Status of wild Atlantic salmon in Norway 2019

Norwegian Scientific Advisory Committee for Atlantic Salmon
The status of Norwegian wild Atlantic salmon is evaluated annually by the Norwegian Scientific Advisory Committee for Atlantic Salmon. This is an English summary of the 2019 annual report.

The committee has been appointed by the Norwegian Environment Agency and given the assignment to evaluate status of salmon and the relative importance of different threats, give science-based catch advice, and give advice on other issues related to wild salmon management. The advice is only related to biological questions, and not to socio-economic challenges in the salmon management.

Thirteen scientists from seven institutes/universities are members of the committee: Torbjørn Forseth (leader), Bjørn T. Barlaup, Sigurd Einum, Bengt Finstad, Peder Fiske, Morten Falkegård, Åse Helen Garseth, Atle Hindar, Tor Atle Mo, Eva B. Thorstad, Kjell Rong Utne, Asbjørn Vøllestad and Vidar Wennevik. The committee is an independent body, and the members do not represent the institutions where they are employed when serving on the committee.

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Short summary

The abundance of wild Atlantic salmon (*Salmo salar*) has declined. The number of salmon returning from the ocean to Norway each year is now less than half of the level in the 1980s. Still, the number of salmon spawning in the rivers has increased. The increased number of spawners despite reduced numbers returning from the ocean is due to reduced fisheries in the sea and rivers. Reduced exploitation has more than compensated for the decline.

The reasons for the decline of Atlantic salmon are impacts of human activities in combination with a large-scale decline in the sea survival. The largest declines are seen in western and middle Norway, and negative impacts of salmon farming have contributed to this. Declines due to salmon lice induced mortality will make it difficult to continue sustainable fisheries, particularly in parts of western Norway.

Escaped farmed salmon, salmon lice and infections related to salmon farming are the greatest anthropogenic threats to Norwegian wild salmon. The present level of mitigation measures is too low to stabilize and reduce these threats.

Hydropower production, other habitat alterations and introduced pink salmon (*Oncorhynchus gorbuscha*) are also major threats to wild salmon. Hydropower production and other habitat alterations significantly reduce salmon populations, and there is large potential for further mitigation measures. Pink salmon is a new threat, and there is need for national and international measures to reduce the risk of negative impacts on native salmonids, including Atlantic salmon.

Due to liming of rivers and reduced emissions, the risk of increased negative impacts due to acid rain is small. Salmon populations in southern Norway have increased due to comprehensive liming programs, which have improved the water quality in rivers affected by acid rain.

Successful efforts to reduce the impacts of acid rain and the introduced parasite *Gyrodactylus salaris* have increased salmon populations in impacted regions. Overfishing is almost eliminated due to fishing regulations reducing exploitation.

The 2019 annual report is published in Norwegian: http://hdl.handle.net/11250/2619889

Extended summary

Catches and pre-fishery abundance

In 2018, the total reported catch in sea and river fisheries was 162 000 Atlantic salmon, equaling 594 metric tons. In addition, 22 000 salmon (96 metric tons) were reported caught and released (22% of the river catches).

The number of wild Atlantic salmon returning from the ocean to Norway each year (pre-fishery abundance) is significantly reduced since the 1980s (**figure 1**). The pre-fishery abundance was more than halved from 1983-1986 to 2015-2018. The pre-fishery abundance was estimated at about 543 000 wild salmon in 2018.

