability level specified by the management target.

With a 20 % reduction in river exploitation, we would not achieve a 75 % probability of reaching the spawning target by the end of the recovery period simulated in Figure 56 (25 years). With a 30 % reduction, the stock recovery period would last 2 generations (14 years), and with a 50 % reduction 1 generation (7 years).

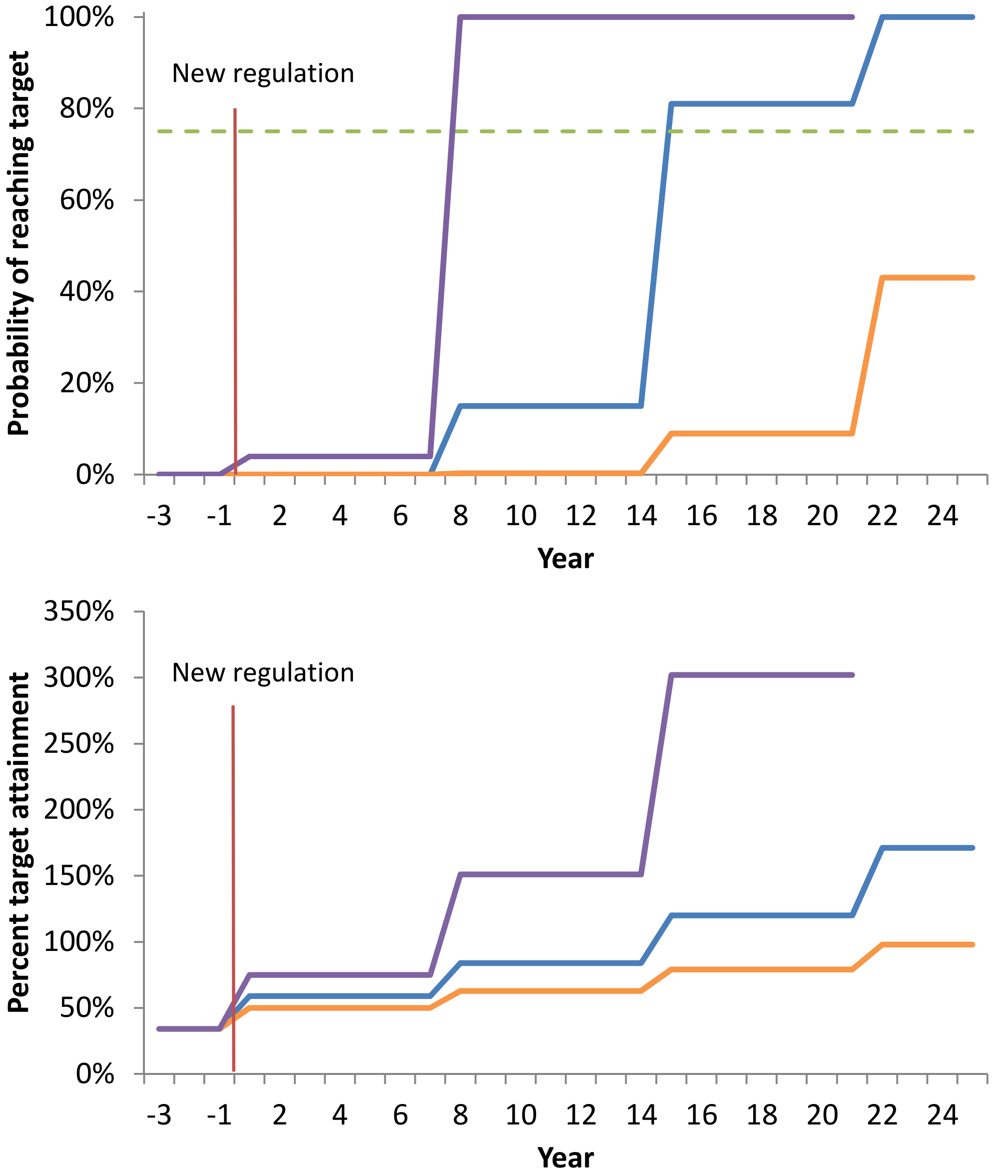


Figure 56. Stock recovery trajectories for Iešjohka, corresponding to three scenarios of reduced river exploitation (Tana main stem + Iešjohka). (Orange) A 20 % reduction, (Blue) a 30 % reduction, and (Purple) a 50 % reduction. Upper panel depicts the development in probability of reaching the spawning target, bottom panel the development in percentage target attainment. The green dotted line represents the 75 % probability line.

5.5.10 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.

5.5.10.1 STATUS ASSESSMENT

The catch in Anárjohka/Inarijoki (including tributaries) varied from 1 908 kg (2011) to 4 285 kg (2012) in the period 2006-2014.

There is no fish monitoring in Anárjohka/Inarijoki, so the target evaluation must be based on an estimated exploitation rate in combination with catch statistics. The following exploitation estimates (based on number of fish) were used in the period 2004-2014: **30 % (20 %-50 %)**.

This exploitation estimate is somewhat lower than the estimates used in Kárášjohka and Iešjohka.

The revised 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 9 950 kg (7 464-14 927 kg) when using a fixed fecundity of 1 800 eggs kg^{-1}, and 7 937 kg (5 928-11 906 kg) when using stock-specific fecundities.

Based on a fixed fecundity level of 1 800 eggs kg^{-1}, percentage target attainment varied from 21 % (2011) to 47 % (2012) in the period 2006-2014 (Figure 57). The average attainment over the last four years was 35 %. The probability of reaching the spawning target was 0 % for all years, and, accordingly, the management target (last 4 year average probability of reaching the spawning target) was also 0 %.

Target attainment increased somewhat when using the stock-specific fecundity levels, varying from 26 % in 2011 to 59 % in 2012. The average attainment over the last four years was 44 %. The probability of reaching the spawning target the last four years (2011-2014) was 0 % in all years except 3 % in 2012. The management target (last 4 year average probability of reaching the spawning target) becomes 0 %.

