Status of wild Atlantic salmon in Norway 2021

Photo: Helge Skoglund

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 2021 report.

The committee is appointed by the Norwegian Environment Agency to evaluate status of salmon and importance of different threats, and to give science-based catch advice and advice on other issues related to wild salmon management.

Thirteen scientists from seven institutions serve on the committee: Torbjørn Forseth (leader), Sigurd Einum, Peder Fiske, Morten Falkegård, Øyvind A. Garmo, Åse Helen Garseth, Helge Skoglund, Monica F. Solberg, Eva B. Thorstad, Kjell Rong Utne, Asbjørn Vøllestad, Knut Wiik Vollset 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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Status of Atlantic salmon - short summary

The number of salmon returning from the ocean to Norway each year is now half of the level recorded 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 population declines are seen in western and middle Norway, and negative impacts of salmon farming have contributed to this. Escaped farmed salmon, salmon lice and infections related to salmon farming are the greatest anthropogenic threats to Norwegian wild salmon. The present mitigation measures are insufficient to stabilize and reduce these threats.

Hydropower production and other habitat alterations are also threats to salmon. There is great potential for improving conditions for salmon in regulated rivers. Invasive 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.

Climate change impacts Atlantic salmon populations negatively. Climate change increases the need to reduce the impacts of other threats to support the ability of Atlantic salmon to adapt to changing environments.

A new classification of the state of all the 449 salmon populations showed that only one fifth of the populations were in a good or very good state, whereas more than one third of the populations were in a poor or very poor state. The state of the populations in 2015-2019 was not improved compared to in 2010-2014, and there was no change in the impact factors that had the strongest negative impact on the populations.

The 2021 annual report is published in Norwegian: https://brage.nina.no/nina-xmlui/handle/11250/2830680

Beiarelva. Photo: Eva B. Thorstad

Extended summary

Catches and pre-fishery abundance

In 2020, the total reported catch in sea and river fisheries was 148 000 Atlantic salmon, equaling 527 metric tons. In addition, 29 000 salmon (115 metric tons) were reported caught and released (23% 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 halved from 1983-1986 to 2017-2020. The pre-fishery abundance was estimated at about 553 000 wild salmon in 2020.

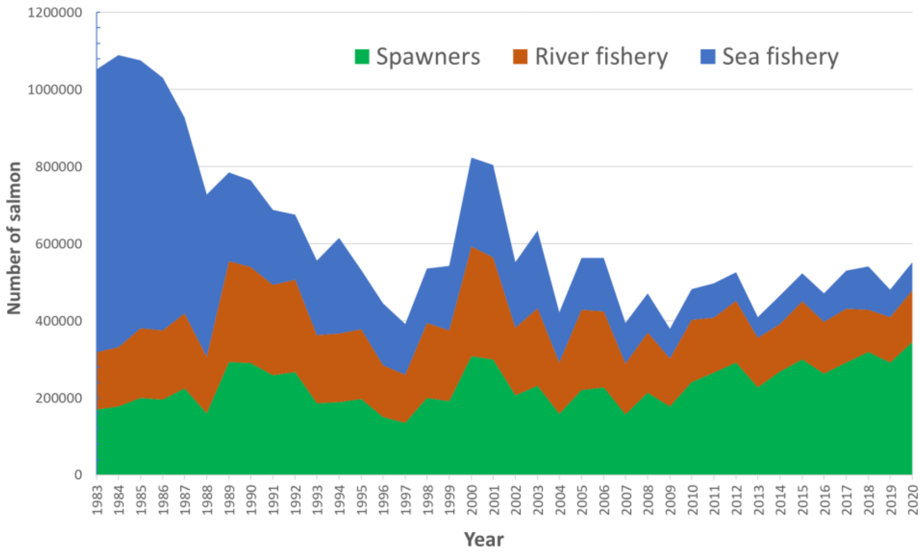


Figure 1. *Estimated number of wild salmon returning from the ocean towards Norwegian rivers each year, divided in number of fish caught in the sea fisheries, number of fish caught in the rivers during angling, and the number of fish left for spawning in the rivers during the period 1983-2020.*

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 and western Norway. The pre-fishery abundance of salmon larger than 3 kg has decreased in middle Norway, but 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 70% 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.