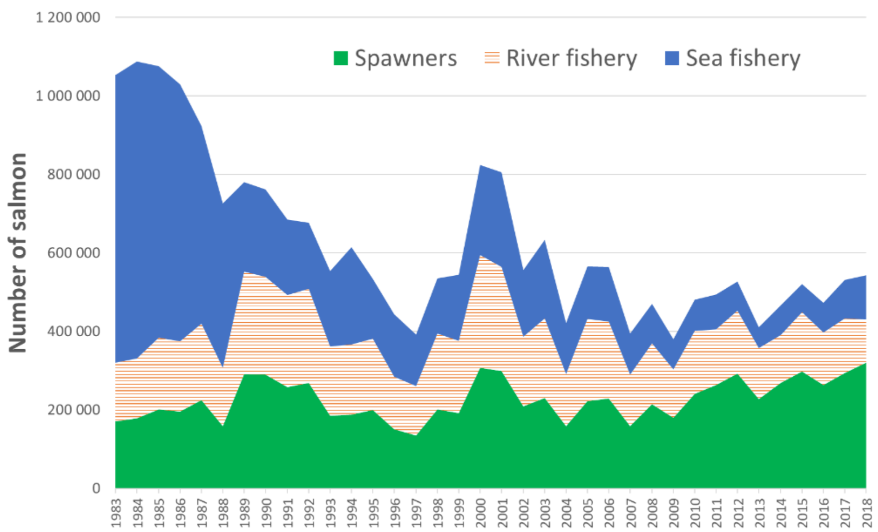

Figure 1. *Estimated number of wild salmon returning from the ocean towards Norwegian rivers each year, divided in number of fish caught in the sea fisheries, number of fish caught in the rivers during angling, and the number of fish left for spawning in the rivers during the period 1983-2018.*

The overall decline is mainly due to a decline of small salmon (body mass < 3 kg). The pre-fishery abundance of small salmon has declined from high levels in the mid-1980s and remained at a low level during the last years, except a temporal increase around year 2000. For Norway as a whole, the abundance of larger salmon (body mass > 3 kg) has not changed after the late 1980s, but there were more large salmon during the mid-1980s.

The temporal changes in numbers of salmon returning from the ocean each year differ among regions. Since 1989, when the offshore drift net fishery was banned, the abundance including all size classes has declined in Middle and Western Norway, and slightly increased in southern and northern Norway (when the Tana watercourse is excluded). The abundance of small salmon has declined in all parts of the country (compared to the period 1989-1993), but to the greatest extent in middle Norway and the smallest extent in northern Norway. The pre-fishery abundance of salmon larger than 3 kg has decreased in Middle Norway and to a varying extent increased in the rest of the country.

The Tana watercourse has had a marked decline in the pre-fishery abundance, in contrast to the rest of Northern Norway, with a 64% reduction in the pre-fishery abundance since 1989. Both small and large salmon have been reduced. This watercourse is shared between Norway and Finland, and overexploitation is the only known impact factor. A new agreement between Norway and Finland was signed in 2017, and exploitation has been reduced.

Marine survival

Monitoring in the River Imsa shows that the marine survival of Atlantic salmon has been low during the last 20-25 years compared to in the 1970s and 1980s, similar to other international monitoring rivers. Results from the Rivers Drammenselva and Imsa showed that the smolts leaving the rivers during 2006-2008 had a particularly low marine survival. The data series from the Drammenselva was terminated in 2008. The marine survival of the smolts that left the River Imsa after 2008 has slightly increased, but the survival remains low. In the best years during the 1980s, the survival of salmon from the River Imsa was 17% from they left the river as smolts until they returned after one year in the ocean. For the salmon that left the Imsa during 2009-2017, the survival was only 1-4%. Knowledge of variation in sea survival for salmon from different regions has been poor due to few monitored rivers. Efforts to monitor sea survival are increasing, and so far, results show that sea survival vary significantly among rivers and years.

Attainment of spawning targets

Attainment of spawning targets (conservation limits) and exploitation were evaluated for 199 salmon rivers for the period 2015-2018. The management target of a population is attained when the average probability of reaching the spawning target over a four-year period is minimum 75%. The scientific foundation for management according to spawning targets and management targets for Norwegian rivers is described by Forseth et al. (2013). For each river, the harvestable surplus was also estimated - as the pre-fishery female abundance minus the spawning target - expressed as percentage of the spawning targets.