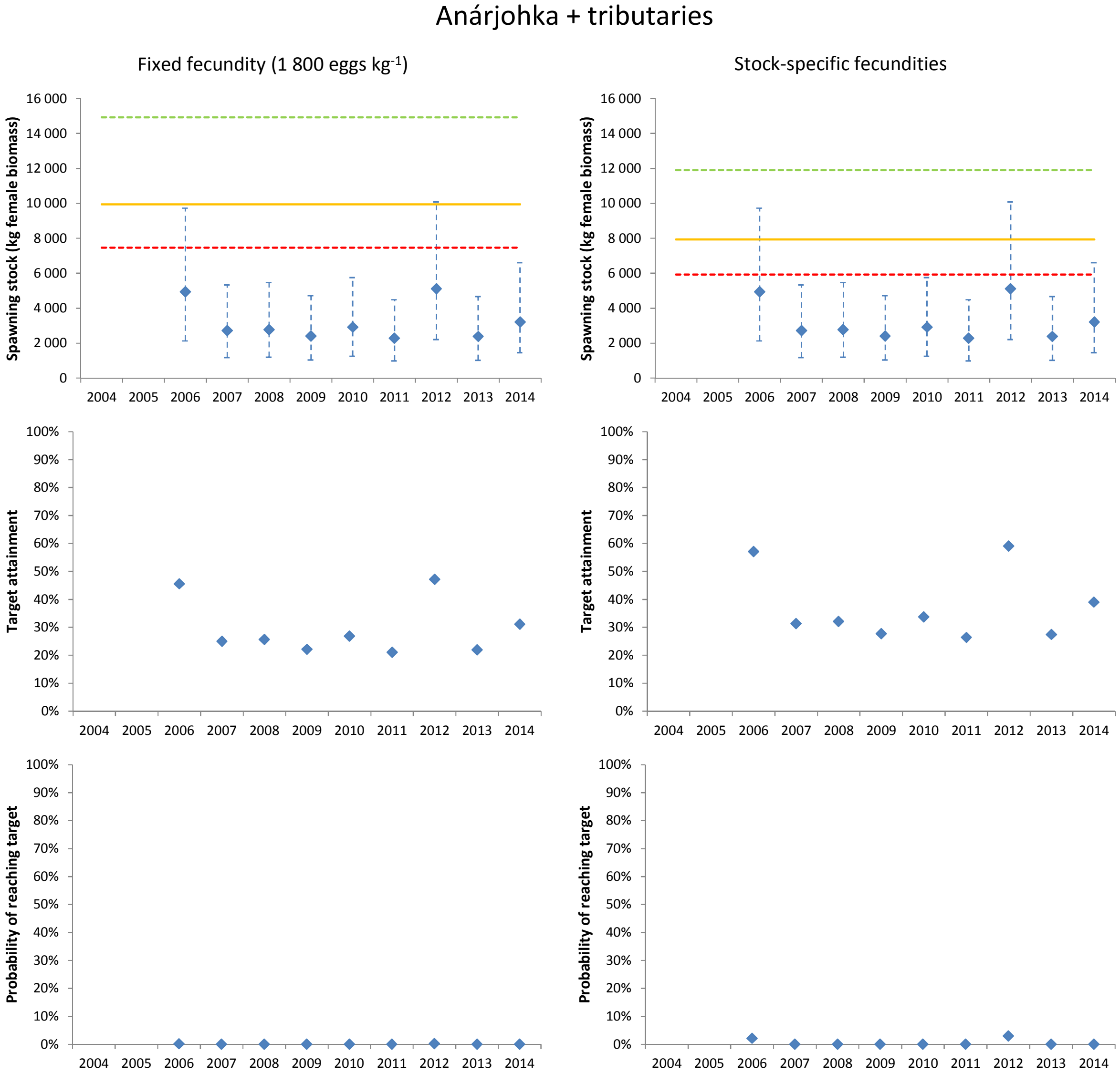


Figure 57. The estimated spawning stock (upper row), percent target attainment (middle row) and probability of reaching the target (bottom row) in the period 2006-2014 in the common headwater river Anárjohka/Inarijoki (including Norwegian and Finnish tributaries). The left column is based on a fixed fecundity of 1 800 eggs kg^{-1}, the right column is based on stock-specific fecundities.

5.5.10.2 EXPLOITATION

The estimated total exploitation rate (based on weight) of Anárjohka/Inarijoki salmon was 74 % in the years 2006-2014 (Figure 52), with 16 % of the pre-fishery abundance caught in coastal fisheries, 47 % in main stem fisheries and 11 % in Anárjohka/Inarijoki itself. The average estimated total pre-fishery abundance was 23 777 kg and the average total catch was 17 687 kg in the period 2006-2014.

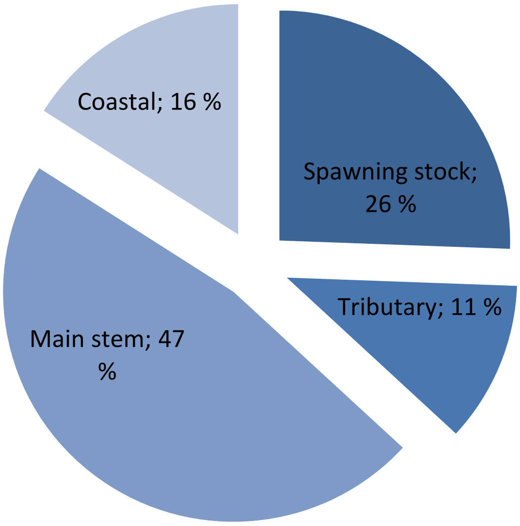


Figure 58. The total amount of salmon belonging to Anárjohka/Inarijoki (+tributaries) in 2006-2014, distributed into surviving spawning stock and salmon caught in fisheries in either coastal, main stem or within-tributary fisheries. The percentages in the figure represent the proportion of the pre-fishery 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 the period 2006-2014 were:

Coastal:	16 %
Tana main stem:	56 %
Within Anárjohka/Inarijoki:	31 %

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 divided by the estimated amount of salmon that have survived the coastal fisheries.

The average overexploitation was estimated at 57 %. This means that exploitation was responsible for reducing the spawning stock size by an amount of 57 % below the spawning target. The average maximum sustainable total exploitation rate in the period was 37 %.

5.5.10.3 STOCK RECOVERY

In the years 2006-2014, the average probability that the spawning target was reached in Anárjohka/Inarijoki was 1 %. A significant reduction in the total exploitation rate is therefore needed to improve status.

The average spawning stock size in the period 2006-2013 was 3 182 kg (1 384-6 311 kg). With the current exploitation estimates, we would need a spawning stock size of almost 9 400 kg to reach a 75 % probability of meeting the spawning target and approximately 13 000 kg to reach 100 % probability. In the years 2006-2014, we have, therefore, on average lacked a female biomass of approximately 6 200 kg in order to reach the 75 % probability level specified by the management target.

With a 20 % reduction in river exploitation, we would not achieve a 75 % probability of reaching the spawning target by the end of the recovery period simulated in Figure 59 (25 years). With a 30 % reduction, the stock recovery period would last 2 generations (14 years), and with a 50 % reduction 1 generation (7 years).

