STATUS OF THE RIVER TANA SALMON POPULATIONS

REPORT 1-2014 OF THE

WORKING GROUP ON SALMON MONITORING AND RESEARCH
IN THE TANA RIVER SYSTEM

1 Introduction

This report presents the evaluation of the stock status of various Atlantic salmon populations of the Tana river system. The report is an interim, short update, intended for the current need and use of the Norwegian and Finnish delegations negotiating the revision of the Tana fisheries agreement. The report includes only the general description of the Tana salmon and their catches, and evaluation of the stock status with assessment of the spawning target attainment levels for selected tributaries and the Tana system as a whole. A complete, updated report following the format of the earlier report by the Tana Group (Anon. 2012) will be completed at a later stage.

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 more than 1 200 km (Table 1).

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. In total, there are more than 100 different combinations of smolt age, sea age and previous spawning times. 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 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.

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 by use of polymorphic microsatellite markers high genetic differentiation among stocks from the different tributaries has been revealed (Vähä *et al.* 2007) (Figure 3). DNA microsatellites have indicated pairwise F_{ST}[1] values between inferred populations ranging from 1.5 % to 20.1 % with an average of 9.2 %.

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.

[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.

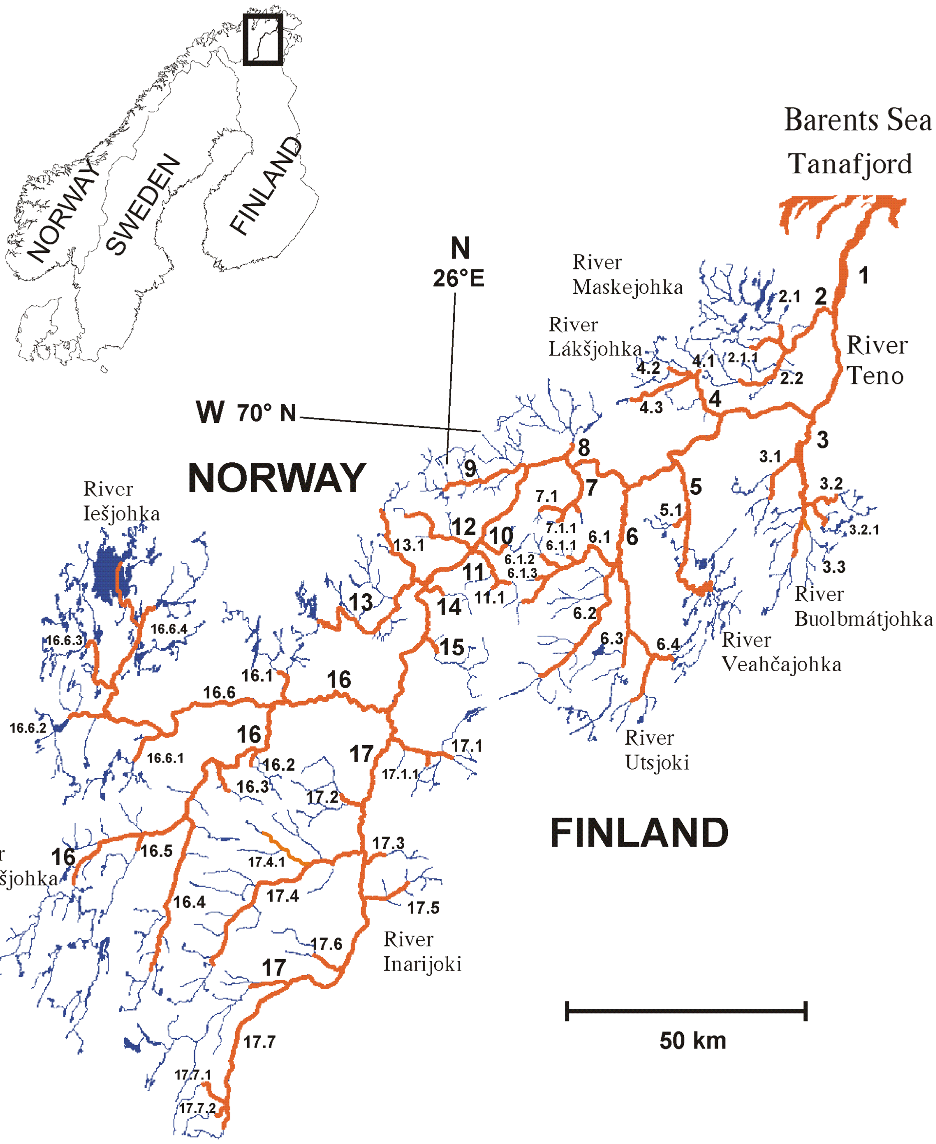

Figure 1. Map of the Tana river system. The orange line indicates the historical distribution of salmon based on historical sources and interviews. The numbers correspond to Table 1. Map from Eero Niemelä, FGFRI.

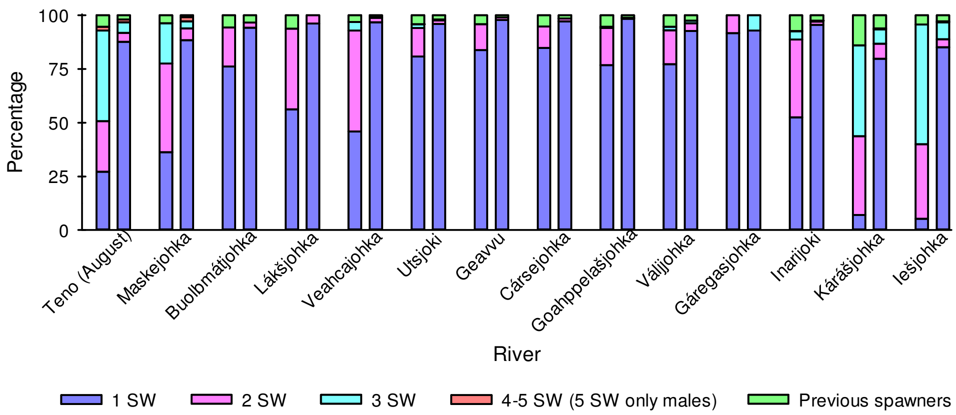

Figure 2. Sea-age distribution of salmon catch in different parts of the Tana river system. Left-hand bars: female salmon; right-hand bars: males. Figure from Niemelä (2004).

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, FGFRI, 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	Njiđgu	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**				

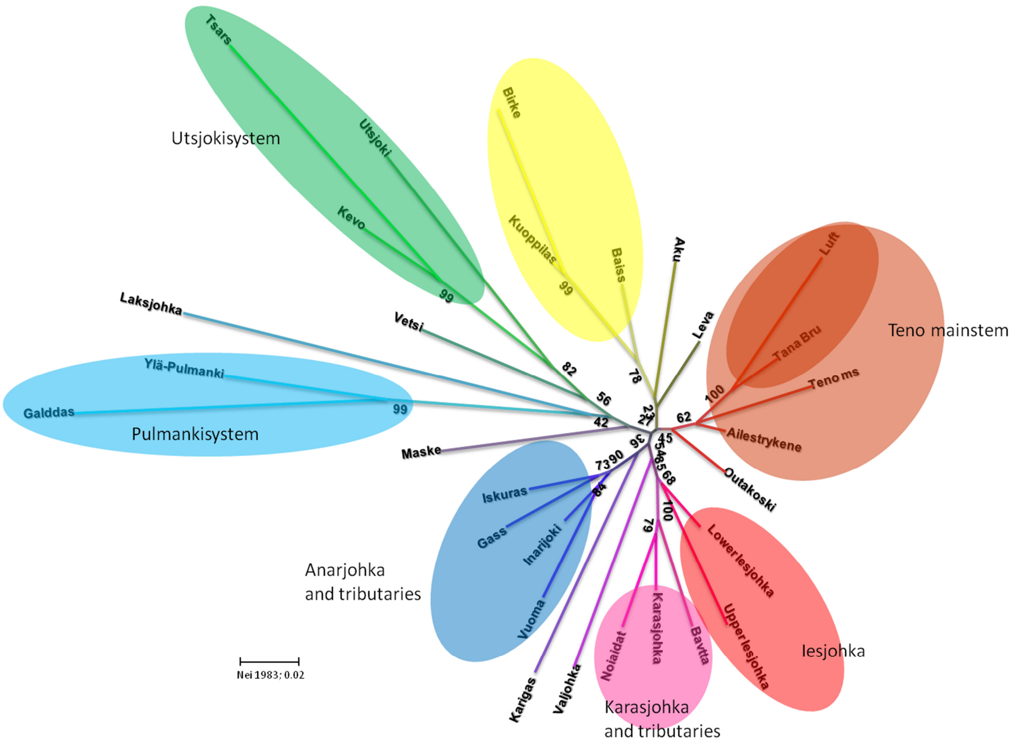

Figure 3. Stock complex of the Tana river system, based on genetic baseline samples from various tributaries and areas (figure from J.-P. Vähä, University of Turku).

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.

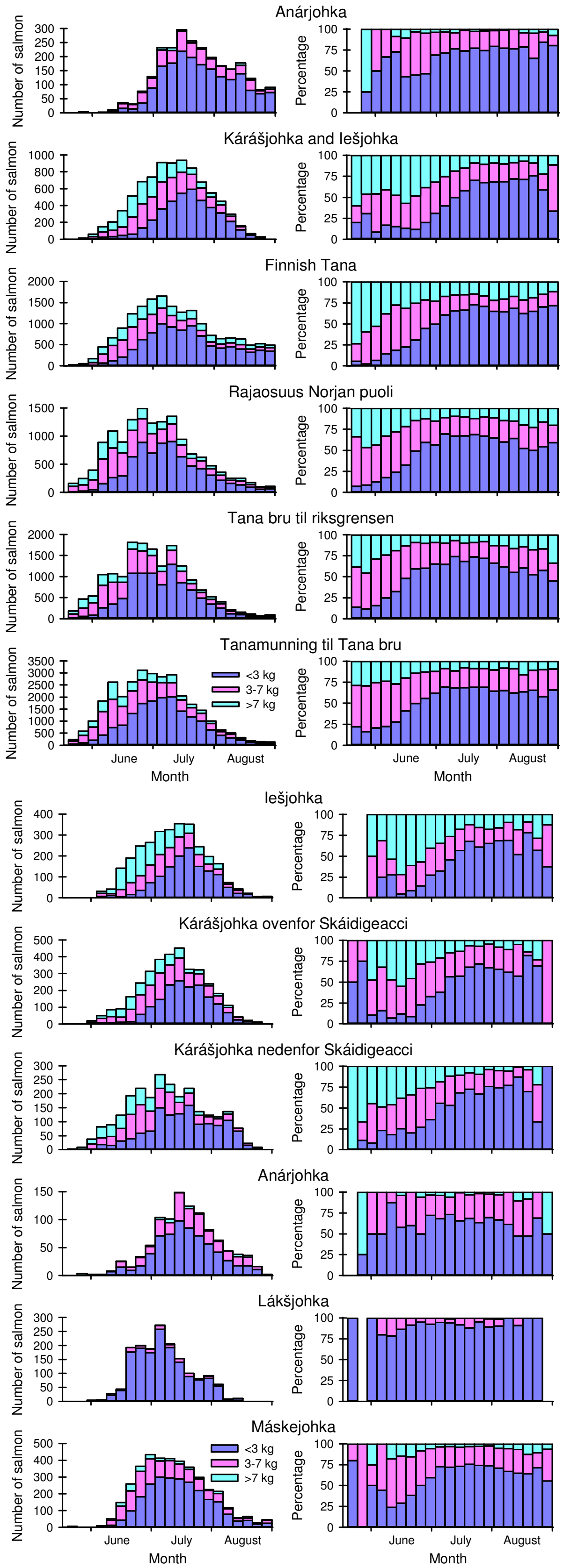

Figure 4. Catch distribution throughout the summer in the different parts of the Tana main stem and some tributaries. Data from the years 2004-2013 are combined.

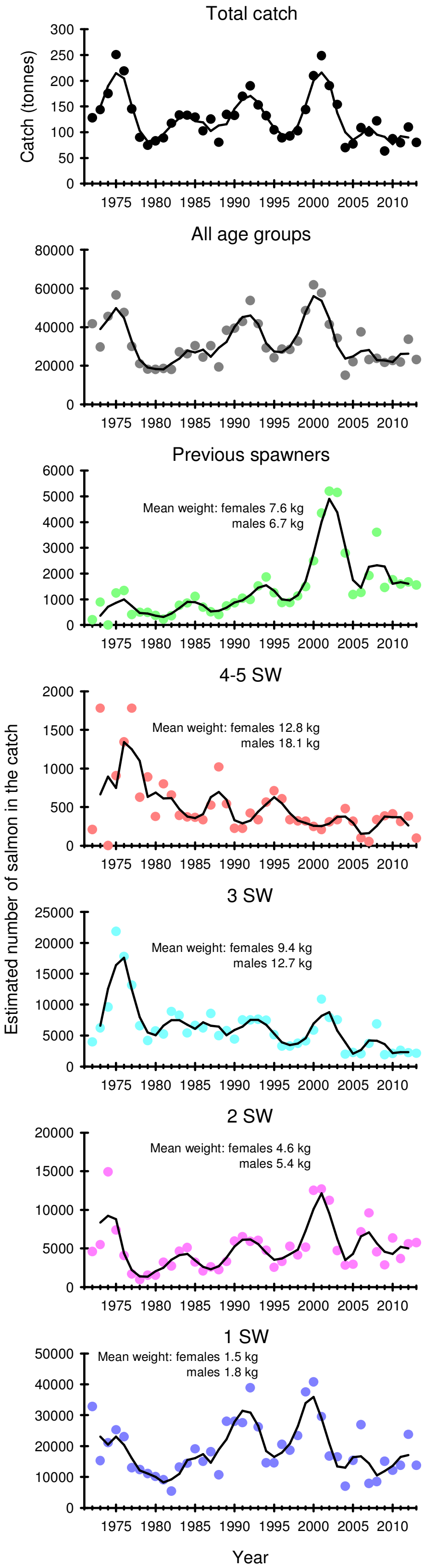

Figure 5. Estimated numbers of captured salmon in different age groups, and the total catch in tonnes.

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 significantly 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*., in prep.).

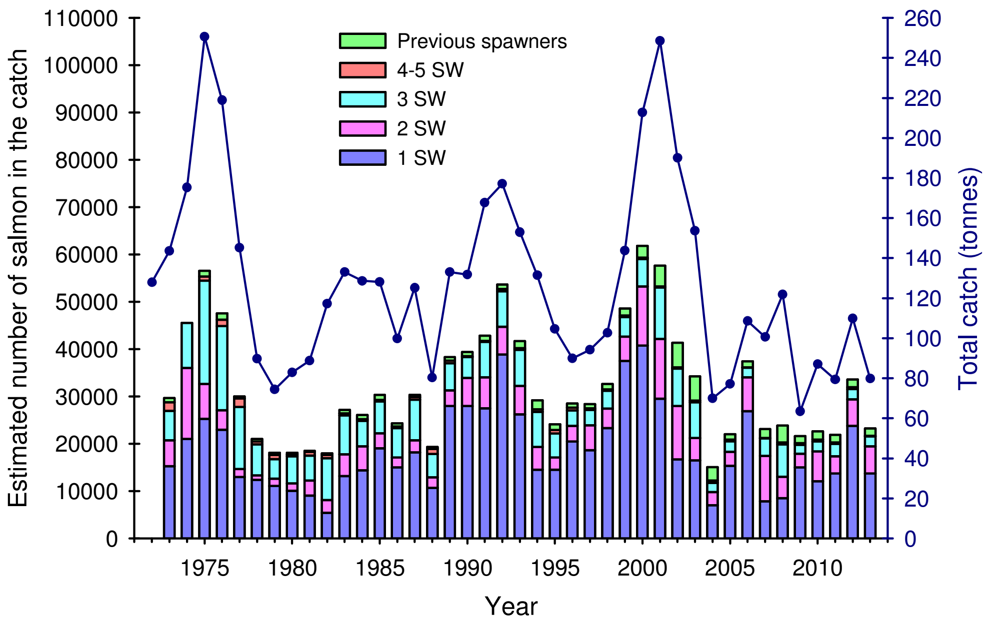

Figure 6. Total salmon catch in the River Tana system (Norway and Finland combined) in 1972-2013 in terms of mass (line) and number of fish (bars). Bars are separated into different sea age groups.

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 Finnish Game and Fisheries Research Institute (FGFRI) compile the catch on the Finnish side.

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 average. 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. In the last five years, salmon catches in Tana have been below the long-term average both in terms of numbers and mass. Following the long-term fluctuations in the total catch, much higher catches were expected in 2009, 2010 and 2011.

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).

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.

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.