The management targets for the period 2013-2016 were attained, or likely attained, for 93% of the populations, when accounting for uncertainty in both the spawning targets and the estimated attainment of the spawning targets(**figure 2**). This is the best results regarding attainment of the management targets since the first evaluation was done in 2009 (**figure 2**). The number and proportion of populations reaching their management targets have increased markedly from 2006-2009 to 2015-2018 (**figure 2**). This increase in proportion of populations reaching the spawning targets is largely due to stricter regulations of fisheries causing reduced exploitation rates, but is also due to increased pre-fishery abundance of multi-sea-winter salmon (salmon larger than 3 kg) during some years in southern and western Norway.

Exploitation

An important principle in Norwegian legislation, which forms the basis for salmon management, is that both conservation and harvestable surplus of salmon should be ensured. The aim of the Salmon and Freshwater Fish Act is to ensure that populations and their habitats are managed such that diversity and productivity are conserved. Further, populations should be managed to ensure increased yields, to the benefit of fisheries stakeholders and recreational fishers. Similar principles are embedded in the Nature Diversity Act (see section on the quality norm below).

Annual nominal catches in the sea and rivers have been reduced from about 1500 metric tons during the 1980s to 500-600 metric tons during the last years. In 1983-1988, more than 60% of the salmon returning from the ocean to the Norwegian coast (pre-fishery abundance) were caught in the sea (**figure 3**). When the drift net fishery was banned from 1989, the exploitation was reduced. The sea fisheries have been further reduced after the 1990s. In 2018, 20% of the salmon returning to the coast were caught in the sea.

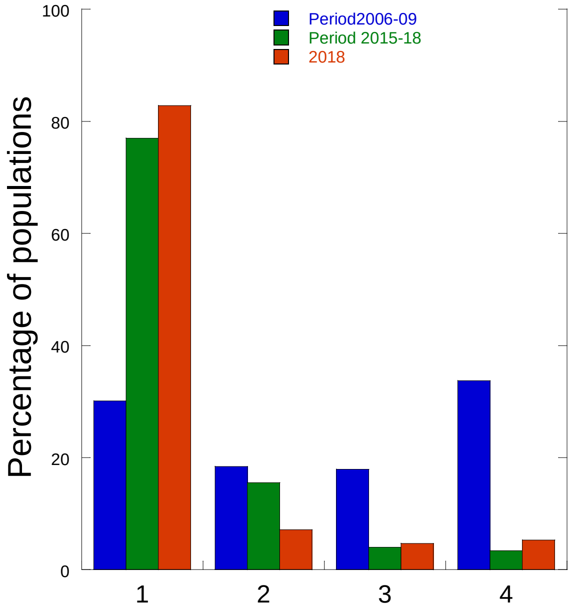

Figure 2. Proportion (%) of the evaluated salmon rivers in category 1: the management target is attained, category 2: there is a risk that the management target is not attained, category 3: the management target is likely not attained, and category 4: the management target is far from being attained. Data are given for the periods 2006-2009 and 2015-2018, as well as for 2018 only.

The proportion of the salmon returning from the ocean each year that are caught in the rivers has been reduced from 2011. In 2018, 20% of the returning salmon were caught in the rivers. Of those salmon entering the rivers (after marine exploitation), exploitation has been markedly reduced from 1983-1988 to 2018 (**figure 3**). On average, 47% of the salmon entering the rivers were killed in fisheries until 2005, whereas in 2018, 26% were killed. However, exploitation rates vary among rivers, and many rivers now have very low exploitation rates, and the fishing has been closed in many rivers after 1982 due to reduced populations. Fishing is currently closed in 110 rivers, of which 36 are closed due to reduced population size, 33 due to poor knowledge on population status, and 28 for other reasons.