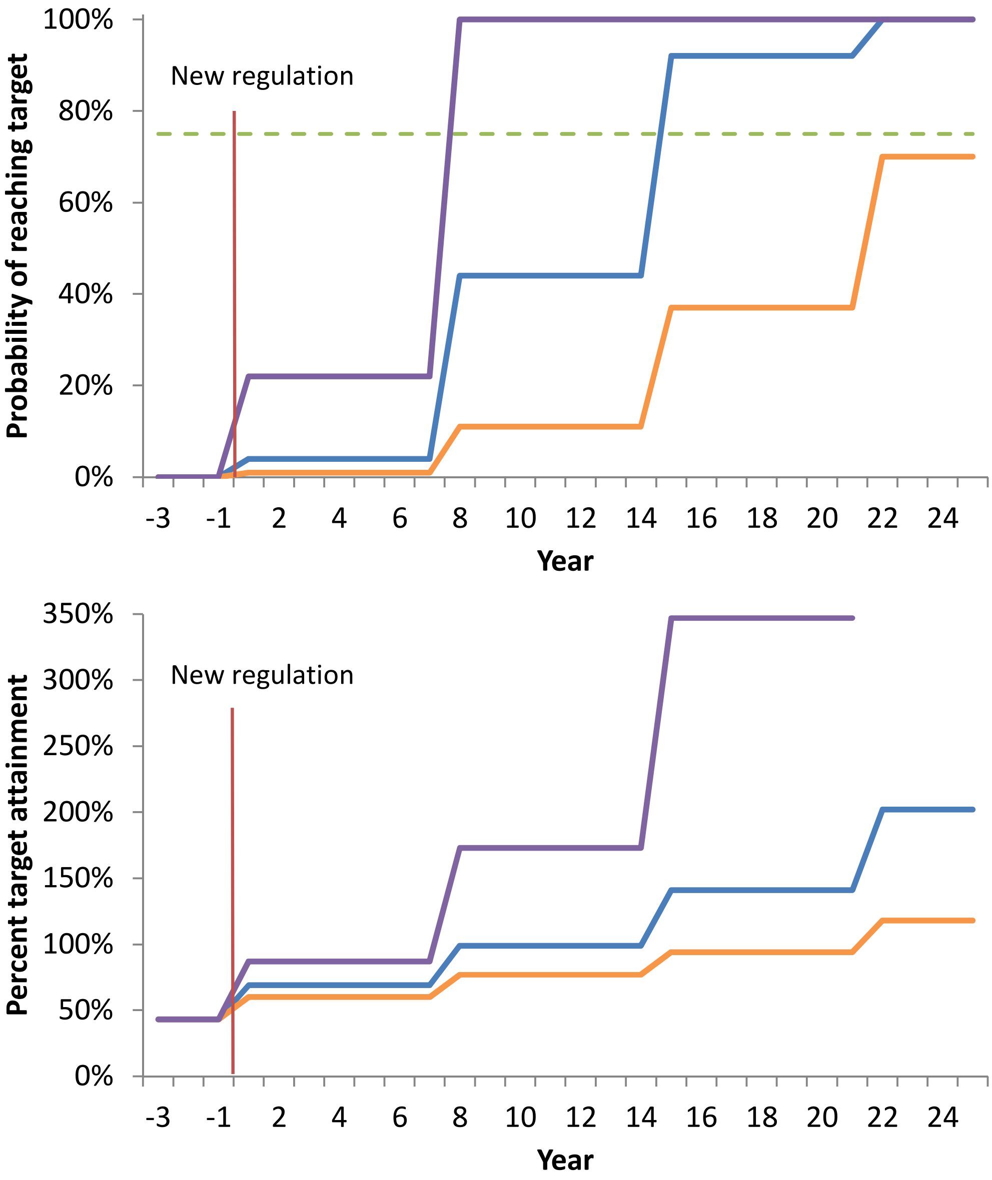


Figure 59. Stock recovery trajectories for Anárjohka/Inarijoki, corresponding to three scenarios of reduced river exploitation (Tana main stem + Anárjohka/Inarijoki). (Orange) A 20 % reduction, (Blue) a 30 % reduction, and (Purple) a 50 % reduction. Upper panel depicts the development in probability of reaching the spawning target, bottom panel the development in percentage target attainment. The green dotted line represents the 75 % probability line.

5.5.11 TANA/TENO (TOTAL)

5.5.11.1 STATUS ASSESSMENT

This particular 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. This 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 total salmon catch in Tana varied from 63.5 tonnes (2009) to 248.5 tonnes (2001) within the period 1993-2014.

The following exploitation rates were used to estimate spawning stock size in Tana throughout the period 1993-2014: **60 % (50 %-75 %)**.

The revised Tana total spawning target is 104 487 286 eggs (77 005 421-155 648837 eggs). The female biomass needed to obtain this egg deposition is 58 048 kg (42 781-86 472 kg) when using a fixed fecundity of 1 800 eggs kg^{-1}, and 51 846 kg (38 277-77 371 kg) when using stock-specific fecundities.

Based on a fixed fecundity level of 1 800 eggs kg^{-1}, percentage target attainment varied from 36 % in 2009 to 100 % in 2000-2002 within the period 1993-2014 (Figure 60). The average attainment over the last four years was 56 %. The probability of reaching the spawning target varied from 0 % (1996, 1997, 2004, 2005, 2009, 2011, 2013) to 87 % (2001). With the fixed fecundity level, the management target (last 4 year average probability of reaching the spawning target) becomes 1 % for the period 2011-2014.

Target attainment increases when using stock-specific fecundity levels, varying from 40 % in 2009 to 100 % in 2000-2002. The average attainment over the last four years was 62 %. The probability of reaching the spawning target varied between 0 % (2004, 2005, 2009, 2011, 2013) to 100 % (2001) throughout the period 1993-2014. With the stock-specific fecundities, management target (last 4 year average probability of reaching the spawning target) becomes 2 %.