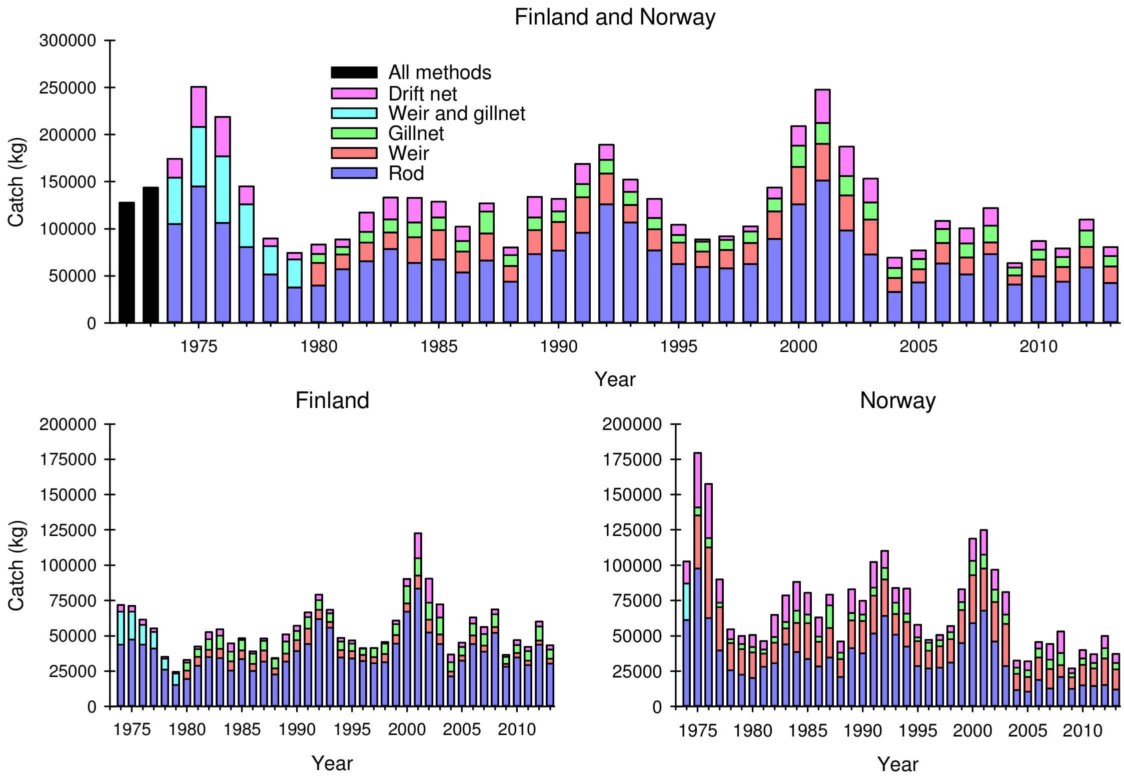

Figure 7. Total salmon catches in the Tana river system by countries and fishing methods.

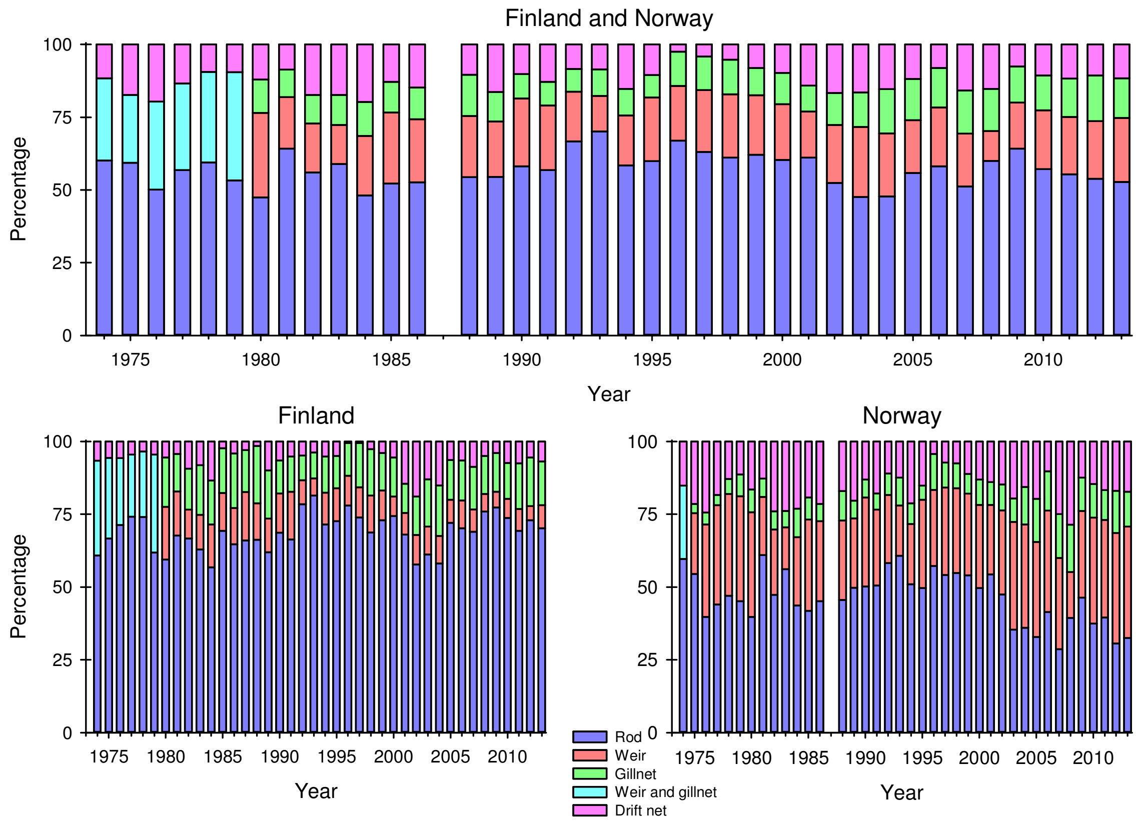

Figure 8. Percentage distribution of salmon catches in terms of mass for fishing gears in Norway and Finland.

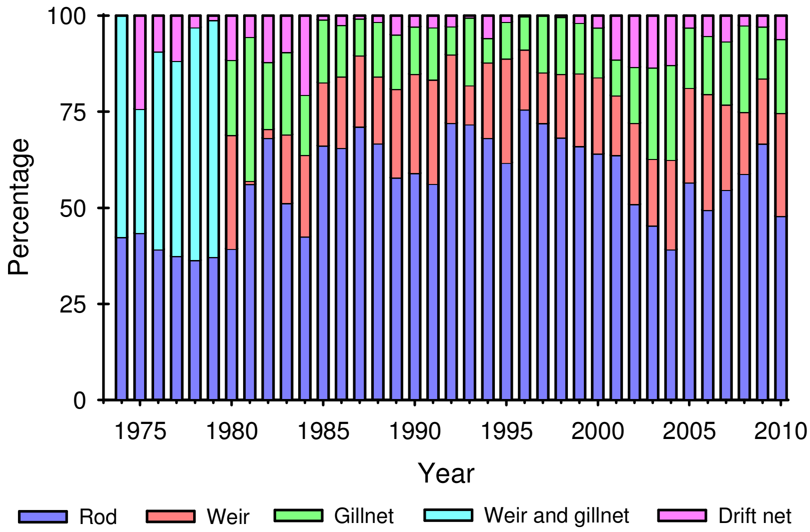

Figure 9. Percentage distribution of salmon catch (based on number of fish) between fishing methods in the River Tana system.

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).

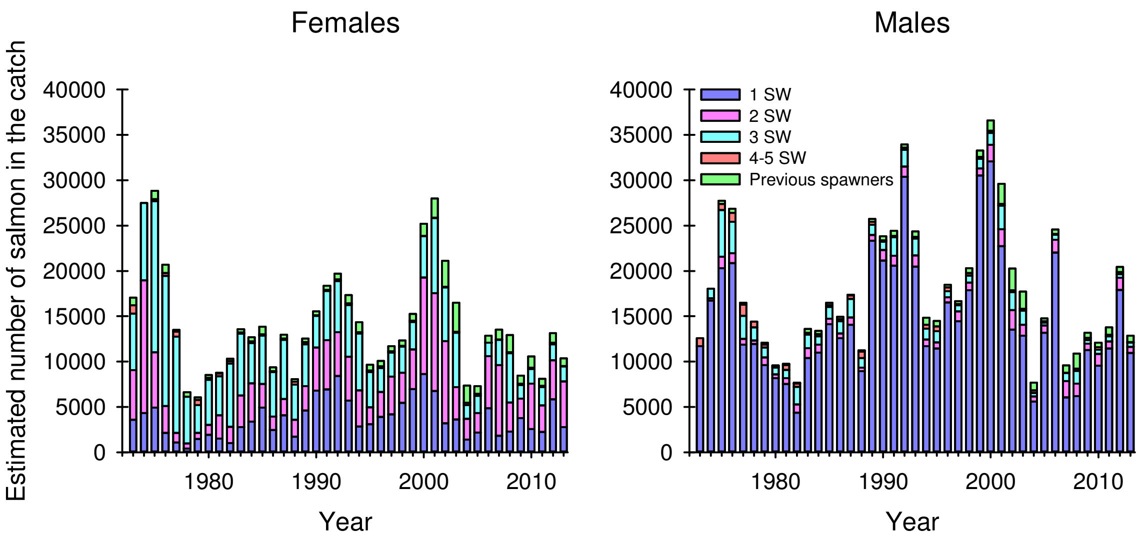

Figure 10. Estimated numbers of salmon in the River Tana catches for 1SW–4-5SW salmon and previous spawners.

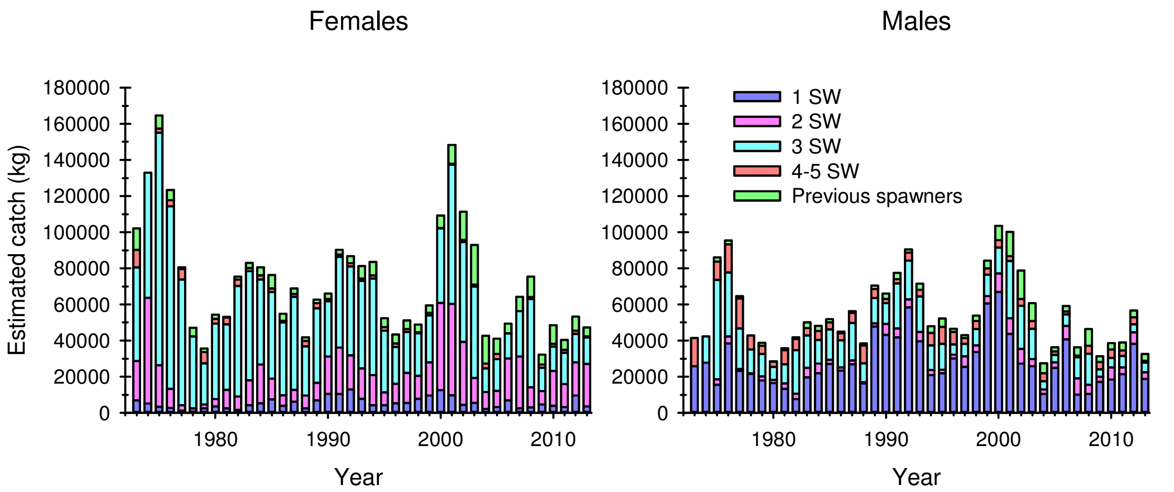

Figure 11. Estimated mass (kg) of salmon in the River Tana catches for 1SW–4-5SW salmon and previous spawners.

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).

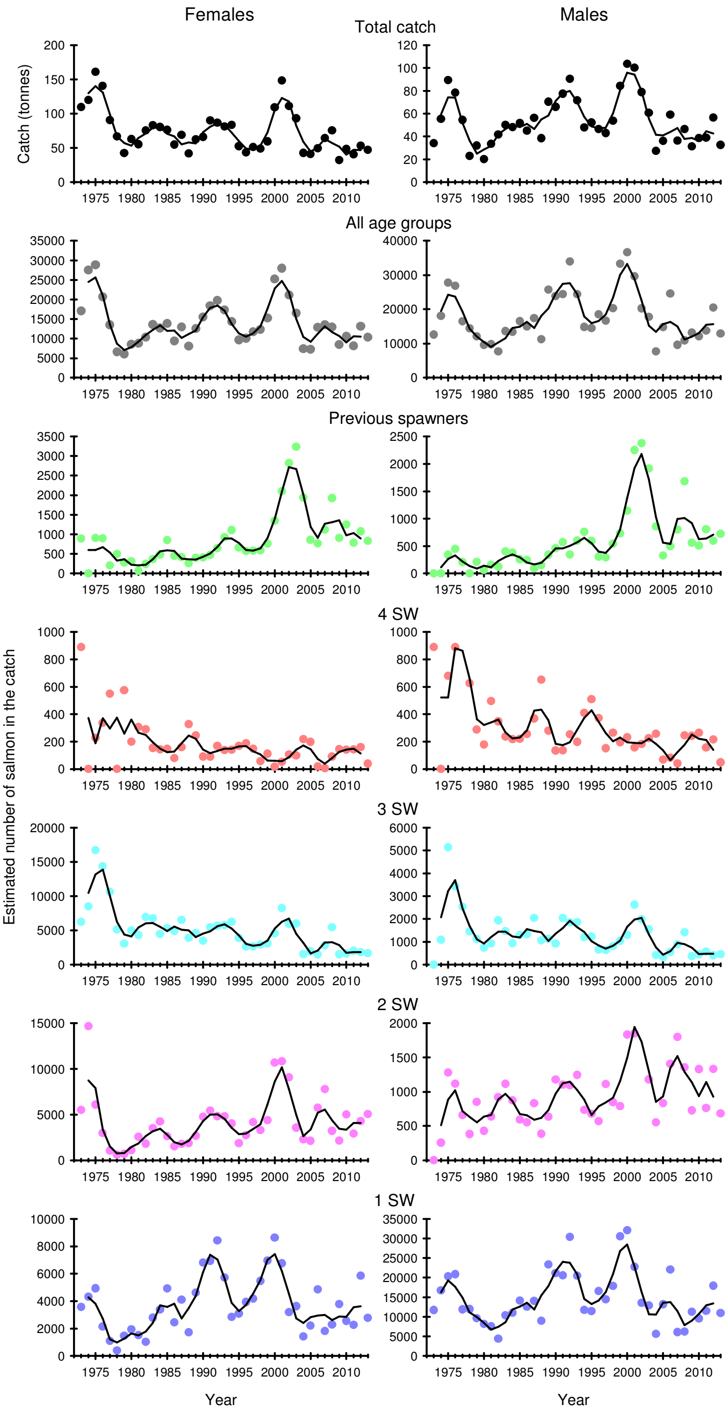

Figure 12. Estimated numbers of salmon of different sea-age-groups in catches of the River Tana system in 1973-2013.

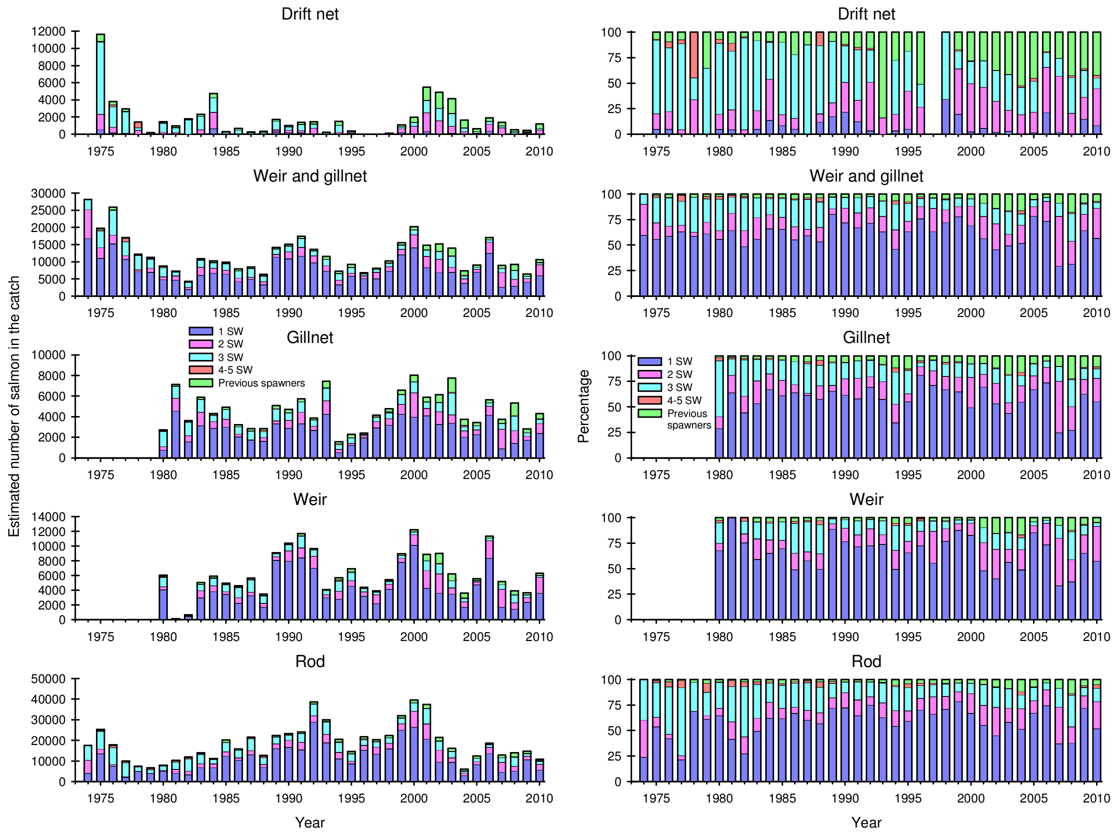

Figure 13. Numbers (figure on the left) and in percentages from the numbers (figure on the right) of salmon (1SW, 2SW, 3SW, 4-5SW, previous spawners) caught in the River Tana system with four different fishing methods.