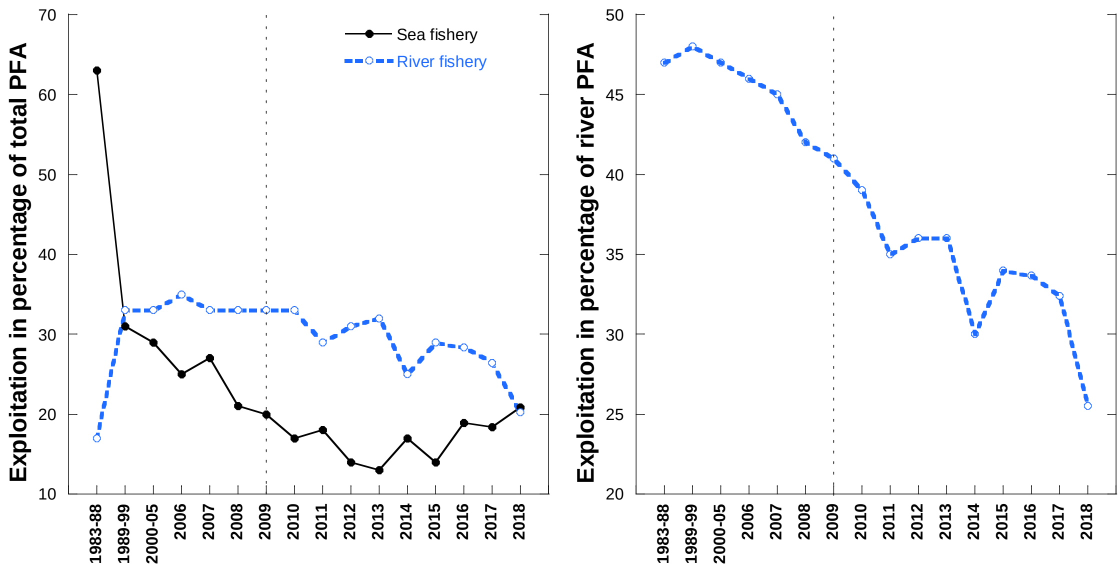

***Figure 3.** Left graph: Exploitation of salmon given as percentage of the pre-fishery abundance (Total PFA, in numbers) for the periods 1983-88, 1989-99 and 2000-05 (averages) and thereafter as annual values. Right graph: Exploitation of salmon in the rivers given as the proportion of salmon entering the rivers (those left after exploitation in sea fisheries, River PFA) for the same periods and years. Hatched line indicates the year when management based on spawning targets was introduced. Note the different scale on the y-axes.*

Reduced exploitation has resulted in an increased number of salmon spawning in the rivers during the last years. In 2018, the number of spawners in the rivers was likely higher than in any other years since 1983 (**figure 1**). The proportion of salmon that were not killed in fisheries but allowed to become a part of the spawning populations, was less than 20% when the drift net fisheries took place (1983-88). This proportion increased to more than 30% during 1989-99, and to 59% in 2018.

Escaped farmed salmon

In 2018, 1 278 000 metric tons of farmed Atlantic salmon were produced in Norway. It was reported that 160 000 farmed salmon escaped from fish farms in 2018. The mean annual number of escaped salmon reported during the last 10 years was 188 400 salmon. (For 2019, 280 000 salmon have been reported escaped per September.) The actual numbers of escaped farmed salmon are potentially 2-4 times higher than the reported numbers, according to studies by the Institute of Marine Research during 2005-2011.

The proportion of escaped farmed salmon in angling catches in monitored rivers during summer has been on average 3-9% in most years after 1989 (**figure 4**). In 2018, the average was 2.8%. The proportion of escaped farmed salmon has been larger during monitoring in the autumn shortly before spawning than in the angling catches in the summer, likely because the escaped farmed salmon tend to enter the rivers later in the season than the wild salmon, often towards the end of or after the angling season. The proportion escaped farmed salmon in the monitored rivers in the autumn was on average 4.1% in 2018 (**figure 4**). In comparison, this proportion was greater than 20% in the years 1989-1998. In the last twelve years, the proportion has varied between 4% and 18%. From 2006, there has been a weak decline in the proportion of escaped farmed salmon in the autumn close to the spawning season.