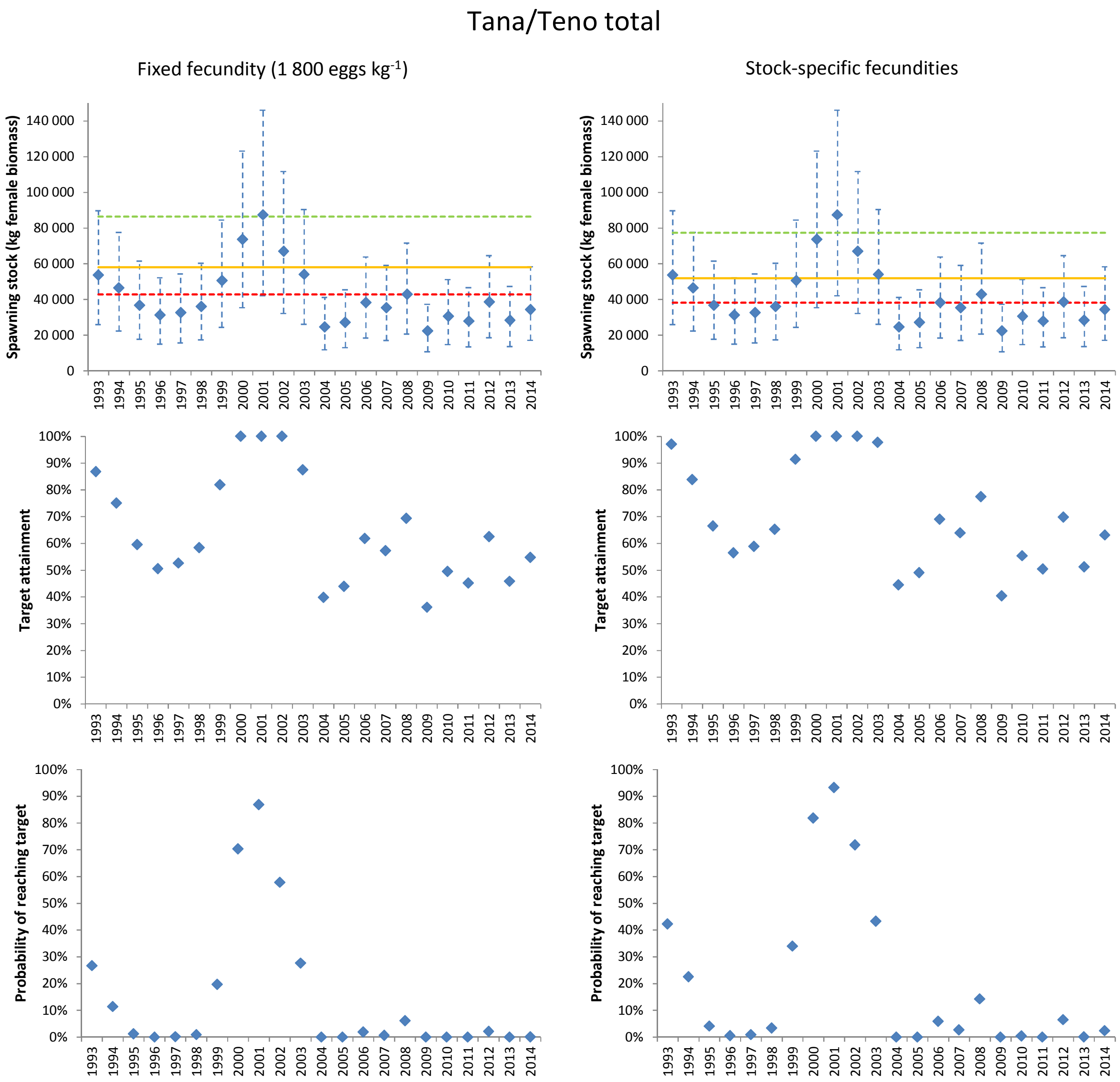


Figure 60. The estimated spawning stock (upper row), percent target attainment (middle row) and probability of reaching the target (bottom row) in the period 1993-2014 in total in Tana/Teno. The left column is based on a fixed fecundity of 1 800 eggs kg^{-1}, the right column is based on stock-specific fecundities.

5.5.11.2 Exploitation

The estimated total exploitation rate (based on weight) of Tana salmon was 66 % in the years 2006-2014 (Figure 61), with 16 % of the pre-fishery abundance caught in coastal fisheries and 50 % in river fisheries. The average estimated total pre-fishery abundance was 188 660 kg and the average total catch was 124 665 kg in the period 2006-2014.

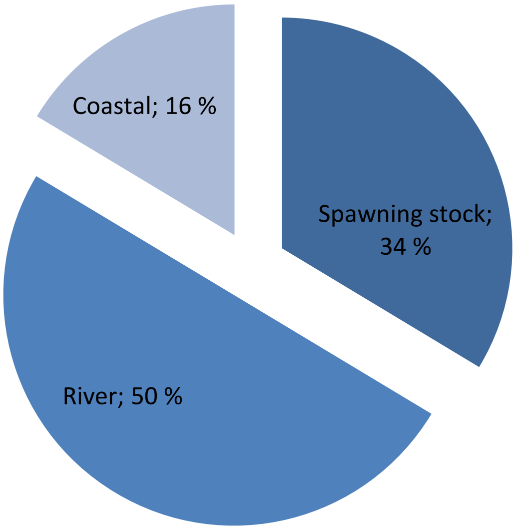


Figure 61. The total amount of salmon belonging to the Tana river system in 2006-2014, distributed into surviving spawning stock and salmon caught in fisheries in either coastal or river fisheries. The percentages in the figure represent the proportion of the pre-fishery abundance that survives to spawning or are caught in coastal or Tana river system fisheries.

Estimated relative exploitation efficiencies (based on weight) in areas in the period 2006-2014 were:

Coastal:	16 %
Tana river system:	60 %

5.5.11.3 STOCK RECOVERY

In the years 2006-2014, the average probability that the spawning target for the entire Tana/Teno river system was reached was 3 %. This means that the entire river system needs a significant reduction in exploitation to improve overall status.

The average spawning stock size in the period 2006-2014 was 33 206 kg (16 038-55 548 kg). With the current exploitation estimates, we would need a spawning stock of close to 66 000 kg in order to reach a 75 % probability of meeting the spawning target and over 108 000 kg to reach 100 % probability. In the years 2006-2014, we have, therefore, on average lacked a female biomass of approximately 33 000 kg in order to reach the 75 % probability level specified by the management target.

With a 20 % reduction in river exploitation, we would exceed a 75 % probability of reaching the spawning target after 3 generations (21 years, Figure 62). With a 30 % reduction, the stock recovery period would last 1 generation (7 years), and with a 50 % reduction we would exceed a 75 % probability immediately.