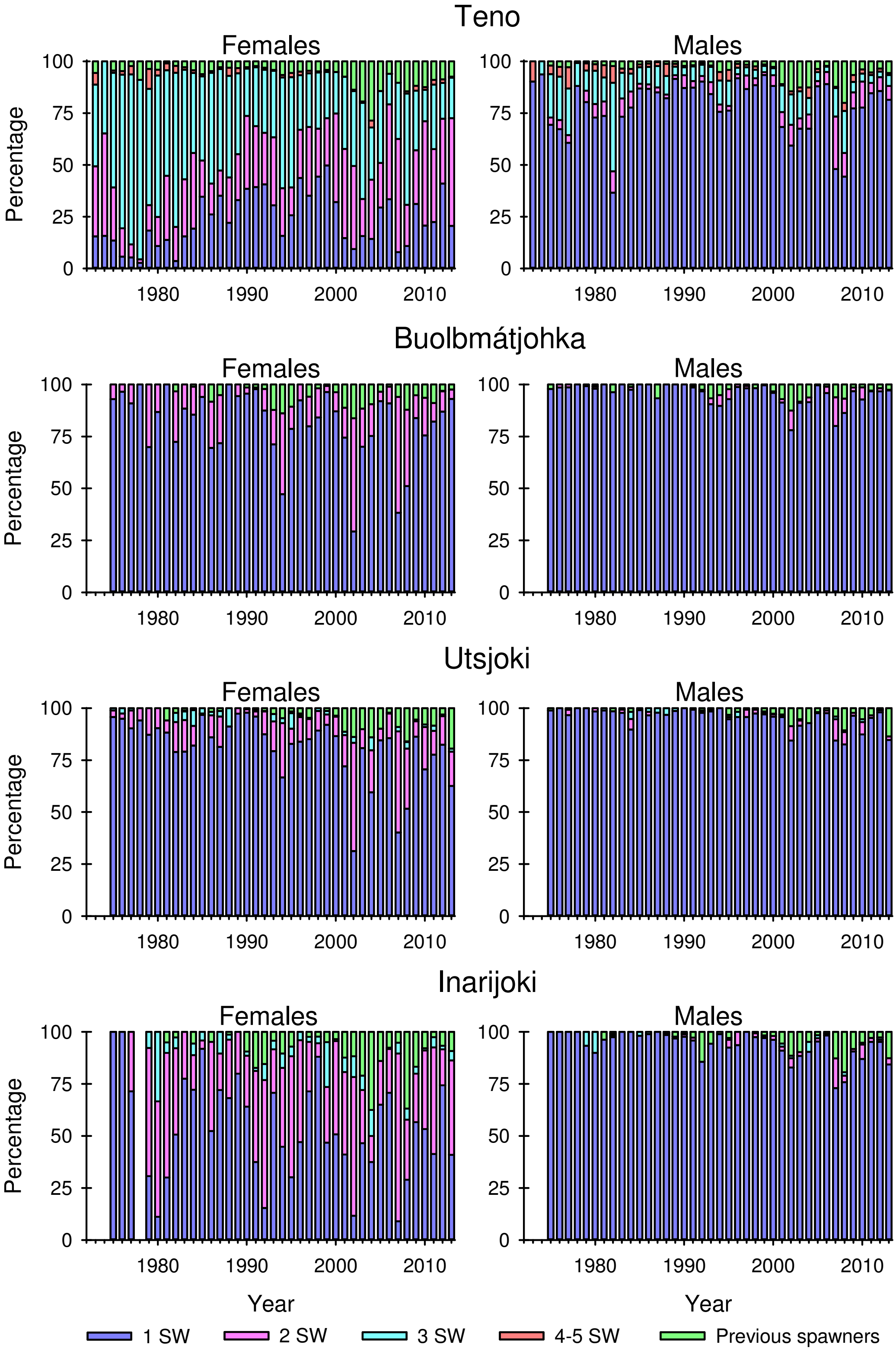

Figure 14. The proportions of various sea ages of salmon caught in Tana main stem and in three major tributaries.

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 %.

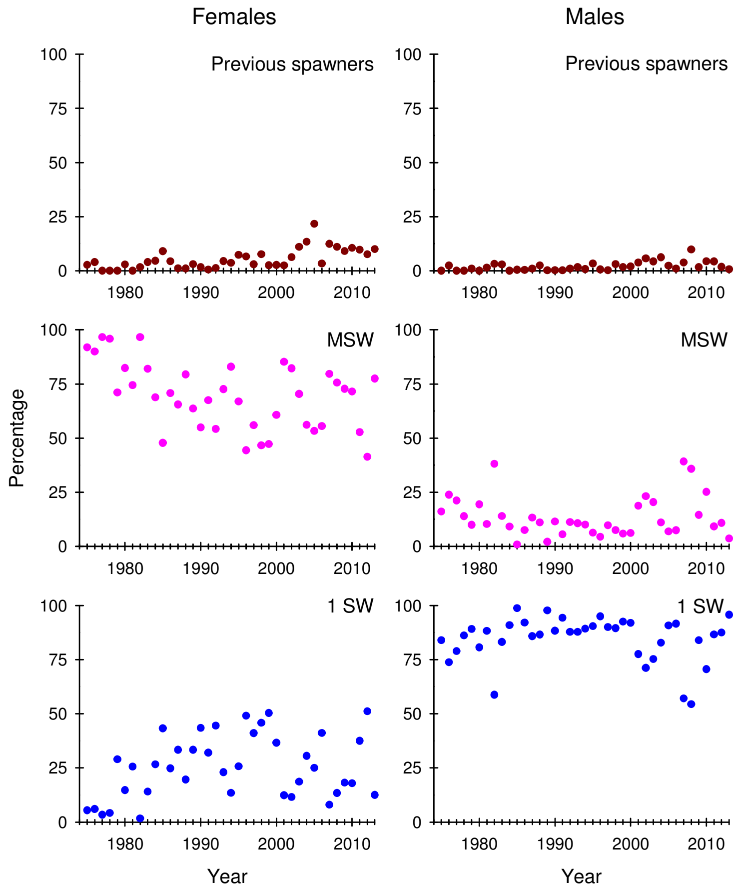

Figure 15. The proportion of female salmon in the spawning stocks (samples from August fishery) in the River Tana main stem.

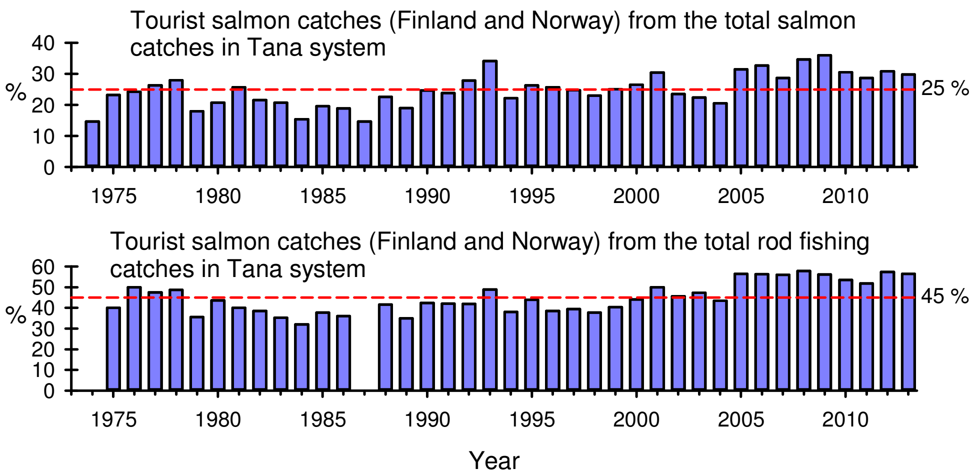

Figure 16. The proportion of tourist salmon catches (Finnish and Norwegian tourist catches together) from the total salmon catches and from the total catches caught with rod fishing methods.

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, but also show the increased proportion of previous spawners. (Figure 18).

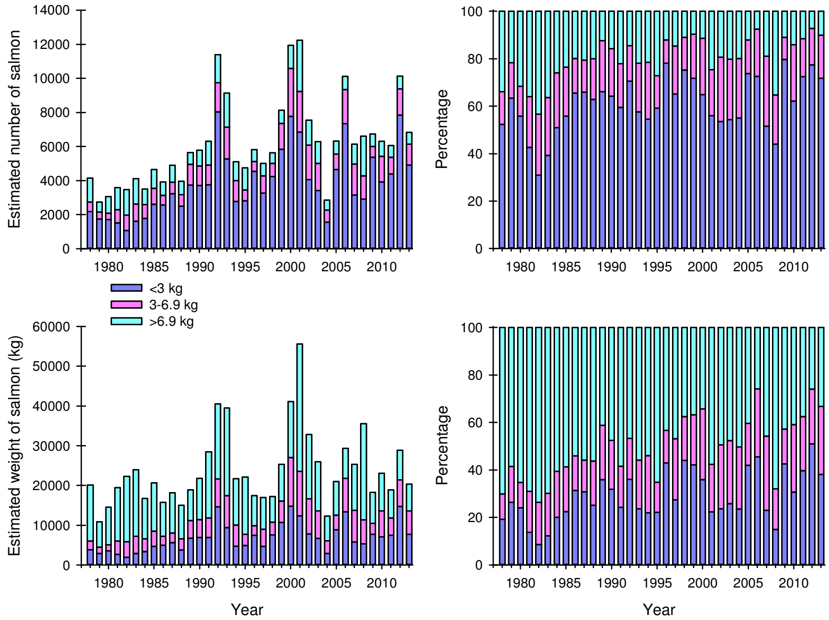

Figure 17. The salmon catches in terms of numbers and weight in three size categories for Finnish tourists in the River Tana and Anárjohka.

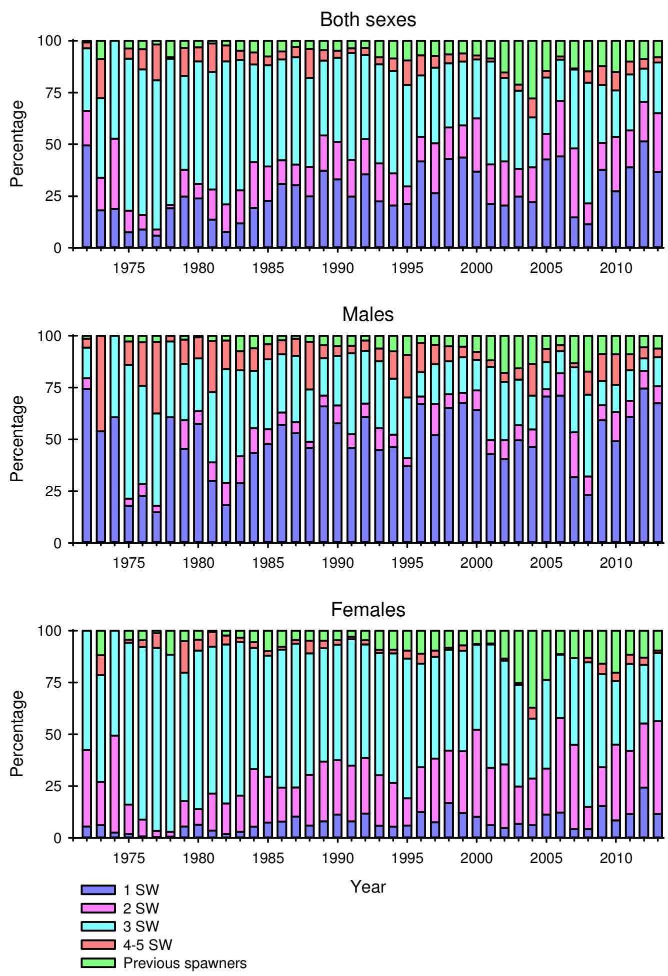

Figure 18. Proportions of different age groups in salmon catches (based on numbers) for Finnish tourist fishers in the Rivers Tana and Anárjohka/Inarijoki.

3 Stock status evaluation

3.1 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.

3.2 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 19). With increasing spawning stock size, the competition effect will gradually become more and more important. Thus, with increasing egg density, the increase in smolt production starts to slow towards an asymptote (middle part of Figure 19). At high levels of egg density, the river reaches its smolt production potential (right part of Figure 19).

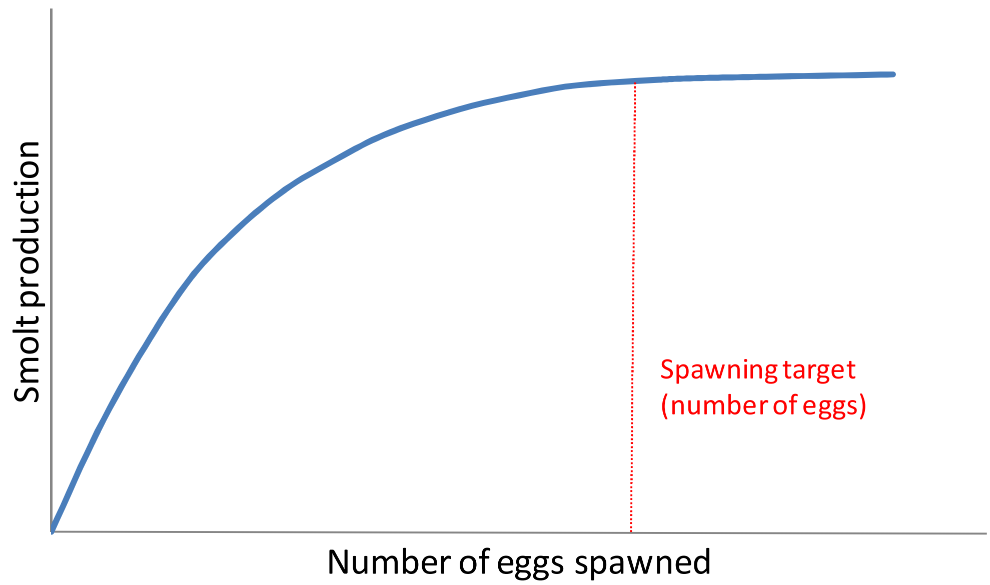

Figure 19. Simplified theoretical relationship between number of eggs spawned and number of smolts produced for a salmon stock.

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 management targets have recently been established as spawning targets for the Tana river system (Table 2; Falkegård *et al*., in prep.), 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 system.

Table 2. Revised spawning targets for the Tana river system (Falkegård *et al*., in prep.).

River	*Revised target (eggs)*	*Female biomass w/fixed fecundity (1 800 eggs kg^{-1})*	*Female biomass w/stock-specific fecundity*
Tana/Teno main stem	41 049 886	22 805	21 893
Máskejohka	3 155 148	1 753	1 502
Luovtejohka		-	-
Buolbmátjohka/Pulmankijoki	1 329 133	738	604
Lákšjohka	2 969 946	1 650	1 350
Veahčajohka/Vetsijoki	2 505 400	1 392	1 193
Ohcejohka/Utsjoki	4 979 107	2 766	2 365
Goahppelašjohka/Kuoppilasjoki	695 950	387	309
Borsejohka	0	0	0
Leavvajohka	499 203	277	232
Nuvvosjohka/Nuvvusjoki	0	0	0
Báišjohka	948 688	527	431
Njiljohka/Nilijoki	519 520	289	239
Váljohka	1 907 595	1 060	867
Áhkojohka/Akujoki	282 532	157	131
Lower Kárášjohka	2 013 178	1 118	1 019
Upper Kárášjohka	10 037 498	5 576	5 082
Geaimmejohka	250 824	139	110
Bávttajohka	1 735 823	964	914
Iešjohka	11 536 009	6 408	5 993
Anárjohka/Inarijoki	11 283 952	6 269	5 310
Garegasjohka/Karigasjoki	598 000	332	278
Iškorasjohka	426 000	236	203
Goššjohka	5 206 840	2 892	2 422
Skiehččanjohka/Kietsimäjoki	398 160	221	194
Tana/Teno (total)	104 487 286	58 048	52 491

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.

3.3 A procedure for target-based stock evaluation

3.3.1 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), 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 20.

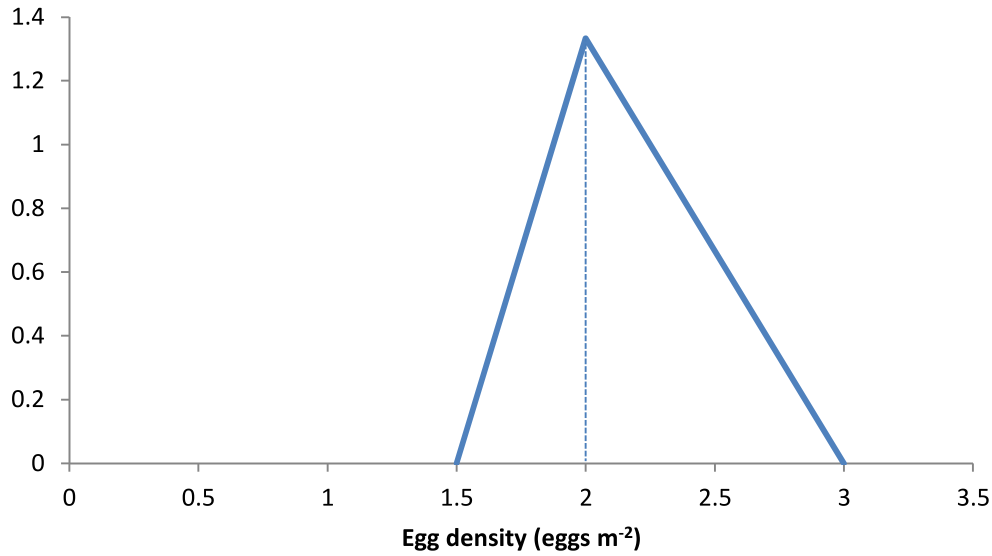

Figure 20. Triangular probability distribution for a spawning target based on the 2 eggs m^{-2} category.

3.3.2 Management target

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 point that must be defined is the management target. The role of this target is to ensure that stocks are kept above the conservation limit. The management target thus represents the stock level that ensures long-term viability of the stock. We define the Tana management target 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 reached. The same definition is used by the Scientific Advisory Committee for Atlantic Salmon Management in Norway in its evaluation of all Norwegian salmon stocks. Failure to meet the management target should directly lead to the implementation of a stock recovery plan.

As shown in Figure 20, 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 21 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.