New studies have shown that there is widespread genetic introgression of escaped farmed salmon in Norwegian wild salmon. In only one third of the mapped rivers, no indication of genetic introgression from escaped farmed salmon was found (75 of 225 rivers). Significant genetic contributions from farmed salmon (introgression) has been found in wild salmon in 83 of 225 studied rivers. Further, there were indications of genetic introgression from farmed salmon in wild salmon in 67 additional rivers.. It should be noted that all wild salmon examined in these studies were salmon produced naturally in the rivers. Another new study has shown how gene flow from escaped farmed salmon has altered the life history of wild Atlantic salmon in Norwegian rivers; individuals with high levels of introgression from farmed fish had altered age and size at maturation.

The scientific evidence that incidence of escaped farmed salmon will negatively affect Norwegian wild salmon, both ecologically and genetically, is strengthened during recent years. Even though the proportion of escaped farmed salmon has decreased in monitored rivers, the proportions are still so high in many rivers that more extensive measures are required to reduce the negative impacts. Many salmon populations are already genetically impacted by farmed salmon introgression, and continued addition of new escaped farmed salmon challenge the recovery of the natural genetic composition of wild populations. The official goal of protecting the genetic integrity and variation of wild Atlantic salmon populations cannot be met with current levels of escaped farmed salmon in the populations, including the levels recorded during monitoring in 2018. In addition to changing the populations genetically, hybridization between wild and escaped farmed salmon is also shown to reduce salmon production and survival.

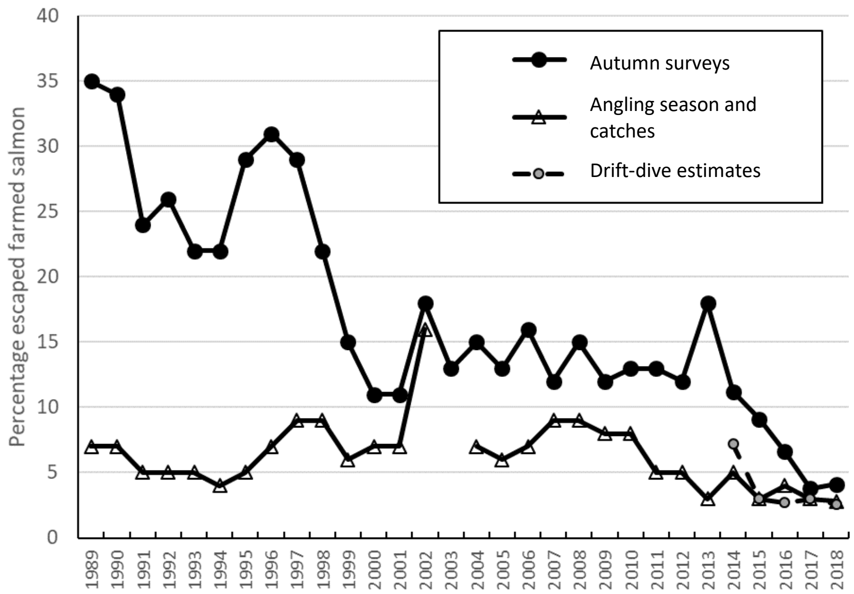

***Figure 4**. Proportion of escaped farmed salmon among adult salmon in the rivers based on samples collected during the angling season, and in monitoring of the rivers immediately before the spawning season in the autumn during the period 1989-2018. In recent years, drift-dive estimates of escaped farmed salmon are also included in the monitoring, and these data are given separately. Data are given as average proportion of escaped farmed salmon in monitored rivers.*

Major threats to Norwegian wild salmon

The committee has developed a classification system to rank different anthropogenic impacts to Norwegian Atlantic salmon populations (**figure 5**, Forseth et al. 2017). Assessments according to this system are updated annually by the committee.

Salmon farming

Escaped farmed salmon, salmon lice and infections related to fish farming were identified as the largest population threats to wild salmon (**figure 5**). Escaped farmed salmon have the greatest negative impact, whereas salmon lice have the greatest risk of causing further losses in the future. Escaped farmed salmon and salmon lice are regarded as expanding population threats, which means they are affecting populations to the extent that populations may be critically endangered or lost in nature and that have a high likelihood of causing even further reductions. Current mitigation measures are insufficient to hinder expansion of negative impacts in the future.