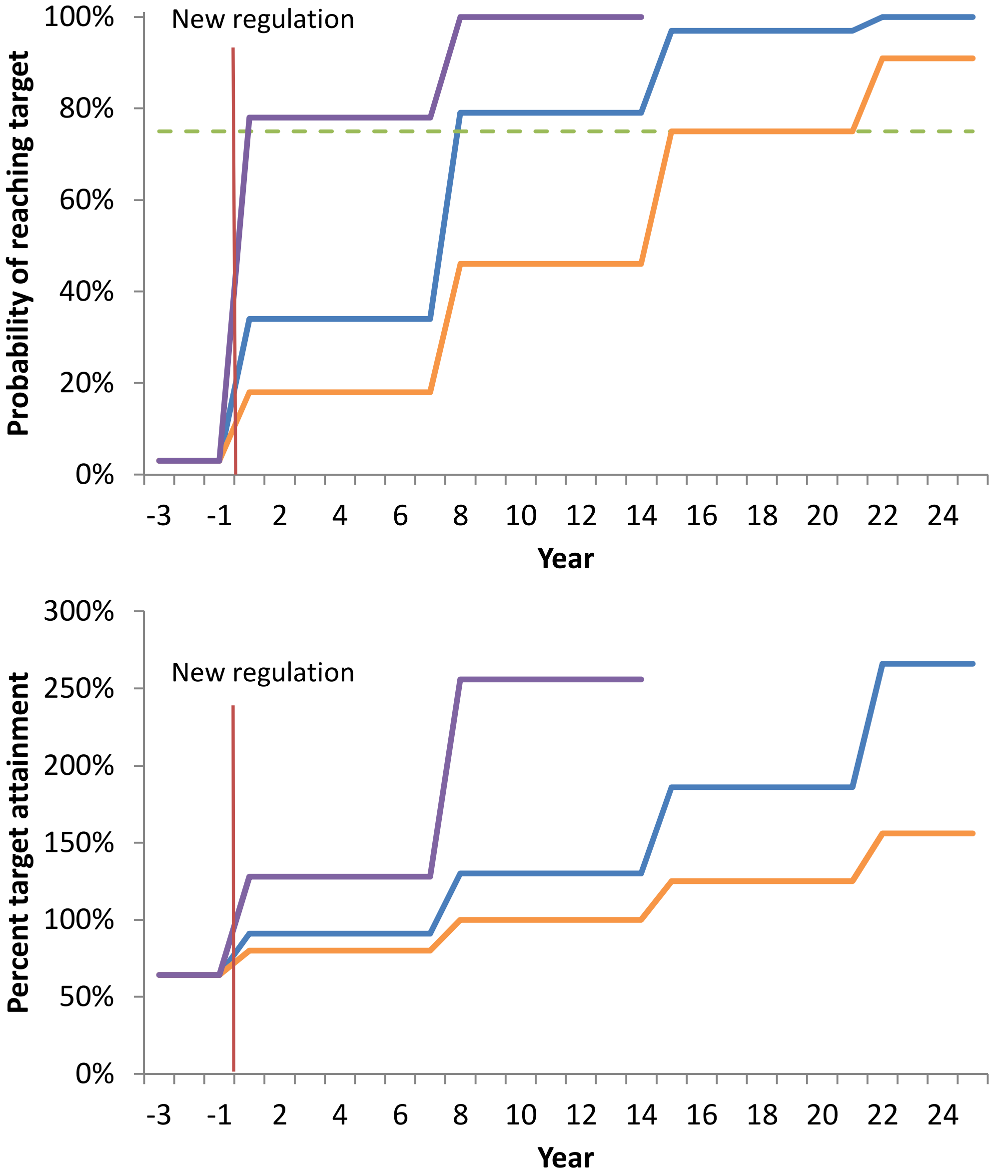


Figure 62. Stock recovery trajectories for Tana/Teno (total), corresponding to three scenarios of reduced river exploitation. (Orange) A 20 % reduction, (Blue) a 30 % reduction, and (Purple) a 50 % reduction. Upper panel depicts the development in probability of reaching the spawning target, bottom panel the development in percentage target attainment. The green dotted line represents the 75 % probability line.

5.5.12 SUMMARY OF STOCK STATUS AND EXPLOITATION PATTERNS

Stock status over the last 4 years (2011-2014) was poor in 7 of the 10 stocks that we evaluated (Figure 63). The best status was found in Ohcejohka/Utsjoki, followed by Váljohka and Akujoki. All of these are low-exploitation tributaries, either partly (Utsjoki) or as a whole (Akujoki and Váljohka). The poorest stock status was found in the upper main headwater areas of Kárášjohka, Iešjohka and Anárjohka/Inarijoki, all of which had low target attainment and low exploitable surplus.

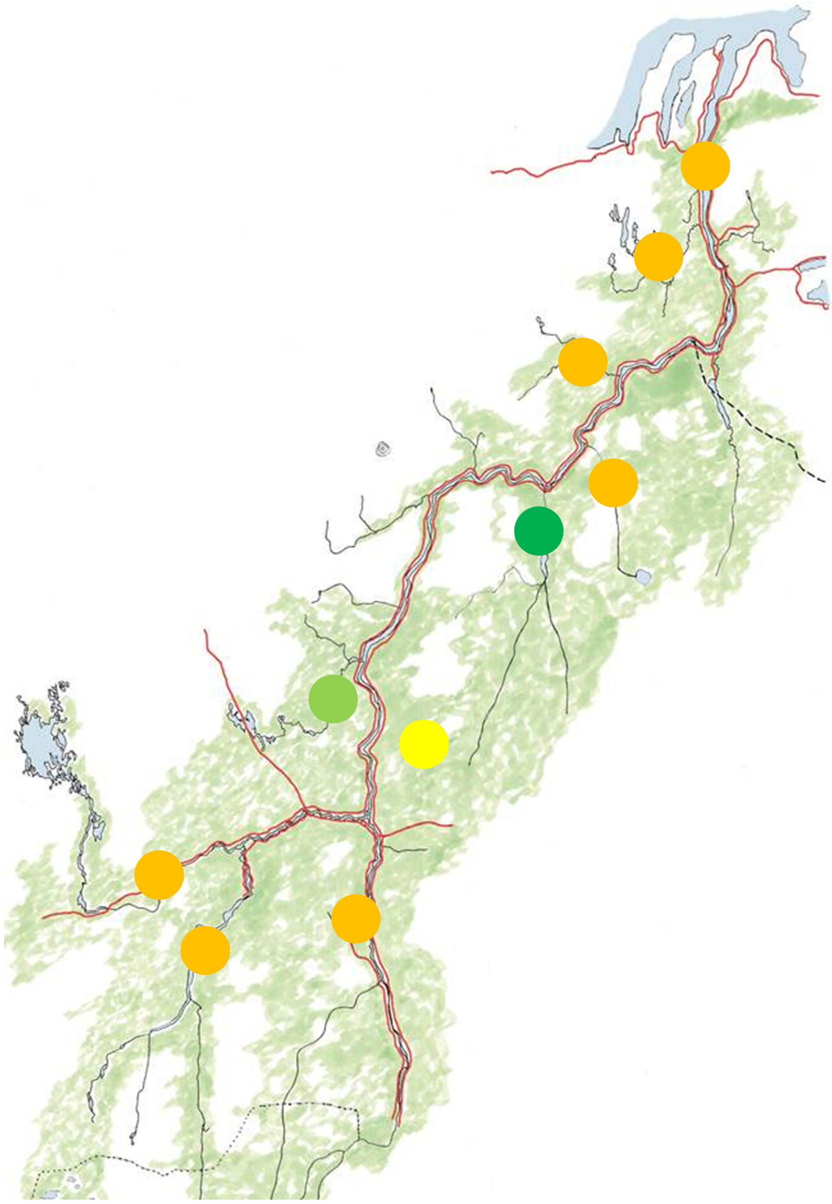


Figure 63. Map summary of the 2011-2014 stock status of the evaluated parts of the Tana river system. Symbol colour designates stock status over the last four years. Dark green = average probability of attaining spawning target higher than 75 %, average target attainment over 140 %. Light green = average probability of attaining spawning target higher than 75 %. Yellow = average probability of attaining spawning target between 40 and 74 %, average target attainment above 75 %. Orange = average probability of attaining spawning target below 40 %, stock has had an exploitable surplus in at least 3 of the last 4 years. Red = an exploitable surplus in less than 3 of the last 4 years.