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. The smolts leaving the river during 2006-2008 had a particularly low survival. The marine survival of the smolts that left the river after 2008 has slightly increased, but the survival remains low. In the best years during the 1980s, the survival was 17% from they left the river as smolts until they returned after one year in the ocean. For the salmon that left the River Imsa during 2009-2018, the survival was only 1-4%. Knowledge of variation in sea survival for salmon from different regions has been poor. Efforts to map sea survival are increasing by the establishment of new monitoring rivers, 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 202 salmon rivers for the period 2017-2020. The management target of a population is attained when the average probability of reaching the spawning target over a four-year period is 75% or higher. 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 2017-2020 were attained, or likely attained, for 92% of the populations (**figure 2**). This is among 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 2017-2020, although there was a slight decrease from 2019 to 2020 (**figure 2**). The increase in proportion of populations reaching their spawning targets is largely due to stricter regulations of fisheries causing reduced exploitation rates.

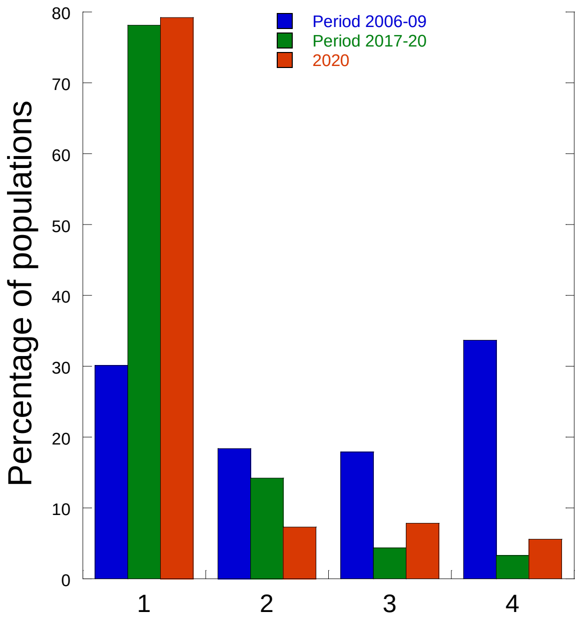


Figure 2*. Proportion (%) of the evaluated salmon rivers in category 1: the management target is attained, category 2: there is a risk that the management target is not attained, category 3: the management target is likely not attained, and category 4: the management target is far from being attained. Data are given for the periods 2006-2009 and 2017-2020, as well as for 2020 only.*

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.

Annual nominal catches in the sea and rivers have been reduced from about 1500 metric tons during the early 1980s to 500-600 metric tons during recentyears. 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 2020, 13% of the salmon returning to the coast were caught in the sea.

The proportion of the salmon returning from the ocean each year that are caught in the rivers has been reduced from 2011. In 2020, 24% 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 2020 (**figure 3**). On average, 47% of the salmon entering the rivers were killed in fisheries until 2005, whereas in 2018, 2019 and 2020, less than 30% 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 due to reduced populations.