The number of salmon returning to the rivers each year is reduced due to the impacts of salmon lice, and this reduction of salmon populations has reduced the harvestable surplus for angling and commercial fisheries. In 2010-2014, we estimated that 50 000 fewer salmon returned from the ocean to Norwegian rivers each year due to the impacts of salmon lice. For 2018, we estimated a reduction of 11 000 salmon due to salmon lice. In 2010-2014, salmon returns were negatively impacted over a larger part of the country than in 2018, but in 2018, the areas severely impacted in western Norway had increased. In both periods, populations in Hordaland were severely impacted by salmon lice, but in 2018, also populations further north, in Sognefjorden, were severely impacted. Also in parts of Sunnmøre, impacts of salmon lice had increased in 2018. In Trøndelag og Sør-Helgeland, returns seemed not significantly impacted by salmon lice in 2018.

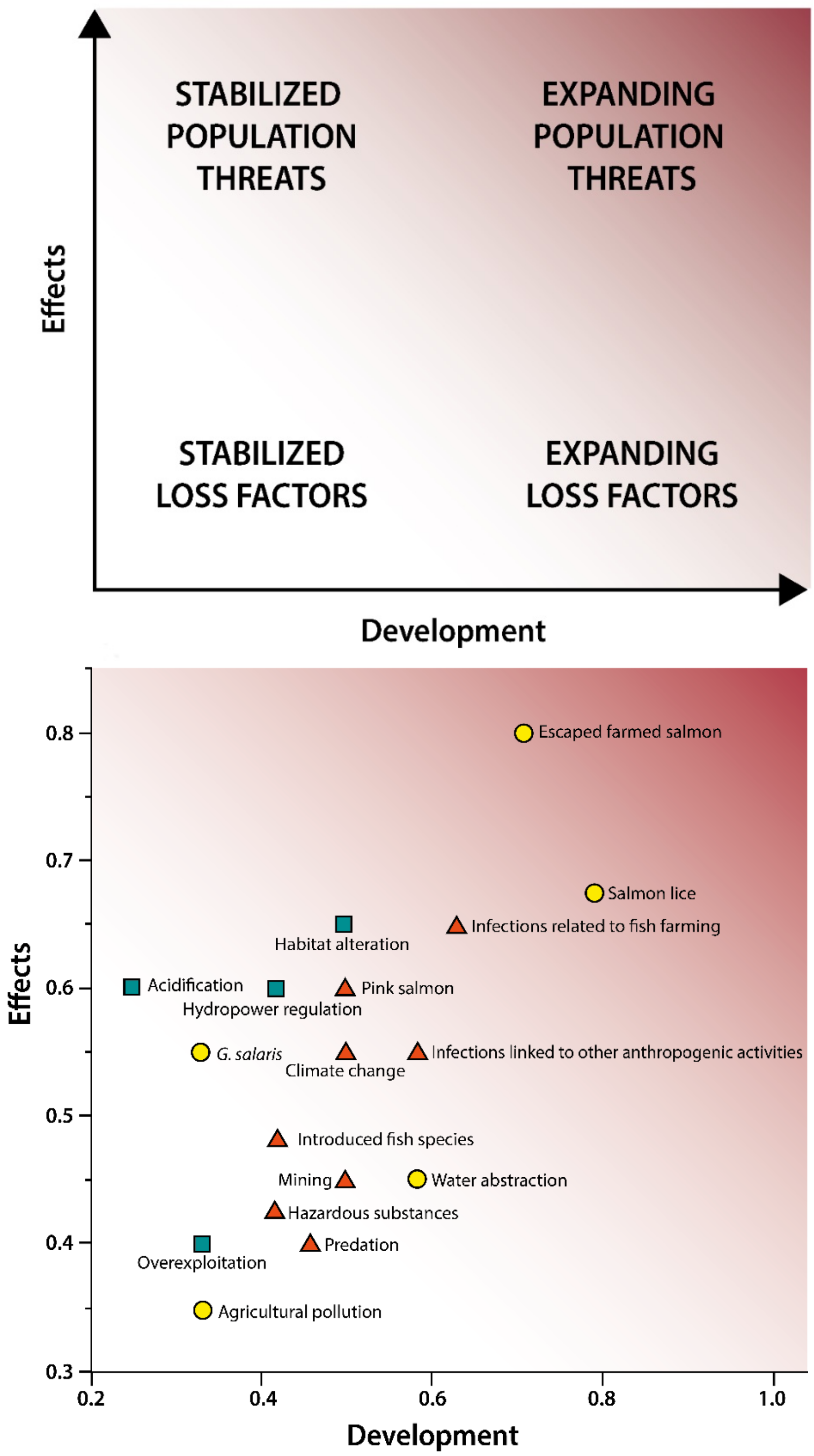

Figure 5.

Upper graph: The classification system developed to rank different anthropogenic impacts to Norwegian Atlantic salmon populations along the effect and development axes. *The four major impact categories are indicated, but the system is continuous. Dark background colour indicates the most severe impacts. The effect axis describes the effect of each impact factor on the populations, and ranges from factors that cause loss in adult returns, to factors that cause such a high loss that they threaten population viability and genetic integrity. The development axis, describes the likelihood for further reductions in population size or loss of additional populations in the future.*

Lower graph: Ranking of 17 impact factors considered in 2019, according to their effects on wild Atlantic salmon populations and the likelihood of a further negative development. *The knowledge of each impact factor and the uncertainty of future development is indicated by the color of the markers. Green squares = Extensive knowledge and small uncertainty, yellow circles = moderate knowledge and moderate uncertainty, and red triangles = poor knowledge and high uncertainty.*