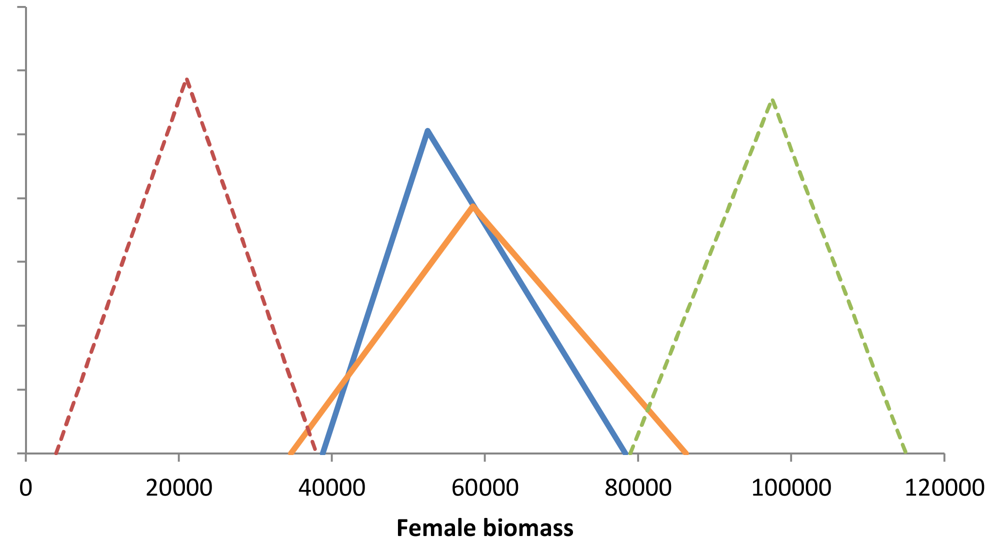

Figure 21. The triangular probability distribution describing the Tana (total) spawning target (blue line) and the triangular probability distributions of three exemplified spawning stock sizes: (1) an estimate completely below the target, representing a 0 % probability that the target was reached (red 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 21. 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 21 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 21) or that the spawning stock was above all possible values of the spawning target (100 % probability, dotted green line in Figure 21).

The most complex situation happens when we have overlap between the spawning stock estimate and the spawning target, as exemplified in Figure 21 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 21 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 21, 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 22. The dotted line is the spawning stock estimate from Figure 21, 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 %.

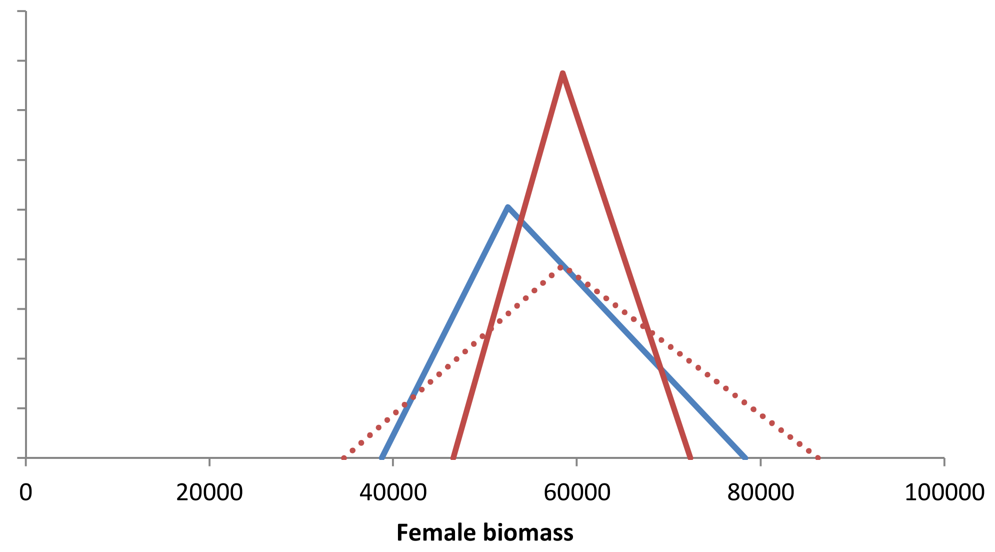

Figure 22. The triangular probability distribution describing the Tana (total) spawning target (blue line) and the triangular probability distribution describing the exemplified spawning stock from Figure 21 (dotted red line). The solid red line indicates the possible shape of this spawning stock distribution if better monitoring data had been available.

3.3.3 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. 2011). 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 23). 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.

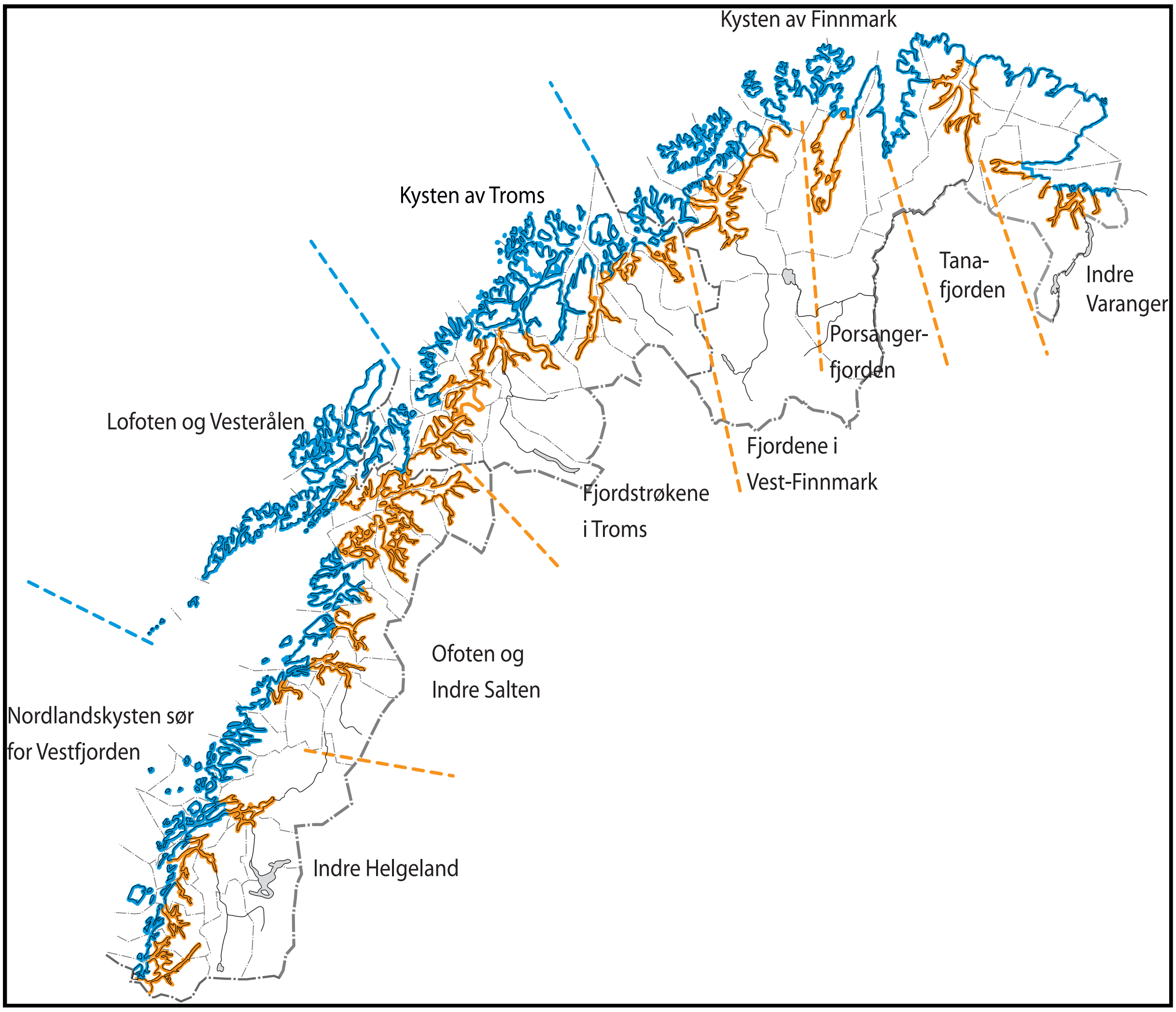

Figure 23. Management regions defined in the salmon management for northern Norway. The outer coastal regions are coloured blue, while the inner fjord regions are orange.

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. In this report we have used only data from 2006-2008, but full data sets from 2011 and 2012 will be available for use in later reports. 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.

3.4 Tributary-specific stock 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 and will be published shortly (Falkegård *et al*., in prep.). However, time constraints have meant that we currently are unable to extend the previous status evaluation to new tributaries in the Tana river system. The stock status in the present report is therefore evaluated for eight areas; five Norwegian tributaries from the earlier set, and two Finnish tributaries together with the Tana system as a whole:

- Máskejohka (in the lower part of the river system)
- Lákšjohka (middle part)
- Válljohka (middle part)
- Ohcejohka (Utsjoki, middle part)
- Áhkojohka (Akujoki, middle part)
- Iešjohka (upper part)
- Kárášjohka (upper part)
- Tana total (an evaluation covering all Tana stocks)

Note that the Norwegian tributaries and Tana (total) are evaluated using a standardized probabilistic approach which, ultimately, provides us with a measure of how likely it is that the respective spawning targets has been reached. This aspect is a necessity to be able to evaluate the management target of the stocks, and we are currently unable to provide the same for the two Finnish tributaries. The evaluation in the two Finnish tributaries is therefore only a measure of year-to-year egg deposition compared with the mid-value of the spawning target.

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 Ohcejohka are based on video counts of ascending adult salmon and the estimated catch. There is no fishing in Áhkojohka, and the spawning target attainment 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.

3.4.1 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.

3.4.1.1 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 1 502 kg (1 086-1 976 kg) when using a stock-specific fecundity of 2 100 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 3.3.1). The following exploitation estimates, based on number of salmon, were used throughout the period 2004-2013:

- Salmon <3 kg: 60 % (probability range 50-70 %)
- Salmon 3-7 kg: 40 % (30-60 %)
- Salmon >7 kg: 30 % (20-50 %)

The catch in Máskejohka varied between 156 kg (2004) and 2 321 kg (2010) in the period 2004-2013. There were considerable localization problems with the Norwegian Tana catches in 2004 and 2005. This likely 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 14 % (2004) to 86 % (2010) in the period 2004-2013. The highest probability of reaching the spawning target was seen in 2010 (22 %), followed by 2012 (17 %) and 2008 (15 %). The management target (last 4 year average) was 10 %.

With a stock-specific fecundity level of 2 200 eggs kg^{-1}, target attainment reached 100 % in 2010 and was close in 2012 (98 %) and 2008 (95 %). The highest probability of reaching the spawning target was 48 % in 2010, and the management target with the stock-specific fecundity was 25 %.

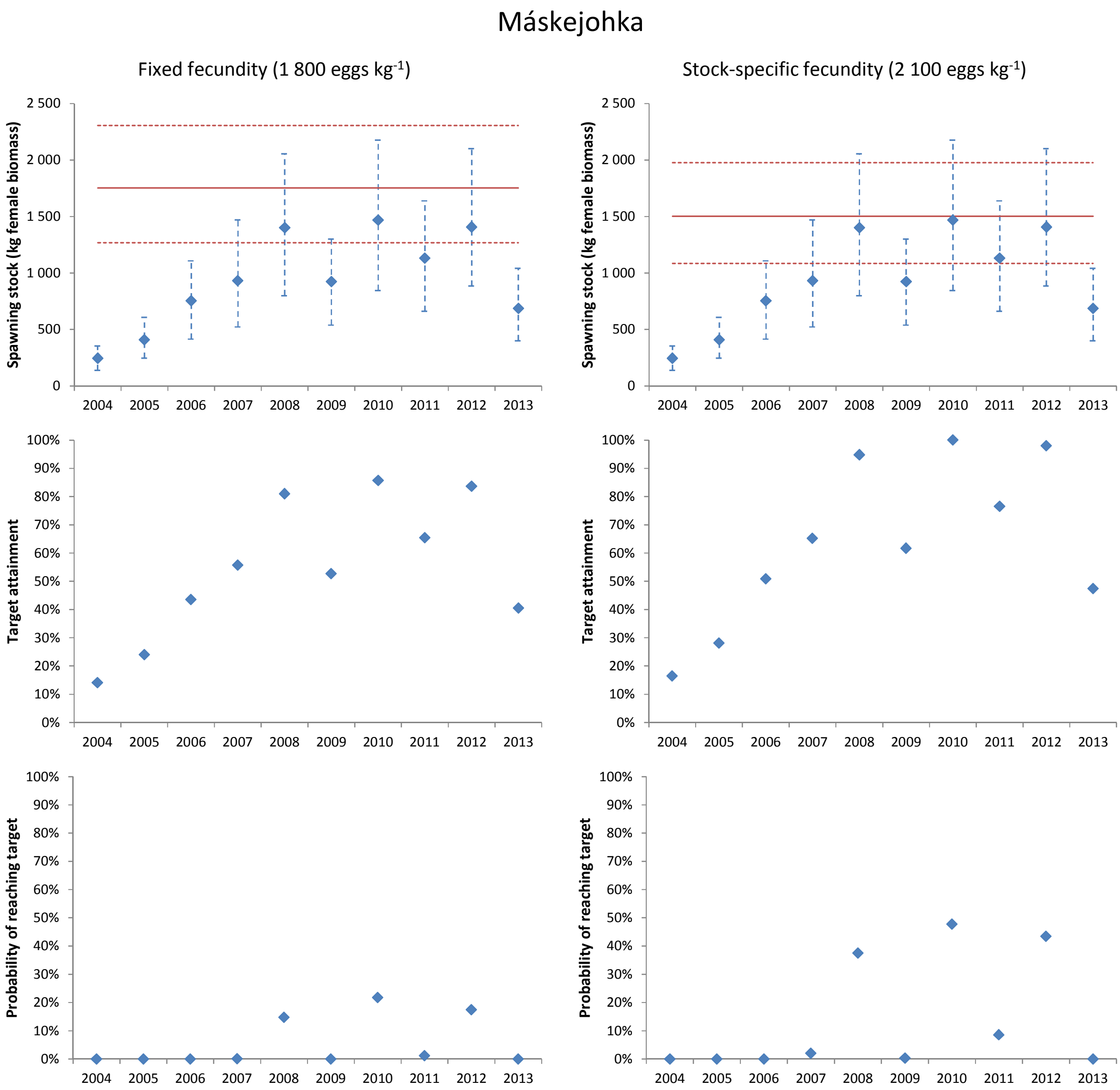

Figure 24. The estimated spawning stock (upper row), percent target attainment (middle row) and probability of reaching the target (bottom row) in the period 2004-2013 in the Norwegian tributary Máskejohka. The left column is based on a fixed fecundity of 1 800 eggs kg^{-1}, the right column is based on a stock-specific fecundity of 2 100 eggs kg^{-1}.

3.4.1.2 Exploitation

The estimated total exploitation (based on weight) in Máskejohka was 66 % in 2009 and 59 % in 2010 (Figure 25). Estimated total pre-fishery abundance was higher in 2010 than 2009 (6 750 kg in 2010, 4 992 kg in 2009). The total catch in the two years were 3 282 kg in 2009 and 4 011 kg in 2010.

The relative catch distribution between coast, main stem and Máskejohka itself varied slightly between the two years. The proportion caught in the coastal fisheries were higher in 2009 than 2010, with 1 226 kg (25 %) estimated to be caught in the coastal fisheries in 2009 and 1 264 kg (19 %) in 2010. The proportion in the main stem fisheries were estimated at 11 % in both years (568 and 776 kg in 2009 and 2010, respectively). In Máskejohka itself, 1 488 kg (30 %) were reported in 2009 and 1 971 kg (29 %) in 2010. The surviving female spawning stock were higher in 2010 than 2009, estimated to be 941 kg (34 % of the pre-fishery abundance) in 2009 and 1 506 kg (41 %) in 2010.

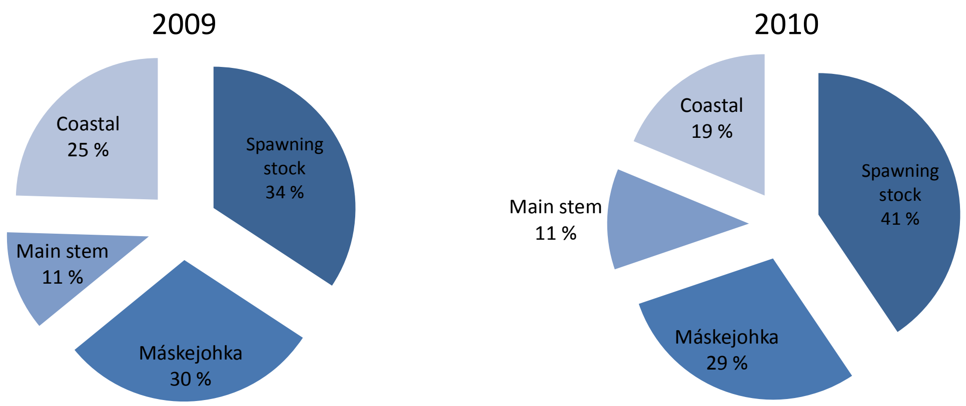

Figure 25. The total amount of salmon belonging to Máskejohka in 2009 (left) and 2010 (right), distributed into surviving spawning stock and salmon caught in fisheries in either coastal, main stem or within-river fisheries.

Estimated relative exploitation efficiencies (based on weight) in 2009 and 2010:

- Coastal: 25 %, 19 %
- Tana main stem: 15 %, 14 %
- Within Máskejohka: 47 %, 42 %

The overexploitation was estimated at 60 % in 2009 and 37 % in 2010.

The maximum sustainable exploitation rate was estimated to be 13 % in 2009 and 36 % in 2010. This means that the entire sustainable surplus in 2009 was caught in the coastal fisheries, while most (over 80 %) of the sustainable surplus in 2010 was caught before the salmon arrived in Máskejohka.