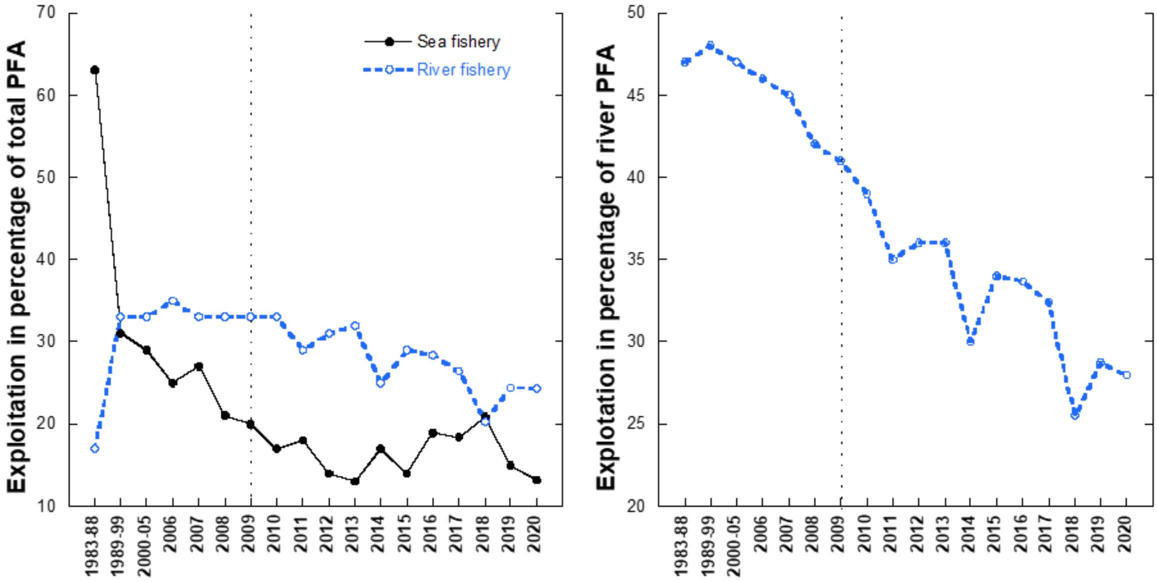


Figure 3. *Left graph: Exploitation of salmon given as percentage of the pre-fishery abundance (Total PFA, in numbers) for the periods 1983-88, 1989-99 and 2000-05 (averages) and thereafter as annual values. Right graph: Exploitation of salmon in the rivers given as the proportion of salmon entering the rivers (those left after exploitation in sea fisheries, River PFA) for the same periods and years. Hatched vertical 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 (**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 around 60% from 2018 and onwards.

Escaped farmed salmon

In 2019, 1 393 000 metric tons of farmed Atlantic salmon were produced in Norway. It was reported that 43 000 farmed salmon escaped from fish farms in 2020. The mean annual number of escaped salmon reported during the last 10 years was 168 000 salmon. The actual numbers of escaped farmed salmon were 2-4 times higher than the reported numbers, according to studies by the Institute of Marine Research during 2005-2011. The are no updated estimates for this difference.

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. In 2020, the average was 1.5%. 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 3.4% in 2020. In comparison, this proportion was greater than 20% in the years 1989-1998. In the last ten years, the proportion has varied between 1.6% and 14%. The proportion of escaped farmed salmon in the autumn has declined during the last ten years.

New studies have shown that there is widespread genetic introgression of escaped farmed salmon in Norwegian wild salmon. In two thirds of the screened rivers, there were indications of genetic introgression from escaped farmed salmon in the wild population (150 of 239 rivers), of which 68 populations were severely impacted (28% of the screened populations). It should be noted that all wild salmon examined in these studies were salmon produced naturally in the rivers. Another 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.

Escaped farmed salmon. Photo: Helge Skoglund

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 2020. In addition to changing the populations genetically, hybridization between wild and escaped farmed salmon is also shown to reduce salmon production and survival.

Salmon lice

The number of salmon returning to the rivers each year is reduced due to the impacts of salmon lice (**figure 4**). This reduction threatens salmon populations in the most impacted areas, and has significantly reduced the harvestable surplus for angling and marine fisheries over large parts of the country. 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 29 000 salmon due to salmon lice, and for 2019 a reduction of 39 000 salmon.

The impact of salmon lice is most severe in western and middle Norway (**figure 4**). In 2019, the areas severely impacted in western and middle Norway had increased. Many wild salmon populations in these areas have been heavily impacted by salmon lice for many years, and are now in a very poor state. Several threats impact these populations, including escaped farmed salmon, but heavy salmon lice burdens is likely the reason that they are not able to recover.

The advisory committee concludes that an increased number of populations are endangered by salmon lice, and that there is a high risk that more populations will be endangered. Sufficient mitigation measures to improve the situation are not implemented, and the production of farmed salmon is increasing.