Infections related to fish farming were also identified as a threat that can significantly impact salmon, and with a large likelihood of causing further reductions and losses in the future. However, knowledge of the impacts of infections related to fish farming is poor, and the uncertainty of the projected development of this impact factor is high. More knowledge on this impact factor is needed. There is a risk that this threat is underestimated due to lack of knowledge.

Hydropower production, other habitat alterations, acid rain and introduced pink salmon
Hydropower production, other habitat alterations, acid rain and introduced pink salmon were also identified as threats to wild salmon, but with a lower risk of causing further loss of wild salmon in the future than the threats related to salmon farming (**figure 5**). Hydropower production and other habitat alterations significantly impact wild salmon, but the negative impact will likely not increase in the future. However, the potential for more extensive mitigation measures is large. Due to large-scale liming of rivers and reduced emissions, the risk of increased negative impacts due to acid rain is low. Salmon populations in southern Norway have increased due to the comprehensive liming programs.

The occurrence of pink salmon in Norwegian rivers has increased significantly in 2017 and 2019. As long as there is reproduction of pink salmon in Russian rivers in the White Sea and Kola Peninsula area, and in northeastern Norway close to Russia, there is a risk that pink salmon may spread further south. To decrease the risk of negative impacts on native salmonids, there is need to strengthen and coordinate mitigation measures both on the national and international level.

Introduced parasite Gyrodactylus salaris
The threat to wild salmon from the introduced parasite *Gyrodactylus salaris* is greatly reduced, because successful eradication programs have strongly reduced the number of rivers infected with the parasite, and the salmon populations have been re-established from live gene banks. Number of rivers with known occurrence of the parasite has been reduced from fifty to seven, due to the eradication measures.

Overfishing and other impacts
Other impacts were identified as less influential, either as stabilized or expanding factors that cause loss in terms of number of returning adults, but not to the extent that populations become threatened. Management based on population specific reference points (conservation limits) has reduced exploitation, and overexploitation was no longer regarded an important impact factor.