3.4.1.3 Stock recovery

During the last 4 years, the average probability that the spawning target was reached in Máskejohka was 25 %. This is a significant distance from the 75 % level defined by the management target.

The average spawning stock size in the last 4 years was 1 173 kg. With the current exploitation estimates, we would need a spawning stock of approximately 1 800 kg to exceed a 75 % probability of reaching the spawning target and approximately 2 400 kg to reach a 100 % probability. During the last 4 years, we have, therefore, on average lacked a female biomass of approximately 600 kg in order to reach a 75 % probability level.

With a 20 % reduction in river exploitation, stock recovery to a 100 % probability of reaching the spawning target would take 2 generations (14 years; Figure 26). With a 30 or 50 % reduction, the stock recovery period would last 1 generation (7 years).

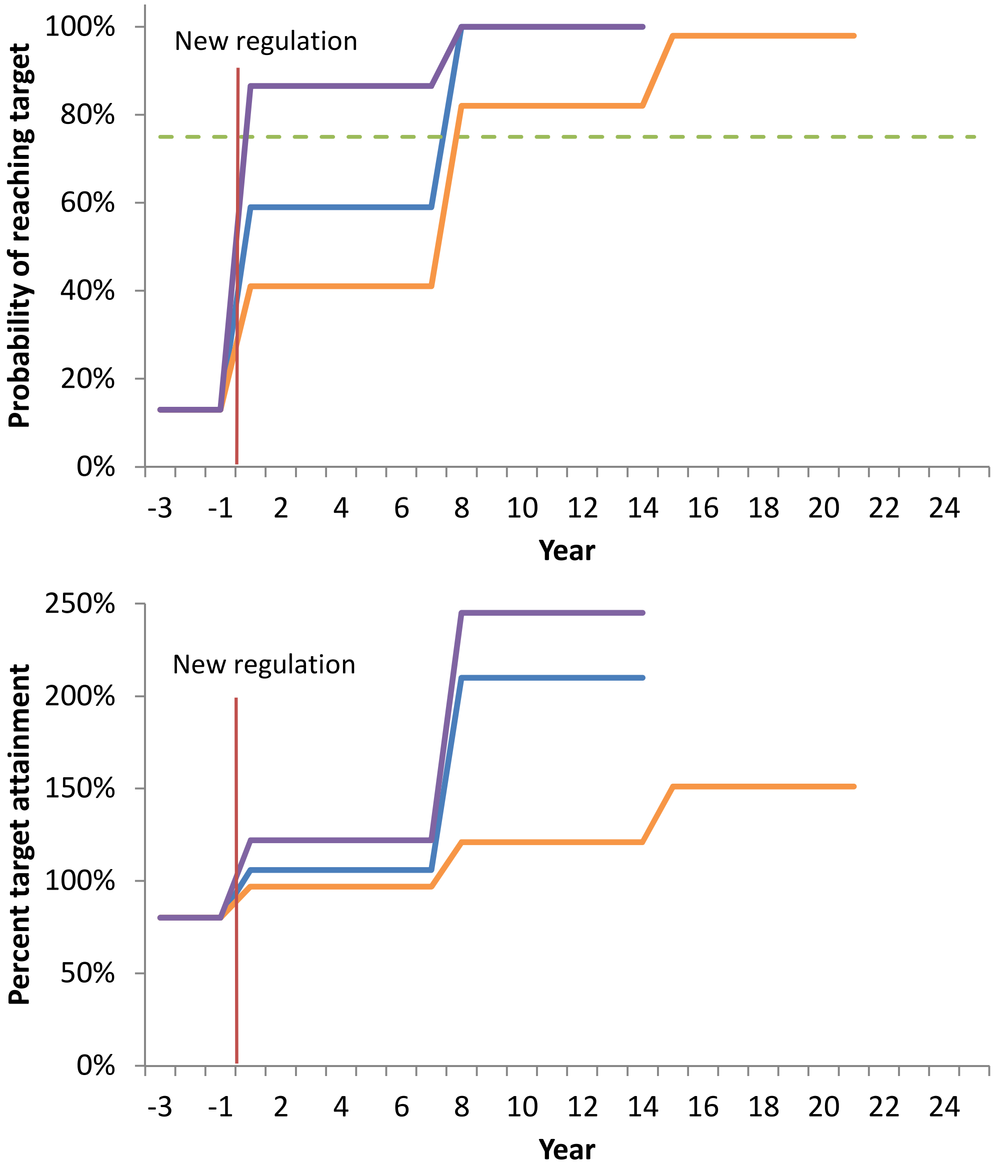

Figure 26. Stock recovery trajectories for Máskejohka, corresponding to three scenarios of reduced river exploitation (Tana main stem + Máskejohka). (Orange) A 20 % reduction, (Blue) a 30 % reduction, and (Purple) a 50 % reduction. Upper panel depicts the development in probability of reaching the spawning target, bottom panel the development in percentage target attainment. The green dotted line represents the 75 % probability line.

3.4.2 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.

3.4.2.1 Status assessment

The catch in Lákšjohka varied from 117 kg (2004) to 700 kg (2006) in the period 2004-2013. There were considerable localization problems with the Norwegian Tana catches in 2004 and 2005. This likely caused some underestimation of the Lákšjohka-catch in these two particular years.

Ascending salmon in Lákšjohka has 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.

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 1 350 kg (1 086-1 976 kg) when using a stock-specific fecundity of 2 200 eggs kg^{-1}.

Based on a fixed fecundity level of 1 800 eggs kg^{-1}, percentage target attainment varied from 6 % (2004) to 45 % (2012) in the period 2004-2013. Probability of reaching the spawning target was 0 % for all years, and, accordingly, the management target was also 0 %.

Target attainment increases somewhat when using a stock-specific fecundity level of 2 200 eggs kg^{-1}, varying from 7 % in 2004 to 56 % in 2012. Probability of reaching the spawning target was still 0 % throughout the period 2004-2013. The same goes for the management target.

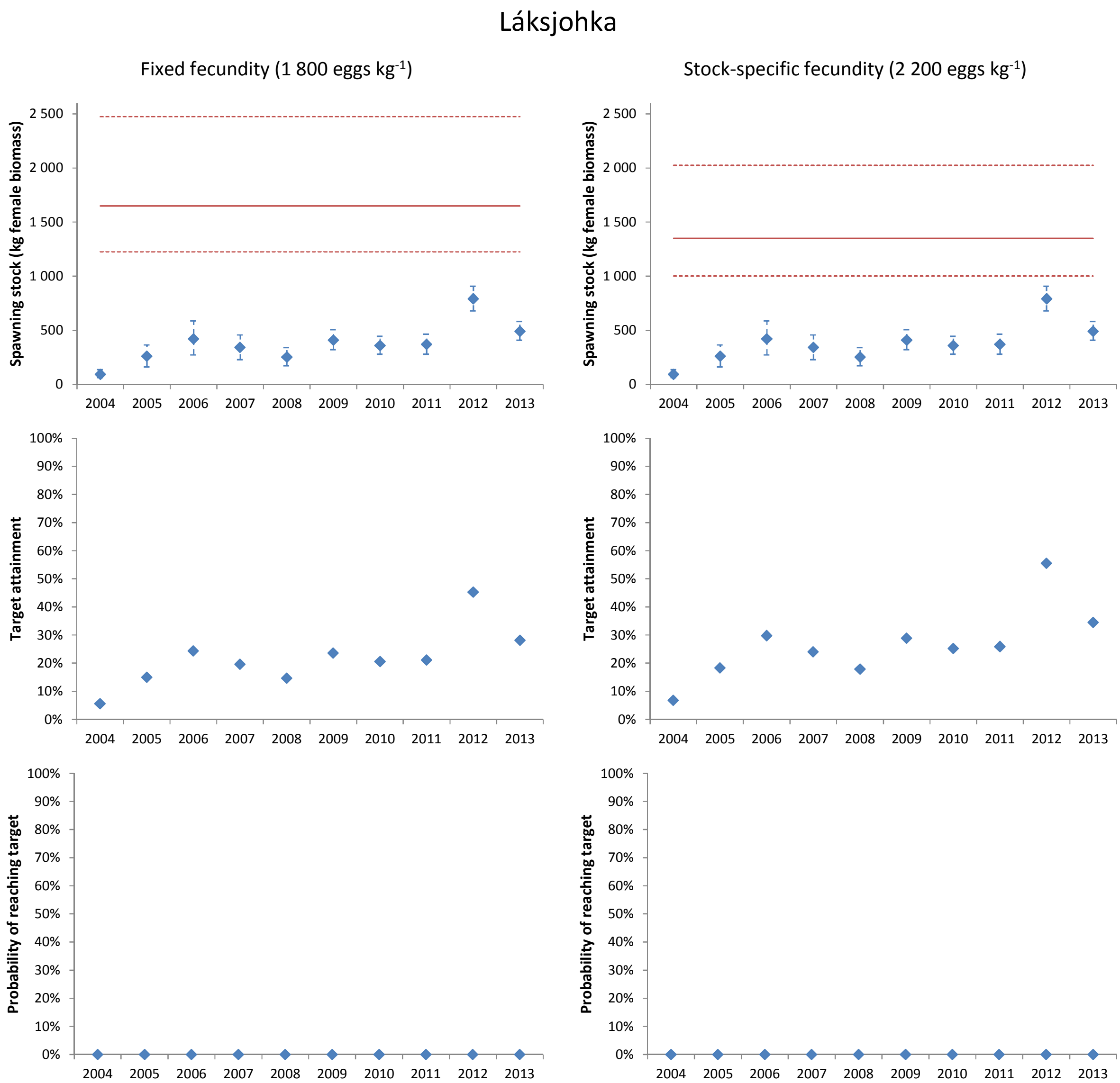

Figure 27. The estimated spawning stock (upper row), percent target attainment (middle row) and probability of reaching the target (bottom row) in the period 2004-2013 in the Norwegian tributary Lákšjohka. The left column is based on a fixed fecundity of 1 800 eggs kg^{-1}, the right column is based on a stock-specific fecundity of 2 200 eggs kg^{-1}.

3.4.2.2 Exploitation

The estimated total exploitation (based on weight) for Lákšjohka salmon was 69 % in 2009 and 73 % in 2010 (Figure 28). The estimated total pre-fishery abundance was 2 294 kg in 2009 and 2 324 kg in 2010, and from this the total catch was estimated to 1 588 kg in 2009 and 1 694 kg in 2010.

The relative proportion caught in the coastal fisheries was slightly higher in 2009 compared with 2010, with 418 kg (18 %) estimated to be caught in the coastal fisheries in 2009 and 317 kg (14 %) in 2010. The exploitation of Lákšjohka salmon in the Tana main stem was estimated to be higher in 2010 than 2009. In 2009, 834 kg (36 %) were estimated caught in the Tana main stem, while the estimate were 1 140 kg (49 %) in 2010. Within Lákšjohka, 336 kg (15 %) were reported in 2009 and 237 kg (10 %) in 2010. The surviving female spawning stock was estimated to be 402 kg (31 % of the pre-fishery abundance) in 2009 and 359 kg (27 %) in 2010.

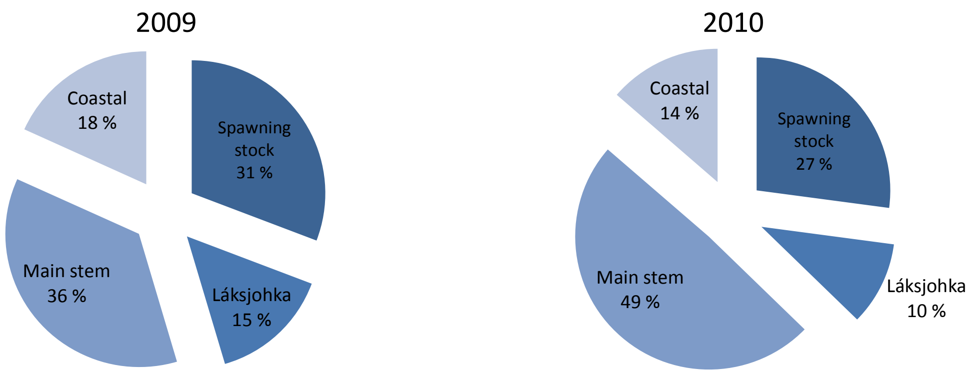

Figure 28. The total amount of salmon belonging to Lákšjohka in 2009 (left) and 2010 (right), distributed into surviving spawning stock and salmon caught in fisheries in either coastal, main stem or within-river fisheries.

Estimated relative exploitation efficiencies (based on weight) in 2009 and 2010:

- Coastal: 18 %, 14 %
- Tana main stem: 44 %, 57 %
- Within Lákšjohka: 32 %, 27 %

The overexploitation was estimated at 55 % in 2009 and 58 % in 2010.

The maximum sustainable exploitation rate was 0 % in both 2009 and 2010, indicating a stock situation with no exploitable surplus.

3.4.2.3 Stock recovery

During the last 4 years, the average probability that the spawning target was reached in Lákšjohka was 0 %. This, in combination with a relatively low target attainment, means that this tributary needs a significant reduction in exploitation to improve status.

The average spawning stock size in the last 4 years was 502 kg. With the current exploitation estimates, we would need a spawning stock of approximately 1 700 kg to exceed a 75 % probability of reaching the spawning target and approximately 2 100 kg to reach a 100 % probability. During the last 4 years, we have, therefore, on average lacked a female biomass of approximately 1 200 kg in order to reach the 75 % probability level specified by the management target.

With a 20 % reduction in river exploitation, the stock recovery would work too slowly to achieve 100 % probability of reaching the spawning target within the recovery period simulated in Figure 29. With a 30 % reduction, the stock recovery period would last 3 generations (21 years), and with a 50 % reduction 2 generations (14 years).

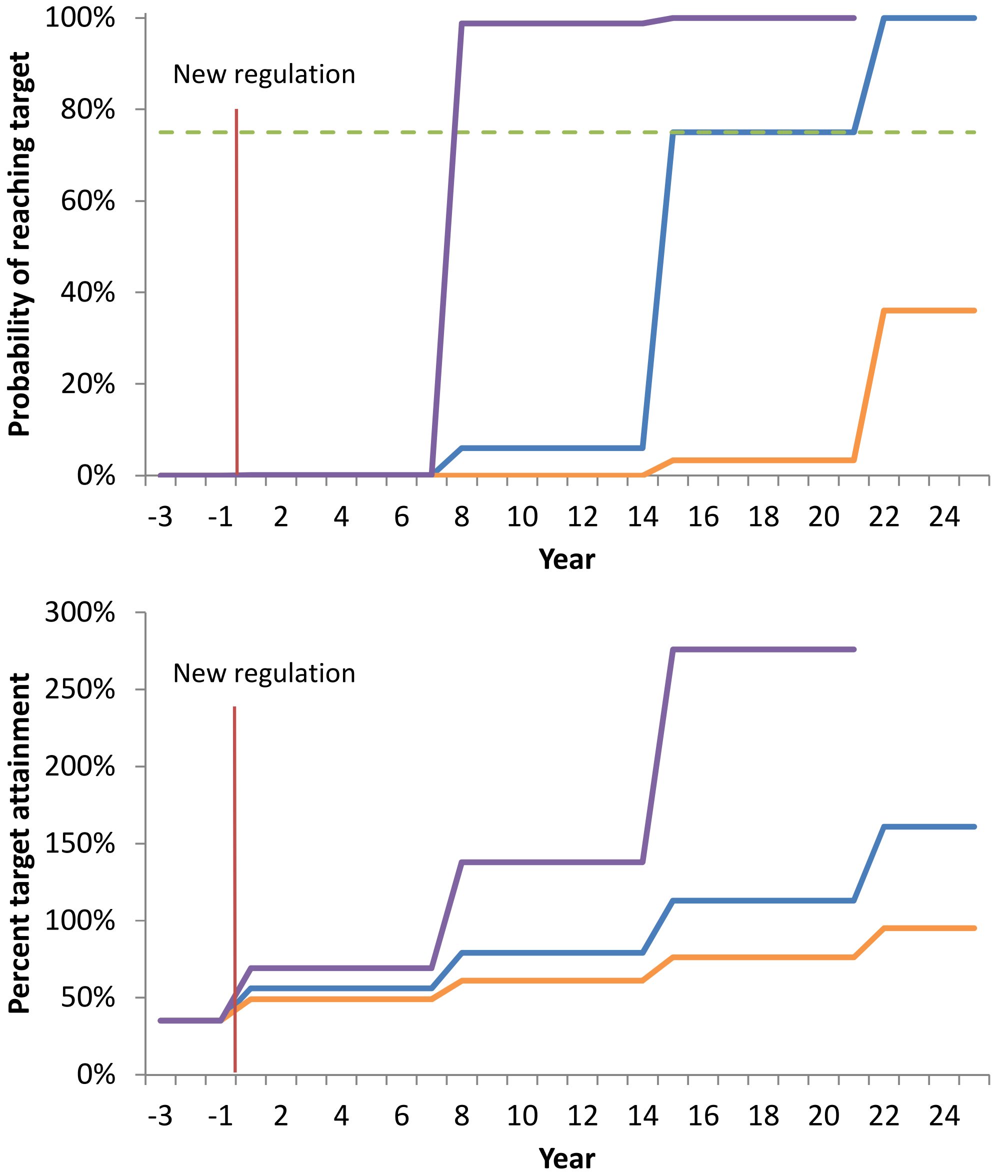

Figure 29. Stock recovery trajectories for Lákšjohka, corresponding to three scenarios of reduced river exploitation (Tana main stem + Lákšjohka). (Orange) A 20 % reduction, (Blue) a 30 % reduction, and (Purple) a 50 % reduction. Upper panel depicts the development in probability of reaching the spawning target, bottom panel the development in percentage target attainment. The green dotted line represents the 75 % probability line.