Overexploitation had either a moderate or a large effect in all evaluated parts of the Tana, except Váljohka (Figure 64).

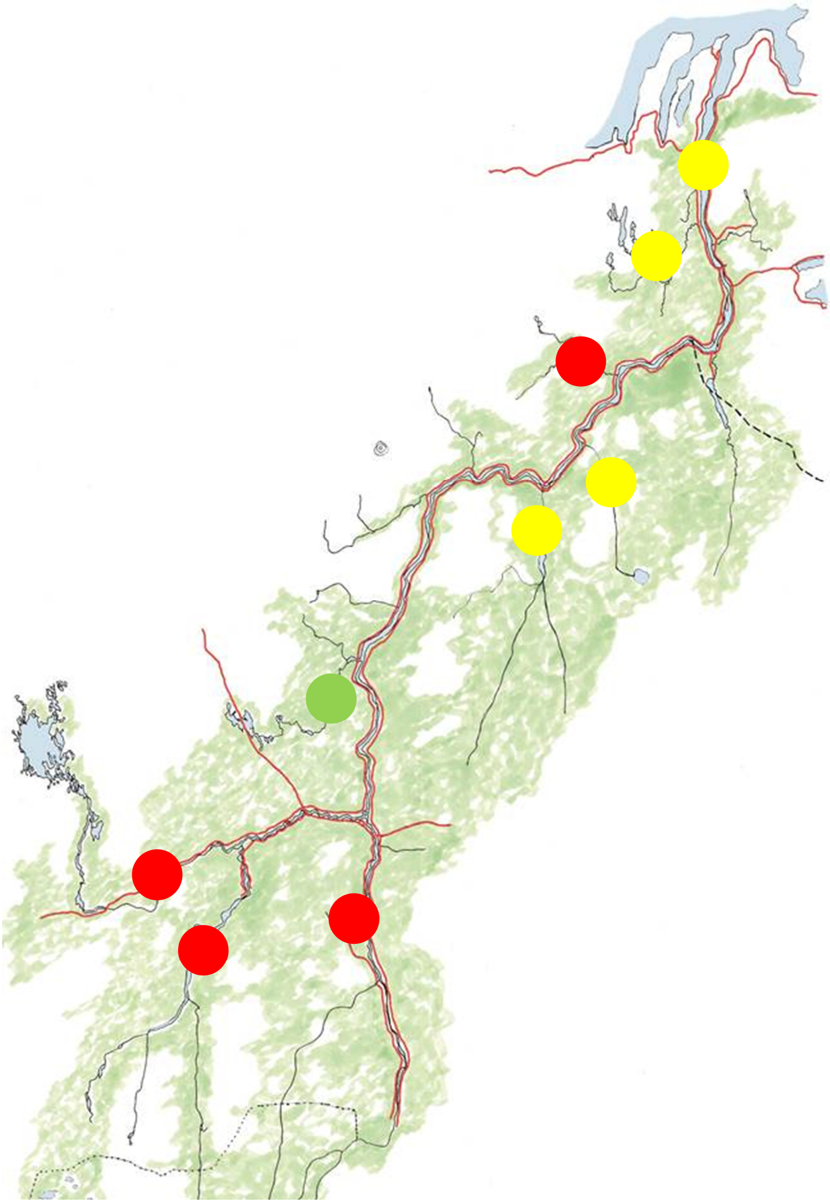


Figure 64. Map summary of the estimated overexploitation experienced in various parts of the Tana river system in the years 2006-2014. Symbol colour represents the extent of the overexploitation (in terms of percentages of the spawning target). Dark green = no effect (0 % of the spawning target), light green = small effect (<10 %), yellow = moderate effect (10-30 %), red = high effect (>30 %).

6 DESIGN AND IMPLEMENTATION OF A STOCK-SPECIFIC MONITORING PROGRAMME IN TANA

6.1 BACKGROUND

Riverine and coastal areas of the Tana River represent one of the world's most important systems for Atlantic salmon, and are by far the most important for Atlantic salmon in Norway and Finland. As indicated in the chapter on threat factors (chapter 3), fisheries in and outside the river represent the main factor affecting the salmon. Hydropower development, pollution or fish farming do not exist in or near the Tana River. There are strong indications that several salmon stocks in the Tana system are significantly overharvested, and mixed stock fisheries, both in coastal areas of Finnmark, and in different parts of the Tana River represent major challenges for future management of the Tana salmon.

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 fail to meet the designated target. This procedure turns the management into an adaptive knowledge-based regime which is transparent and predictable in its decision-making, away from the much more abstract, obscure and rigid traditional regime that current regime that has proven to be insufficient in stopping the negative development in many stocks in the river system.

The present report points towards a target-driven knowledge-based adaptive management which should be fully adopted in the Tana system in the future. Such a management regime puts great demands on the level of monitoring and research that is needed, especially since most of the fisheries in Tana are mixed-stock fisheries. A mixed-stock fishery greatly complicates the management of each stock. Stocks differ in their status, with some stocks doing significantly worse than others. Without detailed exploitation knowledge, the only way to counteract this would be to carefully control the overall exploitation rate in the mixed-stock fishery to ensure the conservation of less-productive stocks within an area of mixed-stock fishery. Overexploitation will, eventually, push the numbers of returning salmon stocks below sustainable levels, and as salmon abundance declines, diversity and resilience are reduced and risk of extinction is increased.

Fish management basically consists of the following four questions:

1) For each stock present in the Tana river system, how many fish should survive to spawn each year?
2) What is the pre-fishery abundance of each stock?
3) Given points 1 and 2, how many fish can then be caught from each stock?
4) And following point 3, where should these fish be caught?

These questions and their implications are summarized in Figure 65. The main challenge for a monitoring programme is to be able to provide accurate information on stock-specific pre-fishery abundance, exploitation and spawning stock size. A detailed discussion on how to achieve some of this is provided in the report from the Norwegian-Finnish temporary working group on monitoring and research in Tana (Johansen *et al*. 2008), and most of this discussion still applies today. A further summary of this discussion is provided in the rest of this chapter.

