Status of wild Atlantic salmon in Norway 2023

Photo: Eva B. Thorstad

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 2023 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

Both the number of Atlantic salmon returning from the ocean to Norway for spawning, and the Atlantic salmon catches were among the lowest ever recorded in 2022 (based on a time series starting in 1980), but slightly higher than the record-low in 2021. The number of salmon returning from the ocean to Norway each year is now less than 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.

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. Salmon lice, escaped farmed salmon, 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. The knowledge on infections related to salmon farming is poor.

Hydropower production and other habitat alterations are also threats to salmon. There is an underexploited potential for improving conditions for salmon in regulated rivers. Invasive pink salmon is a new threat. In 2023, traps are installed in many rivers in Northern Norway, to hinder pink salmon in entering the rivers, but there is lack of knowledge on the effects of pink salmon on native salmonids, and on the efficiency of the implemented measures.

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.

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Spilderelva. Photo: Eva B. Thorstad

Extended summary

Major threats to Norwegian wild salmon

The committee has developed a classification system to rank different anthropogenic impacts to Norwegian Atlantic salmon (**figure 1**, Forseth et al. 2017). Assessments according to this system are updated annually by the committee.

Salmon farming

Salmon lice and escaped farmed salmon were identified as the largest threats to wild salmon (**figure 1**), to a large extent impacting wild populations negatively. Salmon lice and escaped farmed salmon are regarded as expanding population threats, which means they affect populations to the extent that populations may be critically endangered or lost in nature, and that there is a high likelihood they will cause even further reductions. Current mitigation measures are insufficient to hinder expansion of negative impacts in the future.

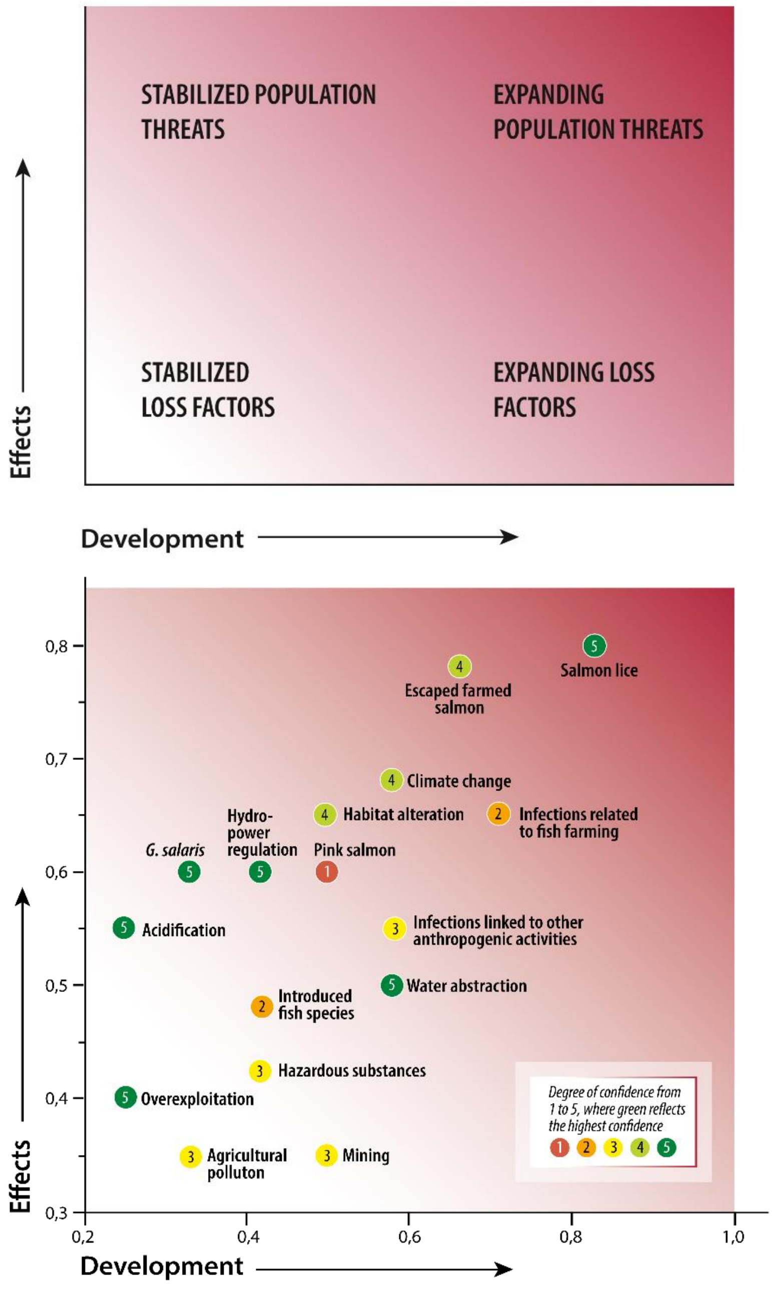

Figure 1.