3.4.3 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.

3.4.3.1 Status assessment

The catch in Váljohka varied from 16 kg (2004) to 365 kg (2012) in the period 2004-2013. 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 fish monitoring in Váljohka, 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 for the period 2004-2013:

- Salmon <3 kg: 50 % (probability range 40-60 %)
- Salmon 3-7 kg: 30 % (20-50 %)
- Salmon >7 kg: 20 % (10-30 %)

These exploitation estimates correspond to the level defined as low exploitation for small Norwegian rivers (Anon. 2014). Recent snorkelling data from (September 2014), however, documented a high number of spawning salmon, despite covering a short stretch only under relatively poor water visibility conditions. This counting indicates that the exploitation estimates above are overestimated.

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 867 kg (566-1 301 kg) when using a stock-specific fecundity of 2 200 eggs kg^{-1}.

Based on a fixed fecundity level of 1 800 eggs kg^{-1}, percentage target attainment varied from 2 % (2004) to 28 % (2012) in the period 2004-2013. Probability of reaching the spawning target was 0 % for all years, and, accordingly, the management target was also 0 %.

Target attainment increases somewhat when using a stock-specific fecundity level of 2 200 eggs kg^{-1}, varying from 2 % in 2004 to 34 % in 2012. Probability of reaching the spawning target was still 0 % throughout the period 2004-2013. The same goes for the management target.

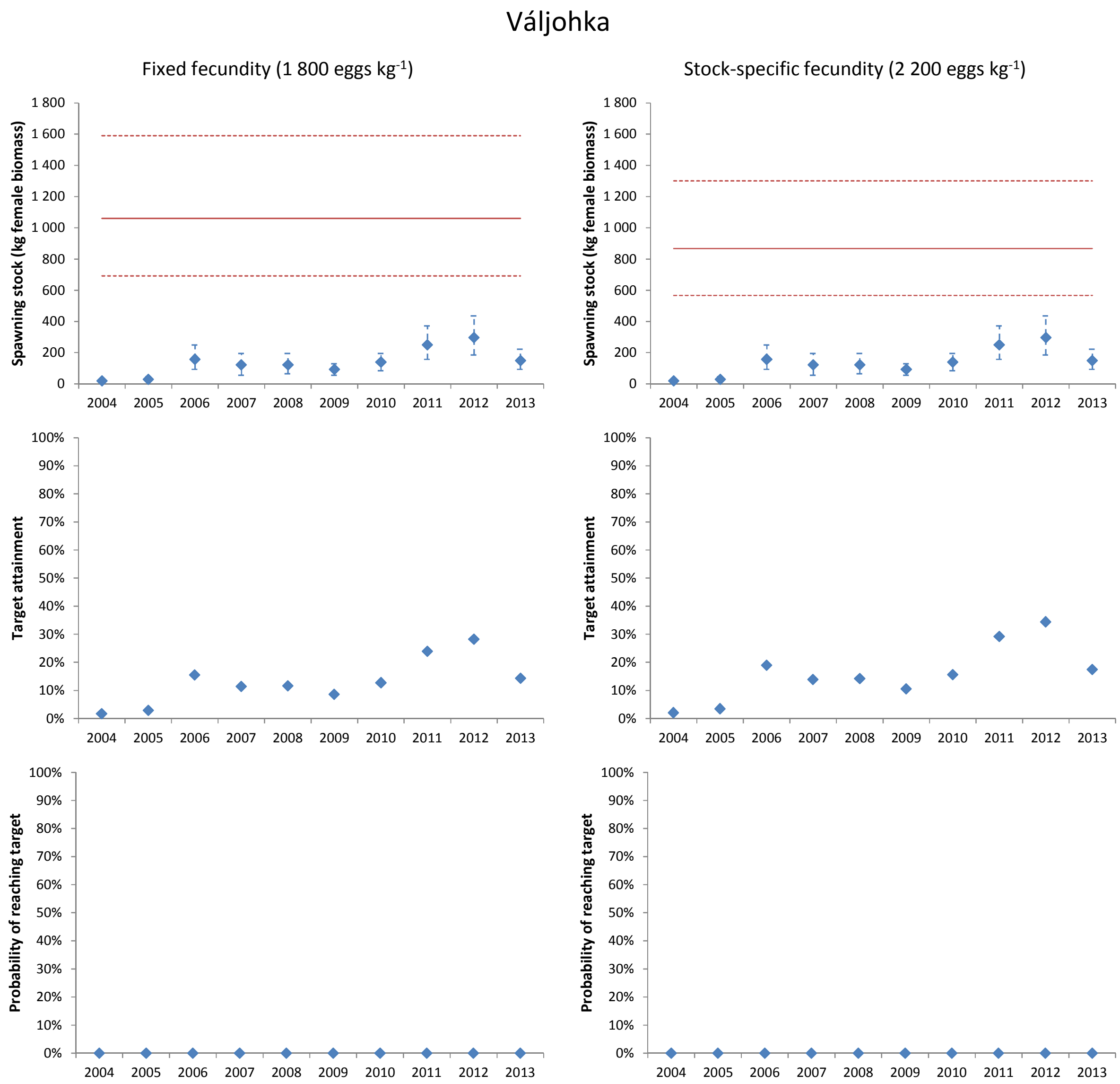

Figure 30. The estimated spawning stock (upper row), percent target attainment (middle row) and probability of reaching the target (bottom row) in the period 2004-2013 in the Norwegian tributary Váljohka. The left column is based on a fixed fecundity of 1 800 eggs kg^{-1}, the right column is based on a stock-specific fecundity of 2 200 eggs kg^{-1}.

3.4.3.2 Exploitation

The estimated total exploitation (based on weight) for Váljohka salmon was 90 % in 2009 and 88 % in 2010 (Figure 31). The estimated total pre-fishery abundance was 1 806 kg in 2009 and 2 290 kg in 2010, and from this the total catch was estimated to 1 618 kg in 2009 and 2 021 kg in 2010.

The relative proportion of Váljohka salmon caught in the coastal fisheries was higher in 2009 compared with 2010, with 398 kg (22 %) estimated to be caught in the coastal fisheries in 2009 and 382 kg (17 %) in 2010. The exploitation of Váljohka salmon in the Tana main stem was estimated to be higher in 2010 than in 2009. In 2009, 1 100 kg (61 %) was estimated caught in the Tana main stem, while the estimate was 1 503 kg (65 %) in 2010. There is only a small fishery within Váljohka itself, with a reported catch of 120 kg (7 %) in 2009 and 136 kg (6 %) in 2010. The surviving female spawning stock was estimated to be 103 kg (10 %) in 2009 and 148 kg (12 %) in 2010.

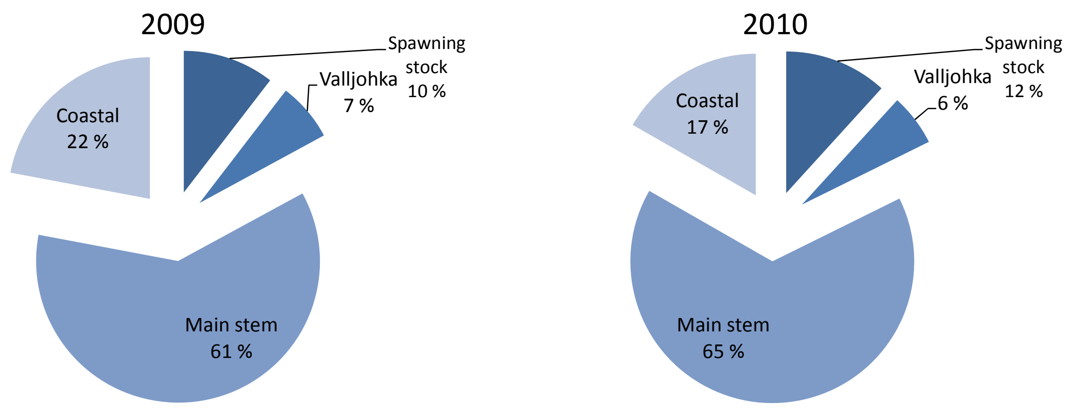

Figure 31. The total amount of salmon belonging to Váljohka in 2009 (left) and 2010 (right), distributed into surviving spawning stock and salmon caught in fisheries in either coastal, main stem or within-river fisheries.

Estimated relative exploitation efficiencies (based on weight) in 2009 and 2010:

- Coastal: 22 %, 17 %
- Tana main stem: 78 %, 79 %
- Within Váljohka: 39 %, 34 %

The overexploitation was estimated at 70 % in 2009 and 57 % in 2010.

The maximum sustainable exploitation rate was 65 % in 2009 and 73 % in 2010. The current exploitation intensities in coastal and main stem areas mean that the entire sustainable surplus in both 2009 and 2010 was caught before the salmon arrived in Váljohka.

3.4.3.3 Stock recovery

During the last 4 years, the average probability that the spawning target was reached in Váljohka was 0 %. This, in combination with a relatively low target attainment, means that this tributary needs a significant reduction in exploitation to improve status.

The average spawning stock size in the last 4 years was 208 kg. With the current exploitation estimates, we would need a spawning stock of over 1 000 kg to exceed a 75 % probability of reaching the spawning target and close to 1 200 kg to reach 100 % probability. During the last 4 years, we have, therefore, on average lacked a female biomass of approximately 800 kg in order to reach the 75 % probability level specified by the management target.

With a 20 % reduction in river exploitation, the stock recovery would work too slowly to achieve 100 % probability of reaching the spawning target within the recovery period simulated in Figure 32. With a 30 % reduction, the stock recovery period would last 3 generations (21 years), and with a 50 % reduction 1 generation (7 years).

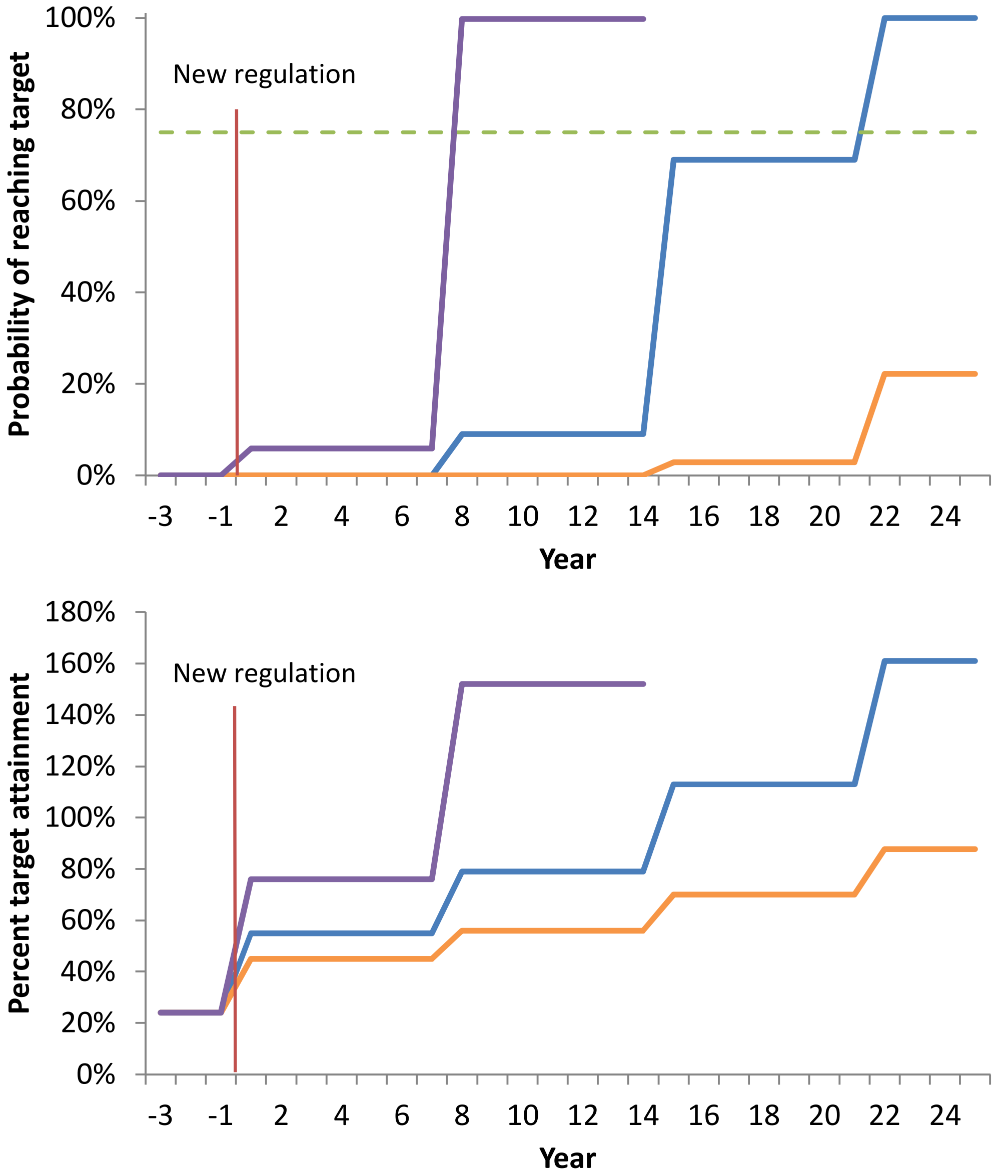

Figure 32. Stock recovery trajectories for Váljohka, corresponding to three scenarios of reduced river exploitation (Tana main stem + Váljohka). (Orange) A 20 % reduction, (Blue) a 30 % reduction, and (Purple) a 50 % reduction. Upper panel depicts the development in probability of reaching the spawning target, bottom panel the development in percentage target attainment. The green dotted line represents the 75 % probability line.

3.4.4 Kárášjohka

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 slowflowing 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.

3.4.4.1 Status assessment

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

The catch in Kárášjohka varied from 1 331 kg (2005) to 4 957 kg (2006) in the period 2004-2013. There were considerable localization problems with the Norwegian Tana catches in 2004 and 2005. This likely caused some underestimation 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, and gave a good estimate of 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:

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

The revised Kárášjohka spawning target 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 7 125 kg (5 344-10 688 kg) when using a stock-specific fecundity of 1 975 eggs kg^{-1}.

Based on a fixed fecundity level of 1 800 eggs kg^{-1}, percentage target attainment varied from 11 % (2005 and 2009) to 57 % (2012) in the period 2004-2013. Probability of reaching the spawning target was 0 for all years, and, accordingly, the management target was also 0 %.

Target attainment increases somewhat when using the stock-specific fecundity level, varying from 12 % in 2005 and 2009 to 62 % in 2012. Probability of reaching the spawning target was still 0 % throughout the period 2004-2013. The same goes for the management target.

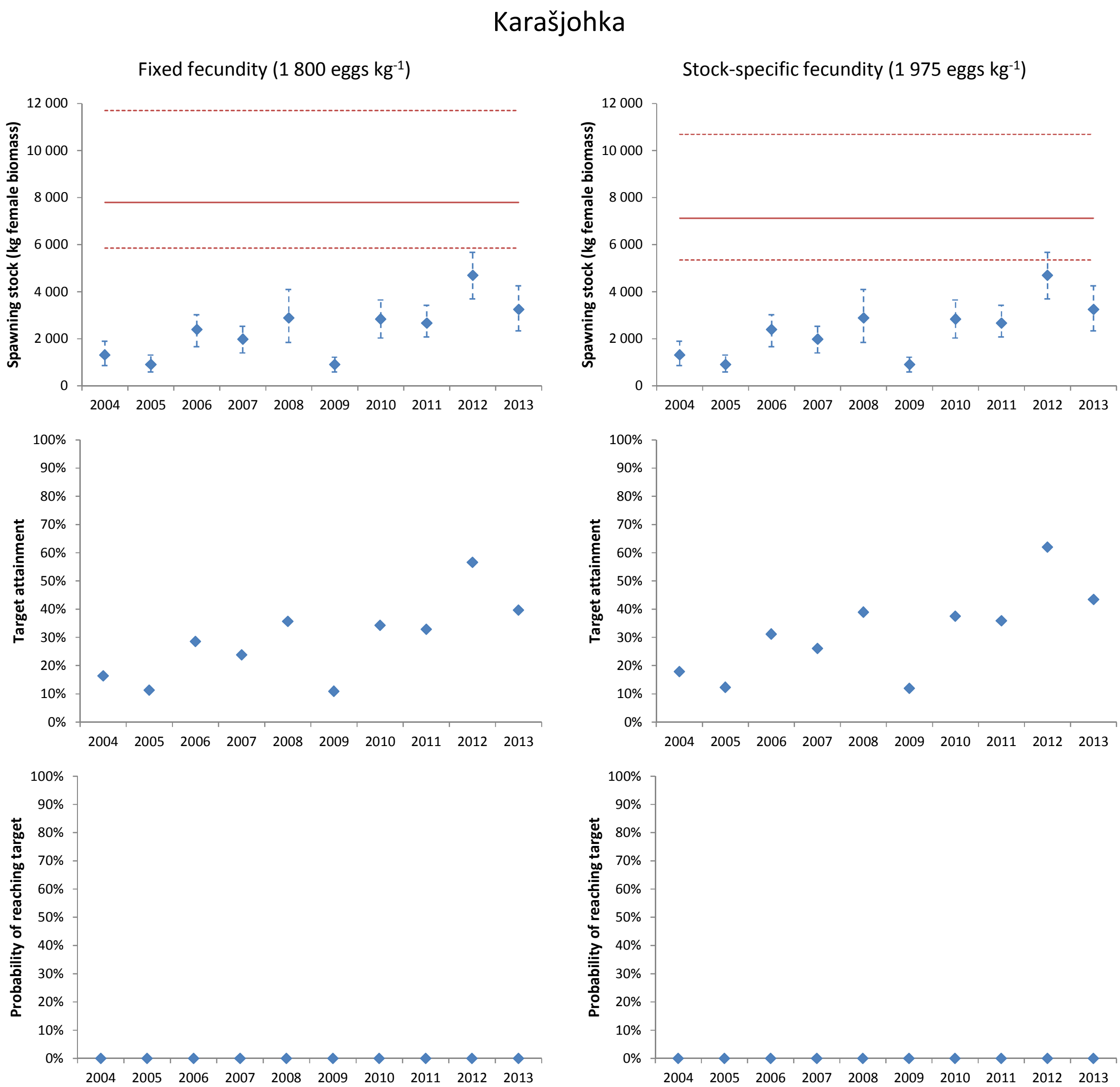

Figure 33. The estimated spawning stock (upper row), percent target attainment (middle row) and probability of reaching the target (bottom row) in the period 2004-2013 in the Norwegian tributary Kárášjohka. The left column is based on a fixed fecundity of 1 800 eggs kg^{-1}, the right column is based on a stock-specific fecundity of 1 975 eggs kg^{-1}.