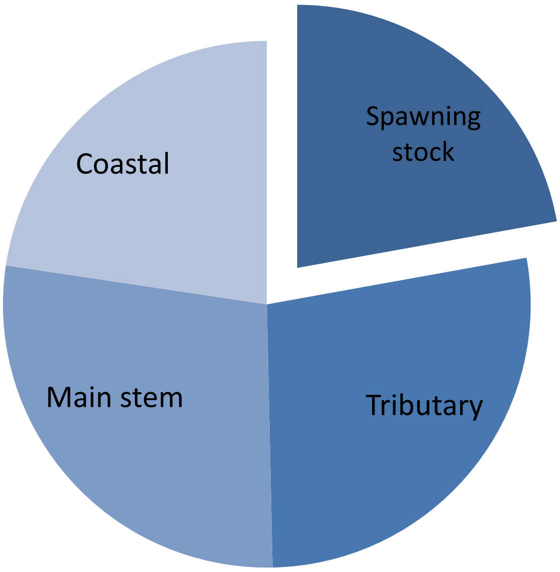


Figure 65. The figure shows how management of a stock really is about allocation. The whole pie chart represents the pre-fishery abundance of a stock, with a proportion caught in different fisheries (coastal, main stem and tributary in this case). The surviving remainder represents the spawning stock size, which should be compared with the stock management target. Ideally, the allocation of catch in different fisheries should be controlled so that the surviving spawning stock remains larger than the target. The pre-fishery abundance will fluctuate from year to year, meaning that the surplus available for exploitation also will vary.

6.2 CATCH STATISTICS

Accurate catch and fisheries statistics form a fundamental part of the stock monitoring, and both countries should establish routines that ensure a comprehensive and detailed statistic is available relatively quickly after each fishing season. This is such a fundamentally important issue that we therefore are not including it as part of an actual monitoring programme.

6.3 IMPLEMENTATION PLAN FOR A TANA STOCK MONITORING PROGRAMME

We have designed the monitoring programme in order to cover the following three core areas of information that are all necessary to follow the Tana salmon recovery on a stock-specific basis, while still allowing for a fairly large-scale salmon fishery:

1) **Stock-specific status assessment** (spawning escapement compared to target)
2) **Stock-specific exploitation patterns** (especially in areas of mixed-stock fisheries)
3) **Juvenile production** (i.e. the resulting production of the spawning escapement)

This will be achieved with three main monitoring methods:

1) **Fish counting**, either ascending number of adult salmon or spawner counts.
2) **Main stem catch samples**, in the form of scale samples that provide life history data and genetic stock identification.
3) **Electrofishing**

The monitoring programme design is based on a system of index rivers that have been selected to reflect the status and exploitation seen in different parts of the river system, from the lowermost part of Tana to the uppermost headwater areas. The monitoring will provide data on exploitation effects starting with the Tana river mouth. All stocks in Tana are also affected by mixed-stock coastal fisheries along the coast of Nordland, Troms and Finnmark, but these fisheries are outside the scope of the programme defined in this report.

6.4 STOCK-SPECIFIC STATUS ASSESSMENT USING A SYSTEM OF INDEX RIVERS

The basis of the status assessment is a stock-specific comparison between number of spawners after the fishing season and the stock spawning target. To achieve this, fish counting must be performed at some point. There are several possibilities here:

1) Counting spawners after the fishing season. This provides a direct estimate of target attainment.
2) Counting the fish entering a tributary and then use the tributary catch statistic to estimate the number of spawners.
3) Counting the number of fish in the Tana main stem and use a combination of catch statistics and genetic stock identification of mixed-stock fishery catch samples to estimate exploitation rates and, subsequently, spawning stock size.

Logistically and technically, fish counting in the Tana main stem remains a daunting task, and it is therefore our current recommendation to focus the counting on tributaries and then use genetic stock identification of main stem catch samples to estimate stock-specific Tana main stem exploitation effects. It is, however, possible to do main stem counting in the Tana, and the methods and resources involved in this should be examined more closely. Actual spawner counts can be obtained in smaller tributaries, but this is logistically difficult in larger tributaries.

There is substantial variation in the exploitation rates experienced by different stocks in different fisheries within the Tana river system. For instance, the Tana main stem exploitation of salmon from Máskejohka is much lower than the Tana main stem exploitation of salmon from Iešjohka. The main reason for this is different migration distances in the Tana main stem. A short migration distance (tributaries in the lower part of Tana) leads to a low main stem exploitation rate, while a longer migration distance (tributaries in the middle and, especially, upper parts of Tana) leads to a higher main stem exploitation rate. Because of this, we need a spatial distribution of the fish counting.

We therefore propose dividing the Tana into three different monitoring areas:

1) The lower Norwegian part of the Tana main stem
2) The common border area of the Tana main stem
3) Upper Tana (the three main headwater rivers Anárjohka, Kárášjohka and Iešjohka)

This geographical distribution will also be of invaluable help in the evaluation of the exploitation in various parts of the main stem mixed-stock fishery, as the localization of fish counting in tributaries in each of the three monitoring areas allows us to more finely calibrate exploitation rate estimates of different parts of the Tana main stem.

6.4.1 LARGE INDEX RIVERS

We propose five large index rivers with continuous fish counting in Tana:

1) Lower part:
   a. **Máskejohka** (N). This is a medium sized river that could potentially be counted with video, but as the river flows through areas with lots of clay there are long periods of low water visibility that excludes video as an effective solution. Ascending salmon must therefore be counted acoustically with an echo-sounder.
2) Middle part:
   a. **Lákšjohka** (N). Video cameras have been operated in this tributary since 2009.
   b. **Utsjoki** (F). Video cameras have been operated in this tributary since 2002.
3) Upper part:

a. **Kárášjohka** (N). This is a large-sized tributary in the upper part, and forms the Tana main stem at its confluence with Anárjohka. The size of this river precludes the use of video, and the ascending salmon must therefore be counted acoustically with an echo-sounder.
b. **Anárjohka/Inarijoki** (N/F). The size of this river precludes the use of video, and the ascending salmon must therefore be counted acoustically with an echo-sounder. The run timing of Anárjohka/Inarijoki differs from the neighbouring Kárášjohka and Iešjohka. The latter two tributaries have early-migrating salmon, whereas the run-timing of Anárjohka/Inarijoki-salmon is later, comparable to the run-timing of Tana main stem salmon.

In addition, we propose video counting in three additional tributaries: Vetsijoki, Váljohka and Goššjohka. These could be covered in a rolling plan in which each river was counted every third year.

6.4.2 SMALL INDEX RIVERS

As a supplement to the large index rivers, we recommend having annual spawner counts in a two small tributaries. These smaller rivers can be covered very cost-efficiently with snorkelling and are, accordingly, much easier to monitor than the larger rivers.