The quality norm for Norwegian Atlantic salmon populations
A quality norm sanctioned by the Nature Diversity Act was adopted by the Norwegian government in 2013. The quality norm is a standard that all salmon populations should attain. The aim is to contribute to the conservation and rebuilding of salmon populations to a size and structure that will ensure diversity and productivity within the species, and that will ensure harvest opportunities.

For a population to attain a good enough standard according to the quality norm, the population must not be genetically impacted by escaped farmed salmon or other anthropogenic activities, it must have a large enough spawning population to reach the spawning target (*i.e.*, the population must be conserved) and it must provide a normal harvestable surplus (given the current ocean survival conditions). Hence, population status can only be classified as good when the spawning targets are attained after a normal exploitation of the population. When a population does not have a normal harvestable surplus, this indicates that local or regional human impact factors are negatively impacting them. A population that reaches the spawning target, but where the fishing is highly reduced or closed, does not have a good status. In total, 176 populations have been evaluated according to the norm.

Only 35 populations (20%) were classifies as having a good or very good quality, which is the requirement of the norm. This means that 141 populations (80%) did not meet the requirements of the quality norm. Of these, 48 populations (27%) had moderate quality and 93 populations (53%) had poor or very poor quality.

Most of the populations reached their spawning targets. The reason that many populations did not attain the quality norm was that they were genetically impacted by escaped farmed salmon (**figure 6**) and/or did not have a normal surplus, indicating that they were impacted by human impacts.

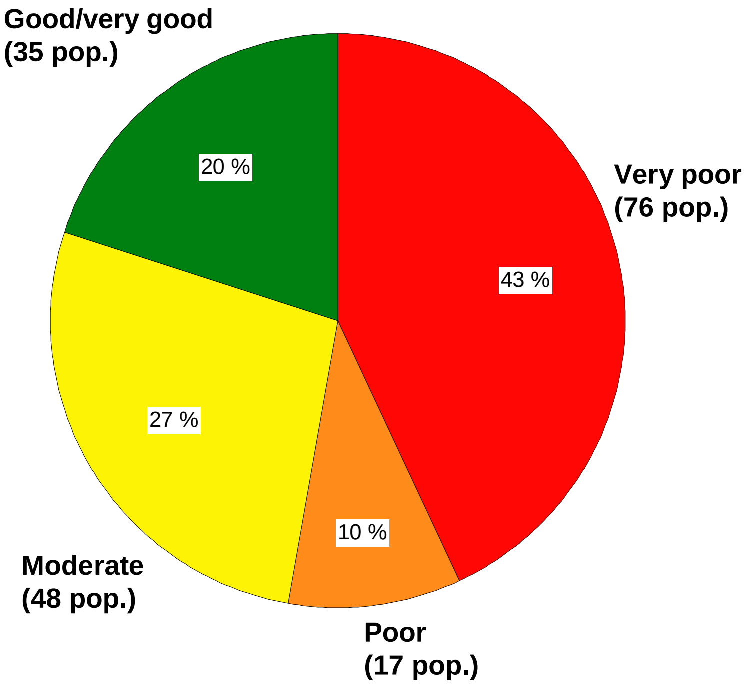

Figure 6*. Status of 176 Norwegian salmon populations given as proportion and number of populations classified as in very good and good status, moderate, poor, or very poor status according to the quality norm sanctioned by the Nature Diversity Act. Only populations in very good and good status met the requirements of the norm (green sector).*

References to scientific publications of work from the Norwegian Scientific Advisory Committee for Atlantic Salmon

Forseth, T., Fiske, P., Gjøsæter, H. & Hindar, K. 2013. Reference point based management of Norwegian Atlantic salmon populations. Environmental Conservation 40: 356-366.

Forseth, T., Barlaup, B.T., Finstad, B., Fiske, P., Gjøsæter, H., Falkegård, M., Hindar, A., Mo, T.A., Rikardsen, A.H., Thorstad, E.B., Vøllestad, A. & Wennevik, V. 2017. The major threats to Atlantic salmon in Norway. ICES Journal of Marine Science 74: 1496-1513.