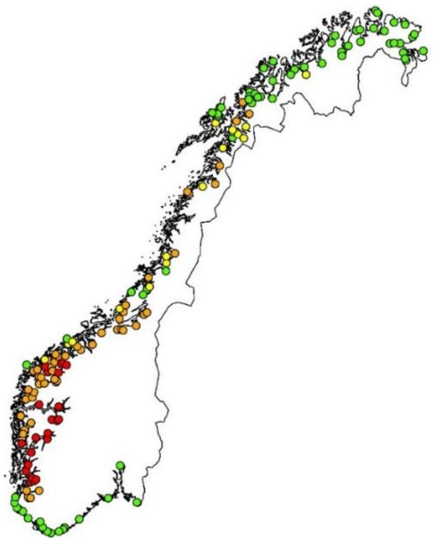


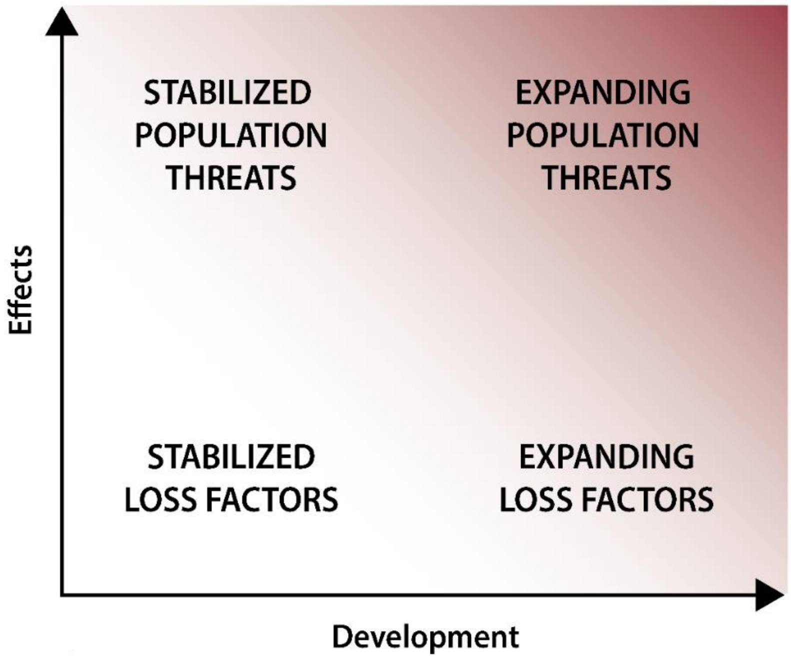
Figure 4. *Estimated impacts of salmon lice on the abundance of adult Atlantic salmon returning from the ocean for spawning in 167 rivers in 2019. Green symbols: < 5 % reduction in number of returning spawners. Yellow: 5.0-9.9 % reduction. Orange: 10-30 % reduction. Red: > 30 % reduction.*

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 and salmon lice were identified as the largest threats to wild salmon (**figure 5**), both to a large extent impacting wild populations negatively. 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. Salmon lice have the greatest risk of causing further losses in the future.