3.4.4.2 Exploitation

The estimated total exploitation (based on weight) for Kárášjohka salmon was 86 % in 2009 and 73 % in 2010 (Figure 34). The estimated total pre-fishery abundance was 11 864 kg in 2009 and 18 296 kg in 2010, and from this the total catch was estimated to 10 203 kg in 2009 and 13 312 kg in 2010.

The relative proportion of Kárášjohka salmon caught in the coastal fisheries was higher in 2009 than 2010, with 3 031 kg (26 %) estimated to be caught in the coastal fisheries in 2009 and 3 576 kg (20 %) in 2010. As was the case for the Iešjohka stock, the Kárášjohka stock also seem to be more exploited in the coastal fisheries than the Máskejohka, Lákšjohka and Válljohka stocks. This reflects the higher proportion of large salmon in the Kárášjohka stock (large salmon are positively selected for in the coastal fisheries).

The exploitation of Kárášjohka salmon in the Tana main stem was estimated to be 5 629 kg (47 %) in 2009 and 7 328 kg (40 %) in 2010. A total of 1 543 kg (13 %) and 2 408 kg (13 %) was reported caught in the fishery within Kárášjohka itself in 2009 and 2010, respectively.

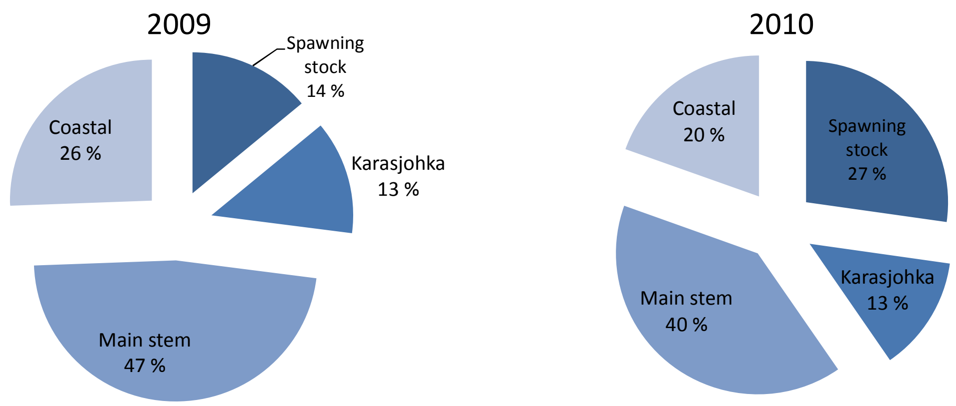

Figure 34. The total amount of salmon belonging to Kárášjohka in 2009 (left) and 2010 (right), distributed into surviving spawning stock and salmon caught in fisheries in either coastal, main stem or within-river fisheries.

Estimated relative exploitation efficiencies (based on weight) in 2009 and 2010:

- Coastal: 26 %, 20 %
- Tana main stem: 64 %, 50 %
- Within Kárášjohka: 48 %, 33 %

The overexploitation was estimated at 48 % in 2009 and 63 % in 2010.

The maximum sustainable exploitation rate was 0 % in both 2009 and 2010, indicating a stock situation with no exploitable surplus.

3.4.4.3 Stock recovery

During the last 4 years, the average probability that the spawning target was reached in Kárášjohka was 0 %. This, in combination with a relatively low target attainment, means that this tributary needs a significant reduction in exploitation to improve status.

The average spawning stock size in the last 4 years was 3 357 kg. With the current exploitation estimates, we would need a spawning stock of approximately 8 700 kg to exceed a 75 % probability of reaching the spawning target and over 11 600 kg to reach 100 % probability. During the last 4 years, we have, therefore, on average lacked a female biomass of approximately 5 300 kg in order to reach the 75 % probability level specified by the management target.

With a 20 % reduction in river exploitation, we would achieve 100 % probability of reaching the spawning target at the end of the recovery period simulated in Figure 35. With a 30 % reduction, the stock recovery period would last 2 generations (14 years), and with a 50 % reduction 1 generation (7 years).

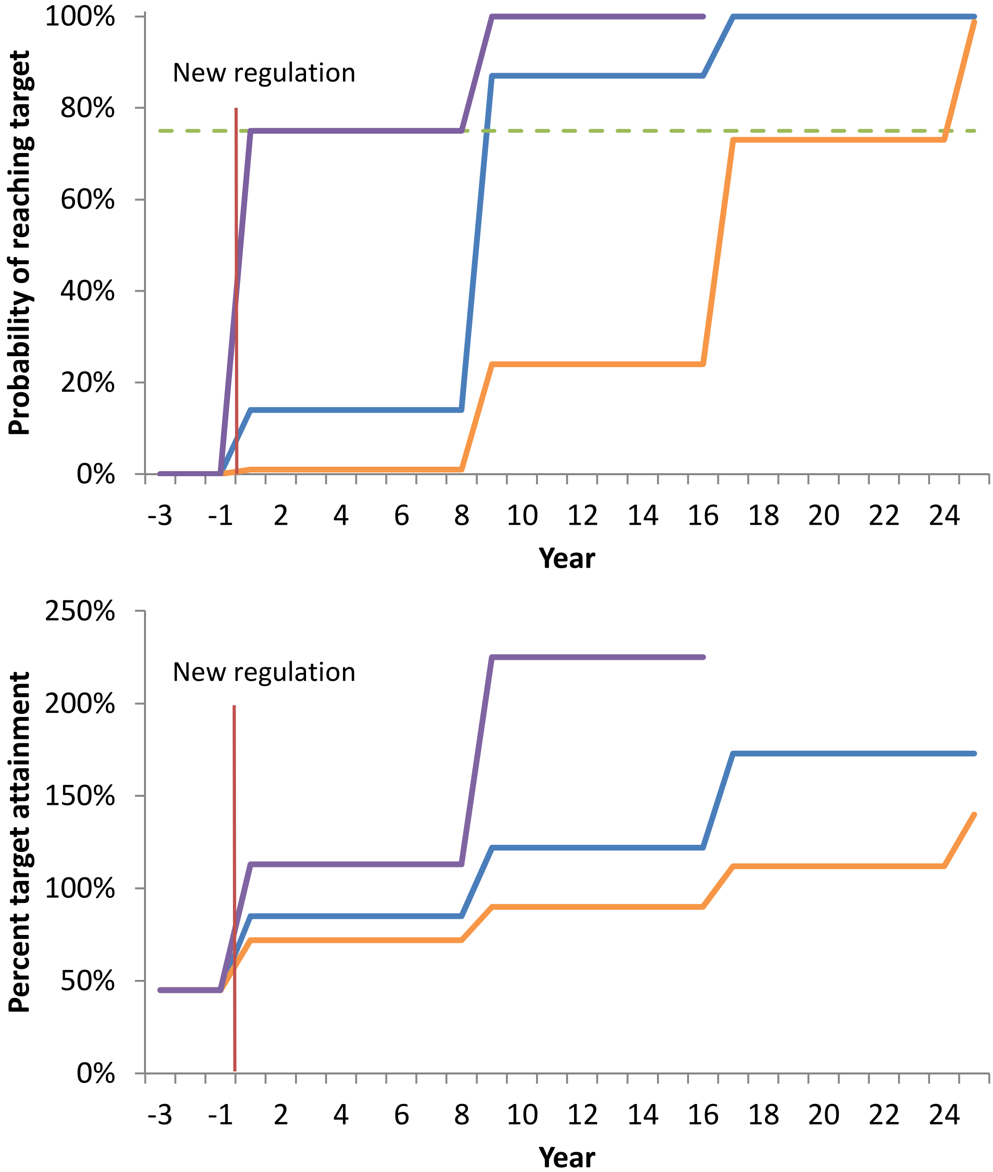

Figure 35. Stock recovery trajectories for Kárášjohka, corresponding to three scenarios of reduced river exploitation (Tana main stem + Kárášjohka). (Orange) A 20 % reduction, (Blue) a 30 % reduction, and (Purple) a 50 % reduction. Upper panel depicts the development in probability of reaching the spawning target, bottom panel the development in percentage target attainment. The green dotted line represents the 75 % probability line.

3.4.5 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, thus forming the Tana main stem. Iešjohka flow relatively fast, with large riffles and rapids and large slowflowing pools inbetween. The only major obstacle for salmon is a waterfall approximately 75 km upstream. It is likely that salmon are able to pass this waterfall only at low water levels.

3.4.5.1 Status assessment

The catch in Iešjohka varied from 733 kg (2004) to 3 498 kg (2008) in the period 2004-2013. There were considerable localization problems with the Norwegian Tana catches in 2004 and 2005. This likely caused some underestimation 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 2004-2013:

- Salmon <3 kg: 20 % (15-25 %)
- Salmon 3-7 kg: 40 % (30-50 %) in 2004-2011, 2013; 35 % (30-45 %) in 2012
- Salmon >7 kg: 40 % (30-50 %) in 2004-2011, 2013; 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 6 408 kg (4 515-9 613 kg) when using a fixed fecundity of 1 800 eggs kg^{-1}, and 5 993 kg (4 222-8 989 kg) when using a stock-specific fecundity of 1 925 eggs kg^{-1}.

Based on a fixed fecundity level of 1 800 eggs kg^{-1}, percentage target attainment varied from 7 % (2004) to 32 % (2012) in the period 2004-2013. Probability of reaching the spawning target was 0 for all years, and, accordingly, the management target was also 0 %.

Target attainment increases somewhat when using the stock-specific fecundity level, varying from 8 % in 2004 to 34 % in 2012. Probability of reaching the spawning target was still 0 % throughout the period 2004-2013. The same goes for the management target.

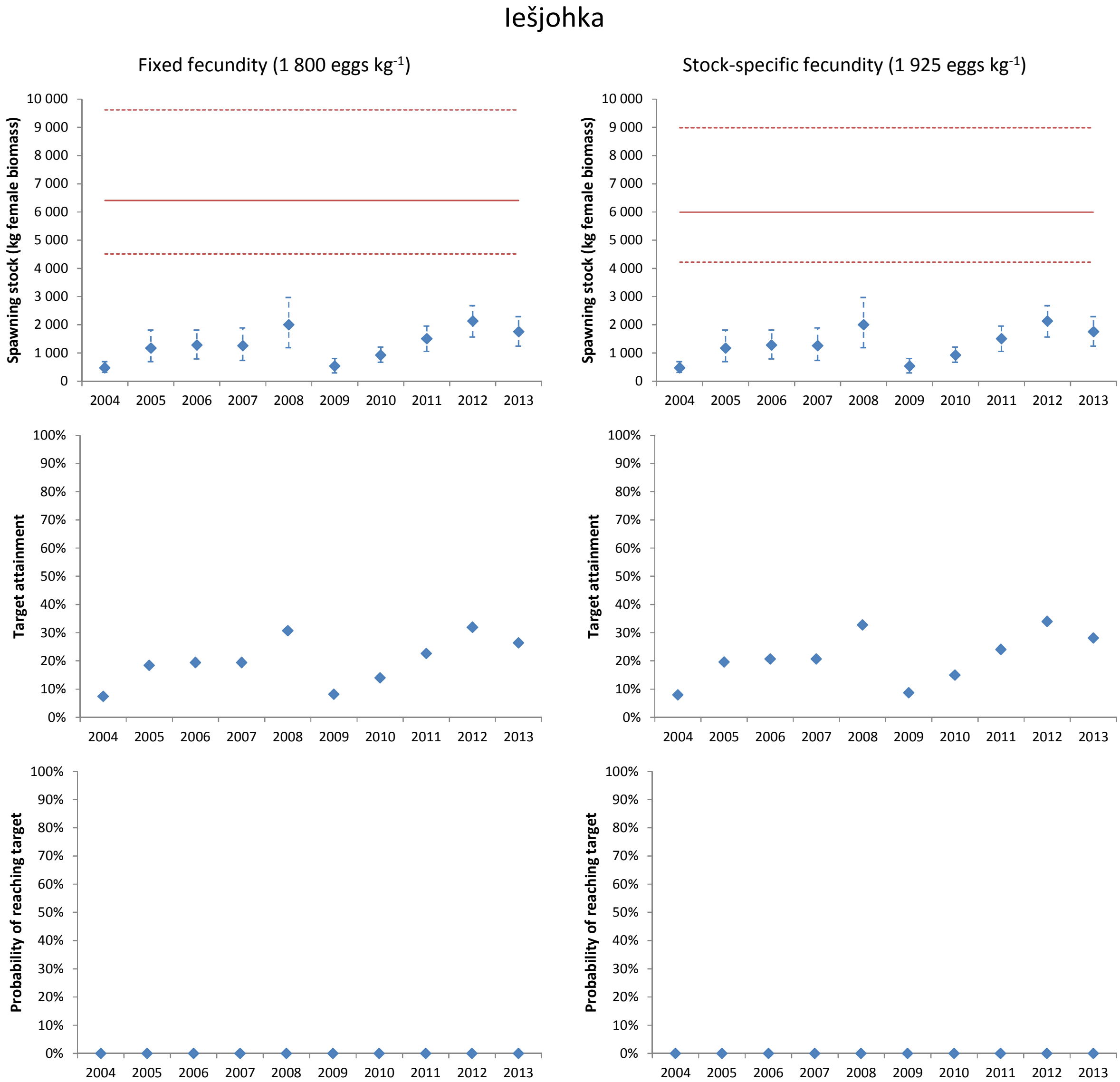

Figure 36. The estimated spawning stock (upper row), percent target attainment (middle row) and probability of reaching the target (bottom row) in the period 2004-2013 in the Norwegian tributary Iešjohka. The left column is based on a fixed fecundity of 1 800 eggs kg^{-1}, the right column is based on a stock-specific fecundity of 1 925 eggs kg^{-1}.

3.4.5.2 Exploitation

The estimated total exploitation (based on weight) for Iešjohka salmon was 91 % in 2009 and 88 % in 2010 (Figure 37). The estimated total pre-fishery abundance was 10 221 kg in 2009 and 13 597 kg in 2010, and from this the total catch was estimated to 9 266 kg in 2009 and 12 004 kg in 2010.

The relative proportion of Iešjohka salmon caught in the coastal fisheries was higher in 2009 than 2010, with 2 631 kg (26 %) estimated to be caught in the coastal fisheries in 2009 and 2 679 kg (19 %) in 2010. This is also a higher proportion than estimated for Máskejohka, Lákšjohka and Válljohka, which reflects the high proportion of large salmon in the Iešjohka stock (large salmon are positively selected for in the coastal fisheries).

The exploitation of Iešjohka salmon in the Tana main stem was estimated to be 5 640 kg (55 %) in 2009 and 7 710 kg (57 %) in 2010. A total of 995 kg (10 %) and 1 615 kg (12 %) was reported caught in the fishery within Iešjohka itself in 2009 and 2010, respectively.

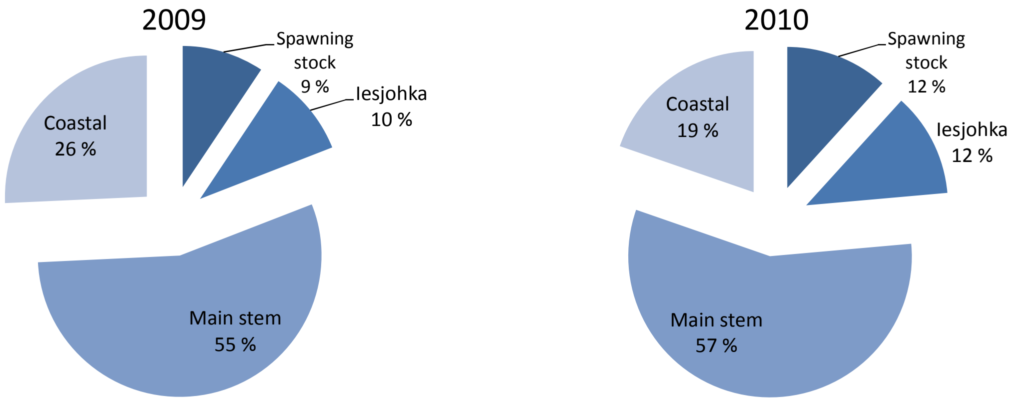

Figure 37. The total amount of salmon belonging to Iešjohka in 2009 (left) and 2010 (right), distributed into surviving spawning stock and salmon caught in fisheries in either coastal, main stem or within-river fisheries.

Estimated relative exploitation efficiencies (based on weight) in 2009 and 2010:

- Coastal: 26%, 19 %
- Tana main stem: 74 %, 71 %
- Within Iešjohka: 51%, 50 %

The overexploitation was estimated to be 90 % in 2009 and 85 % in 2010.