The following tributaries are suggested:

1. Upper parts of the **Pulmanki**-system (F)
2. **Akujoki** (F)

6.5 CONTROLLING THE TANA MAIN STEM MIXED-STOCK FISHERY

The complex stock situation in Tana, with 20-30 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 are able to 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, different times of the season and different life history classes.

Taken together, the following annual monitoring activities will provide the necessary knowledge to control 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.

6.6 JUVENILE PRODUCTION

Juvenile assessments using electrofishing is a cost-effective monitoring method that has been used in the Tana river system since 1979 with a total of 57 sites being annually monitored. These sites are spaced out in the Tana main stem, the river Inarijoki/Anárjohka and the river Utsjoki/Ohcejohka. This program has provided data on changes in juvenile salmon production (densities), occurrence and densities of other fish species, and long-term growth variations of juveniles.

In addition, frequent electrofishing mapping surveys have been undertaken in most Tana tributaries. Surveys like this are potentially highly informative for assessments of spawning and territory saturation, which is an important part of the evaluation of target attainment in various parts of the Tana river system.

6.7 OVERALL MONITORING OUTPUT

The monitoring outlined here is designed to be complementary, and taken together, the three approaches (fish counting in tributaries, main stem catch sampling, juvenile production) provide a complete basis for:

1) Stock-specific evaluations of spawning target attainment
2) Stock-specific evaluations of exploitation rates in the main stem mixed-stock fishery
3) Stock-specific evaluations of the effects of different regulations as they are implemented

The approaches are mutually beneficent but also mutually dependent, e.g. the evaluation of the main stem mixed-stock fishery depends highly on the existence of fish counting in tributaries as those counts serve as a calibration for the relative exploitation rates seen in the main stem catch samples.

6.8 DATA INFRASTRUCTURE, SHARING AND DATABASES

The monitoring programme outlined above will generate large amount of data on a variety issues important for sustainable management of the Tana stocks. The collected information will doubtless continue to be important, and it is of great importance that these data are available for future management and research. We strongly recommend that infrastructure and routines for data sharing and storage are established to ensure that these important data are not corrupted or lost. Such measures will ensure transparency regarding the scientific basis of the bilateral management, and shared access to data will further prevent the possibility of misgiving between the two countries in regard to data interpretation.

6.9 MONITORING AND MID-SEASON VS. END-OF-SEASON EVALUATIONS

The suggested monitoring programme is mainly tailored towards fulfilling the needs of a comprehensive annual assessment where stock status is evaluated in the winter between fishing seasons. There are additional challenges involved in designing a monitoring programme that also can provide faster information during the fishing season, and the framework and logistics of this need further consideration.

6.10 MONITORING ACTIVITIES AND COST ESTIMATES

In the following tables, monitoring activities are summarized with current cost estimates. The cost estimates are based on joint Norwegian-Finnish participation in the monitoring, with an estimated cost of joint proposals (Norwegian and Finnish institutes together) within a competitive bidding framework with open calls for the different monitoring tasks.

In summary, the annual cost estimates in the tables below are € 310 000 for fish counting, € 200 000 for monitoring the main stem mixed stock fishery and € 85 000 for monitoring of juvenile production. Total annual running cost then becomes € 595 000.

There are some additional annual costs not directly related to the monitoring tasks below. Foremost are the costs associated with running the Norwegian-Finnish working group on salmon monitoring and research in the Tana river system. Current annual running costs to meet the working group mandate on the Norwegian side are € 50 000. The second additional cost estimate below concerns specific research needs that might arise from year to year.

6.10.1 FISH COUNTING

	Method	Investment costs	Annual costs	Country
Large index rivers				
Lower part:				
Máskejohka	Acoustic	€ 80 000*	€ 55 000	N
Middle part:				
Lákšjohka	Video	€ 10 000**	€ 45 000	N
Ohcejohka/Utsjoki	Video	€ 20 000**	€ 45 000	F
Upper part:				
Anárjohka/Inarijoki	Acoustic	€ 80 000*	€ 55 000	N/F
Kárášjohka	Acoustic	€ 80 000*	€ 55 000	N
Rolling plan:				
Vetsijoki, Váljohka, Goššjohka	Video	€ 10 000**	€ 45 000	N/F
Small index rivers				
Upper Pulmanki	Snorkelling	€ 1 500***	€ 5 000	F
Áhkojohka/Akujoki	Snorkelling		€ 5 000	F
		€ 281 500	**€ 310 000**	

* Investment costs, acoustic: These are costs that will have to be realized at the start of the monitoring programme. Subsequently, acoustic equipment will have to be replaced at a c. 10 year interval.

** Investment costs, video: These costs will be realized when old equipment needs replacing, at a c. 10 year interval.

*** Investment costs, snorkelling: These are dry suit equipment that must be replaced every second/third year.

6.10.2 MAIN STEM FISHERIES MONITORING

	Collection costs	Analysis costs	Country
Scale sampling programme	€ 50 000	€ 50 000	N/F
Genetic stock identification		€ 100 000	N/F
	€ 50 000	**€ 150 000**	

6.10.3 JUVENILE PRODUCTION

	Investment costs	Annual costs	Country
Electrofishing (long-term sites)	€ 5 000*	€ 35 000	F
Tributary mapping		€ 50 000**	N/F
	€ 5 000	**€ 85 000**	

* Investment costs, electrofishing: These costs will be realized when old equipment needs replacing, at a c. 10 year interval.

** Annual costs, tributary mapping: Most parts of the Tana river system are not covered by the permanent sites. A useful tool for monitoring the stock situation in other tributaries is electrofishing trips. It is therefore proposed to do mapping trips in 2-3 tributaries per year to look at juvenile densities and juvenile distribution. Annual costs here will strongly depend on which tributaries are chosen, the given figure is a rough average of three tributaries covered with a combination of Finnish and Norwegian personnel.

6.11 NORWEGIAN SALMON CENTER IN TANA

Several attempts to establish a salmon center in Tana, the so called Joddu, has been tried during the last decade. Based on an evaluation by a national project group appointed by the Norwegian Environmental Agency in 2013, the Norwegian Parliament allocated NOK 4 mill for 2015. According to the decision by the Parliament, the money allocated for 2015, shall primarily be prioritized for information and collaboration projects in Tana. Presently (August 2015), the detailed frames for the allocation is not decided, but it is expected that the projects in Tana will become a new arena and meeting place for the people and organizations involved in different activities connected to the Tana salmon. The projects will probably be organized in close connection with Tanavassdragets fiskeforvaltning. We also expect that the Working Group on Salmon Monitoring and Research in the Tana River System will be involved in several of the projects that will be started during the last half of 2015.

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