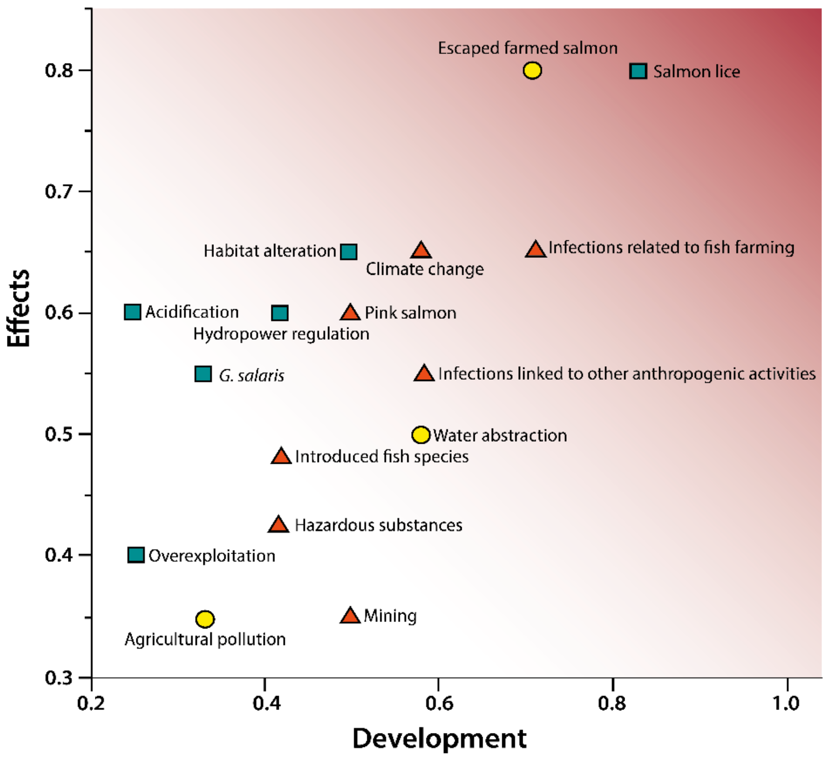


Figure 5.

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 16 impact factors considered in 2020, 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, invasive pink salmon

Hydropower production, other habitat alterations, and acid rain 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.

Invasive 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. The occurrence of invasive pink salmon in Norwegian rivers increased significantly in 2017, 2019 and 2021 compared to earlier years. The knowledge on the impacts on native salmonids is limited. It should be noted that this assessment is based on the occurrence of pink salmon in 2019. The data for 2021 were not yet complete when this assessment was performed, but the numbers of pink salmon occurring in the rivers increased considerably in 2021 compared to 2017 and 2019.

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-one to eight, due to the eradication measures. Measures are ongoing for four of the remaining eight infected populations.

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.

Climate change
Climate change is a global threat, which is already impacting salmon populations, and will impact salmon populations to a great extent in the future. Climate change impacts the life of the Atlantic salmon at all life stages, through changes in water temperature, precipitation, water quality and other environmental factors. There is extensive knowledge on how these factors impact Atlantic salmon in the freshwater phase, but less knowledge on the marine phase. There is also little knowledge on how climate change will impact long-term genetic and ecological changes and adaptations in different populations. Since salmon populations are genetically different, and will experience different changes in climate, it is likely that different populations will respond differently to climate change.

Climate change amplifies the negative effects of other threats to Atlantic salmon populations. Threats like escaped farmed salmon, salmon lice, other infections related to salmon farming, habitat alterations, negative impacts of inasive species, pollution and others become even larger when occurring in a changing climate. This is also the case for river regulation for hydropower production, but such regulation can also in some cases be adapted to help reducing the impacts of climate change.

Climate change is a threat that increases the importance of having large and genetically variable populations to enable them to meet the rapid changes in the best possible way. Hence, it is important to protect and preserve the size and genetic variation and integrity of salmon populations, and thereby the abilities of populations to adapt to new and changing conditions. Climate change increases the needs to reduce the impacts of other threats to Atlantic salmon.

Classification of the state of all Norwegian Atlantic salmon populations

The state of 449 Norwegian Atlantic salmon populations was classified, using data from the period 2015-2019. The impact from different human activities was also determined. Only 21% of the populations were in a good or very good state, 37 % in a moderate state, and 38 in a poor or very poor state, whereas 4 % were under re-establishment after being treated against the introduced parasite *Gyrodactylus salaris*.

Escaped farmed salmon, salmon lice, hydropower production and other habitat alterations had the largest negative impact on the salmon populations in terms of the number of populations impacted. In terms of the reductions in population size the same four impacts were the most severe, but with salmon lice having the most negative impact, followed by escaped farmed salmon, hydropower production and other habitat alterations. In addition to reducing population size, escaped farmed salmon also genetically alter the wild populations. Invasive pink salmon impacted a large number of populations, but the effect on populations was not evaluated due to lack of knowledge.

The state of the populations in 2015-2019 was not improved compared to a similar assessment in 2010-2014. There was also no change in which impact factors were the most severe.

The state of the populations was classified either according to the quality norm, or following a simplified classification system. The quality norm for Norwegian Atlantic salmon populations is sanctioned by the Nature Diversity Act and 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, 185 populations were evaluated according to the norm, whereas 264 populations were evaluated according to the simplified system resembling the quality norm but adapted to populations for which less data are available.

Scientific publications 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.