The maximum sustainable exploitation rate was 0 % in 2009 and 24 % in 2010. This indicates a stock situation with very little, if any, sustainable surplus. The current exploitation intensities in coastal and main stem areas mean that the entire sustainable surplus in 2010 was caught before the salmon arrived in Iešjohka.

3.4.5.3 Stock recovery

During the last 4 years, the average probability that the spawning target was reached in Iešjohka was 0 %. This, in combination with a relatively low target attainment, means that this tributary needs a significant reduction in exploitation to improve status.

The average spawning stock size in the last 4 years was 3 357 kg. With the current exploitation estimates, we would need a spawning stock of approximately 7 200 kg to exceed a 75 % probability of reaching the spawning target and over 9 000 kg to reach 100 % probability. During the last 4 years, we have, therefore, on average lacked a female biomass of approximately 5 600 kg in order to reach the 75 % probability level specified by the management target.

With a 20 % reduction in river exploitation, we would not be able to achieve 100 % probability of reaching the spawning target before the end of the recovery period simulated in Figure 38. With a 30 % reduction, the stock recovery period would last 3 generations (24 years), and with a 50 % reduction 1 generation (7 years).

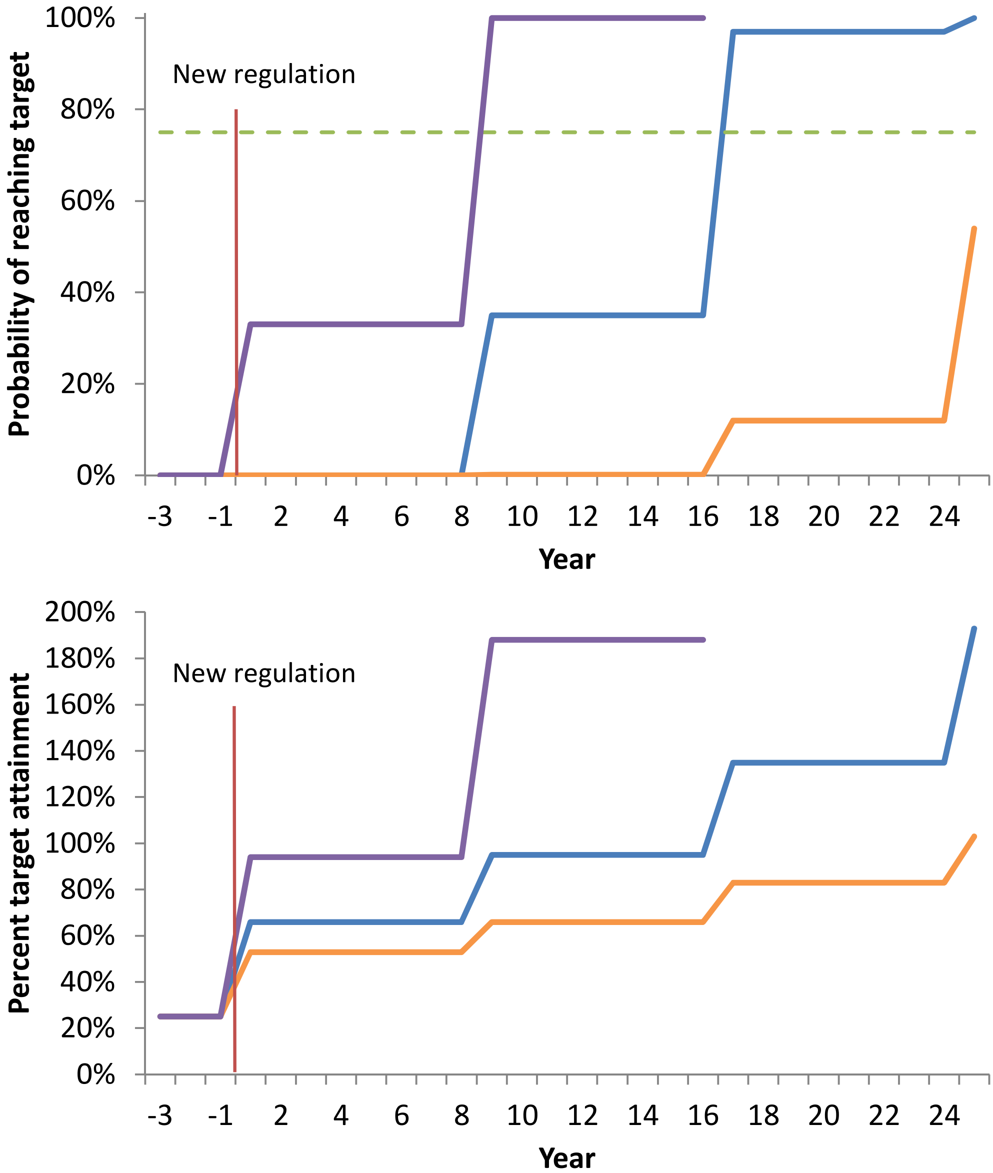

Figure 38. Stock recovery trajectories for Iešjohka, corresponding to three scenarios of reduced river exploitation (Tana main stem + Iešjohka). (Orange) A 20 % reduction, (Blue) a 30 % reduction, and (Purple) a 50 % reduction. Upper panel depicts the development in probability of reaching the spawning target, bottom panel the development in percentage target attainment. The green dotted line represents the 75 % probability line.

3.4.6 Tana/Teno (total)

3.4.6.1 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 and 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) in the period 1993-2013.

The following exploitation rates were used to estimate spawning stock size in Tana:

- Salmon <3 kg: 65 % (50-70 %)
- Salmon 3-7 kg: 55 % (50-70 %)
- Salmon >7 kg: 50 % (40-70 %)

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 52 491 kg (38 766-78 343 kg) when using stock-specific fecundities.

Based on a fixed fecundity level of 1 800 eggs kg^{-1}, percentage target attainment varied from 40 % (2009) to 169 % (2001) in the period 1993-2013. Probability of reaching the spawning target varied between 0 % (1996, 1997, 2004, 2005, 2009, 2011, 2013) and 99 % (2001). With this fecundity level, the management target is currently at 2 %.

Target attainment increases when using stock-specific fecundity levels, varying from 44 % (2009 to 186 % (2001). Probability of reaching the spawning target varied between 0 % (2004, 2005, 2009, 2011, 2013) to 100 % (2001) throughout the period 1993-2013. With the stock-specific fecundities, management target is currently at 5 %.

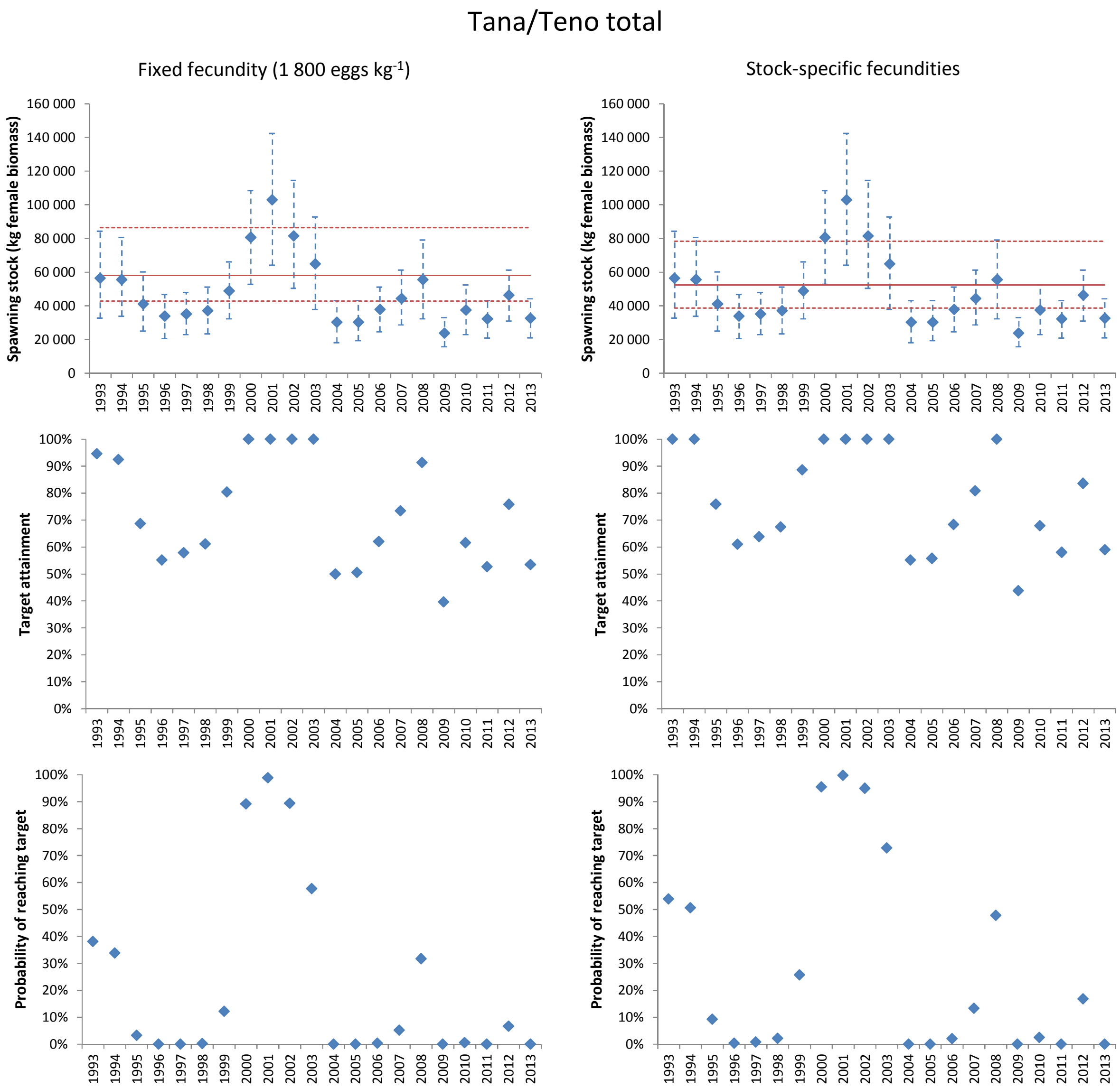

Figure 39. The estimated spawning stock (upper row), percent target attainment (middle row) and probability of reaching the target (bottom row) in the period 1993-2013 in total in Tana/Teno. The left column is based on a fixed fecundity of 1 800 eggs kg^{-1}, the right column is based on stock-specific fecundities.

3.4.6.2 Stock recovery

During the last 4 years, the average probability that the spawning target for the entire Tana/Teno river system was reached was 0 %. This, in combination with a relatively low target attainment, means that the entire river system needs a significant reduction in exploitation to improve overall status.

The average spawning stock size in the last 4 years was 37 184 kg. With the current exploitation estimates, we would need a spawning stock of approximately 66 000 kg to exceed a 75 % probability of reaching the spawning target and over 108 000 kg to reach 100 % probability. During the last 4 years, we have, therefore, on average lacked a female biomass of approximately 28 800 kg in order to reach the 75 % probability level specified by the management target.

With a 20 % reduction in river exploitation, we would achieve 100 % probability of reaching the spawning target at the end of the recovery period simulated in Figure 40 (24 years). With a 30 % reduction, the stock recovery period would last 2 generations (16 years), and with a 50 % reduction 1 generation (8 years).

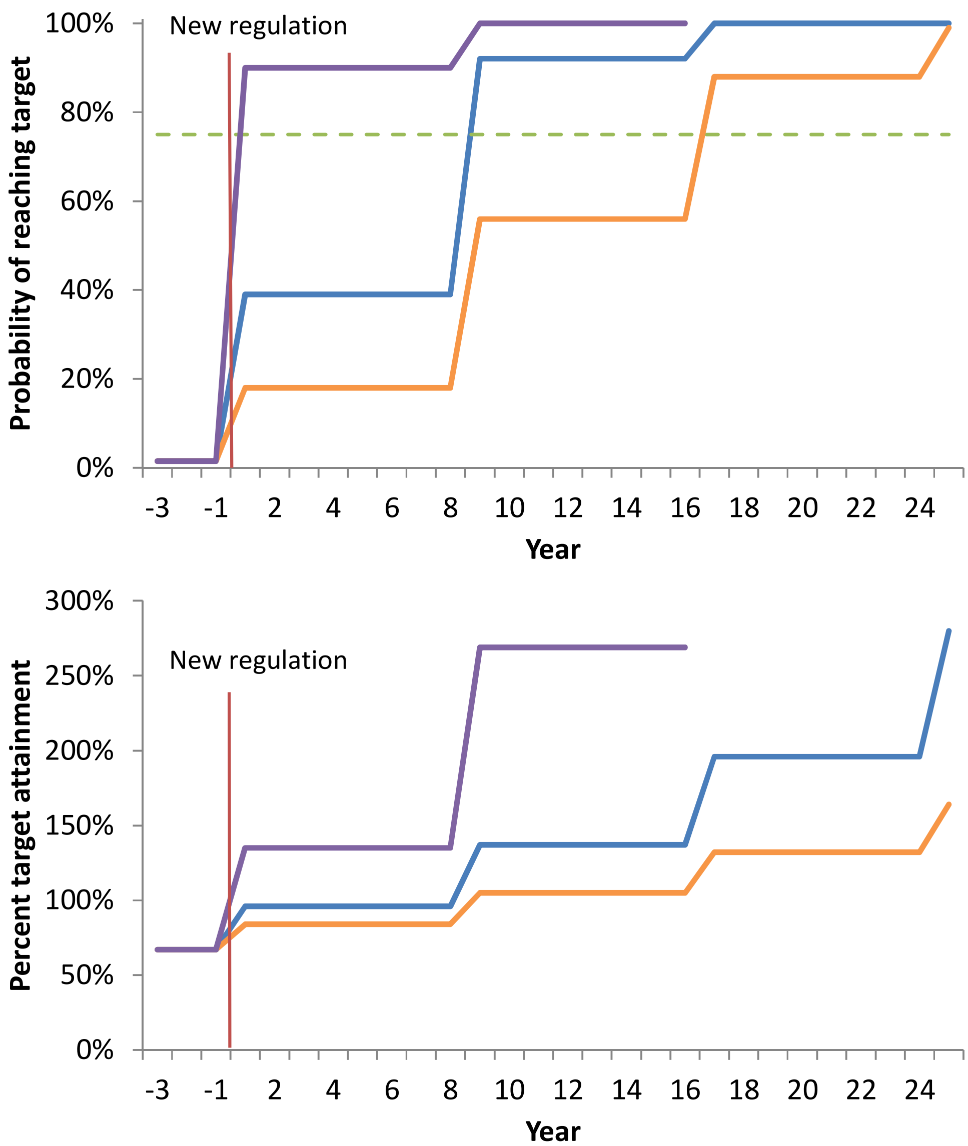

Figure 40. Stock recovery trajectories for Tana/Teno (total), corresponding to three scenarios of reduced river exploitation. (Orange) A 20 % reduction, (Blue) a 30 % reduction, and (Purple) a 50 % reduction. Upper panel depicts the development in probability of reaching the spawning target, bottom panel the development in percentage target attainment. The green dotted line represents the 75 % probability line.

3.4.7 Ohcejohka/Utsjoki

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 Teno mainstem 106 km upstream from the sea. The mainstem of the River Utsjoki comprises large numbers of deep lakes with connecting river stretches. Two major tributaries, the rivers Geavojohka/Kevojoki and Carsejohka/Tsarsjoki, drain to the middle part of the River Utsjoki

3.4.7.1 Status assessment

All ascending salmon have been counted using an array of video cameras in Ohcejohka. The exploitation rate and the escaping spawning population have been estimated by subtracting the estimated catches from the video counts.

The catch in Ohcejohka varied between 730 (2010) and 1 688 (2006) salmon in the period 2004-2013. Based on stock- and sea age -specific fecundities, target attainment reached 100% in 2006, 2012 and 2013, and was close in 2011 (99%) and 2007 (86%).

3.4.8 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, whereafter an impassable waterfall prevents upstream migration.

3.4.8.1 Status assessment

There is no fishing in Áhkojohka , the tributary itself, and therefore direct counts of salmon in the river at spawning time, based on snorkelling, are good estimates of the spawning population (see Orell et al. 2011).

Based on stock- and sea age -specific fecundities, target attainment reached 100% in 2006 and 2012.

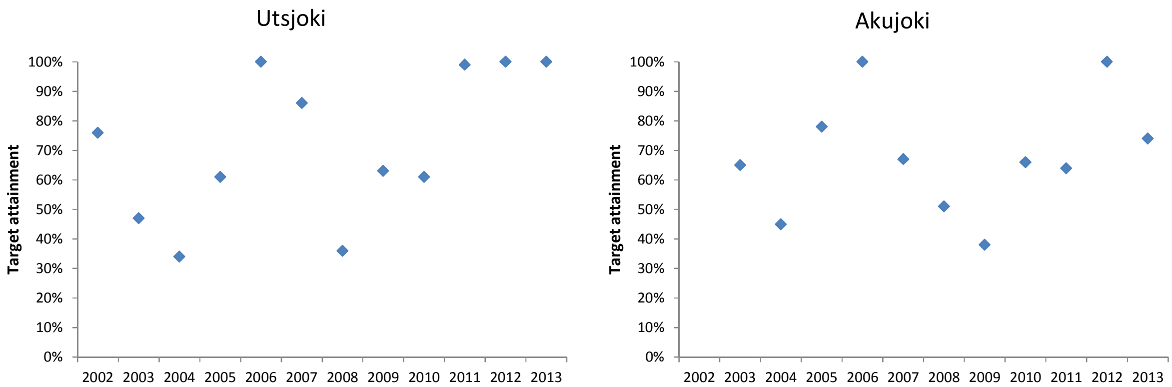

Figure 41. The percent target attainment of Utsjoki (left panel) and Akujoki (right panel) in the period 2002-2013.

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