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 2022, according to their effects on wild Atlantic salmon populations, and the likelihood of a further negative development. *Confidence for the assessment of effect by each threat is indicated by the color of the markers, where green indicates the highest confidence level and red the lowest.*

Salmon lice have the greatest impact on Norwegian wild salmon, and by far the greatest risk of causing further losses in the future. The number of salmon returning to the rivers each year is reduced due to post-smolt mortality caused by salmon lice. This reduction threatens salmon populations in the most impacted areas and has significantly reduced the harvestable surplus for river and marine fisheries over large parts of the country. The impact of salmon lice is most severe in western and middle Norway. The areas severely impacted have increased during the last five years. 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 are likely the reason that they are not able to recover. Sufficient mitigation measures to improve the situation are not implemented, and the production of farmed salmon is increasing.

According to reports from fish farmers, 56 000 salmon escaped from aquaculture farms in 2021. The actual number is uncertain, but higher than the reported numbers. Due to a reduced occurrence of escaped farmed salmon recorded in rivers, the threat is adjusted slightly down compared to previous years. 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). The scientific evidence that incidence of escaped farmed salmon will negatively affect Norwegian wild salmon, both ecologically and genetically, is strengthened during recent years. In addition to changing the populations genetically, hybridization between wild and escaped farmed salmon is also shown to reduce salmon production and survival.

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 and other habitat alterations

Hydropower production and other habitat alterations, together with climate change and 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 1**). Hydropower production and other habitat alterations have reduced many salmon populations and caused the loss of salmon in some rivers. The potential for more extensive mitigation measures related to hydropower production and other habitat alterations is large.

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 Atlantic salmon at all life stages, through changes in water temperature, precipitation, water quality and other environmental factors. 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 invasive 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.

Invasive pink salmon
Pink salmon is a new threat, and the occurrence of invasive pink salmon in Norwegian rivers increased significantly in 2017, 2019 and 2021 compared to earlier years. Pink salmon were recorded in 271 rivers, and 205 000 pink salmon were caught in rivers and coastal fisheries in 2021. The highest abundance of pink salmon was recorded in Northern Norway. In 2023, traps are installed in more than 30 rivers in the most affected areas to remove pink salmon and reduce the negative impacts on native salmonids. The knowledge on the impacts on native salmonids and the effect of the mitigation measures is limited, because the area with high abundance of pink salmon may increase faster than the implementation of measures. It should be noted that this risk assessment was performed before the return of pink salmon during the 2023 season.

The invasive 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 in four of the remaining eight infected rivers.

Acid rain
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.

Overfishing and other impacts
Overfishing and 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. Overexploitation is defined as a reduction in number of spawning females in a population to levels below the spawning target due to fishing in rivers and at sea. This means that if fisheries in rivers and the sea harvest more than the harvestable surplus of a population, and fishing is the reason for a reduced smolt output from a river, this is regarded as overexploitation.

Overexploitation is no longer regarded an important impact factor. Management based on population specific reference points (conservation limits) from 2009 has reduced exploitation in rivers and at sea. Harvest of populations with low or no harvestable surplus has been strongly reduced or closed, and salmon fishing was closed in 183 rivers in 2022.

Predation
This threat assessment covers the threats from human activities, and predation is not regarded as an anthropogenic threat *per se*. However, several human activities may lead to elevated predation at life stages where this may reduce salmon populations. Examples may be the introduction of northern pike *Esox lucius* to new watercourses, slower smolt migration in combination with improved habitats for predators in hydropower reservoirs, and elevated predation of post-smolts at sea because they are weakened due to salmon lice or freshwater acidification. This type of predation is assessed under the different human activities that are the ultimate case for the elevated mortality.

A salmon population that is reduced to very low levels due to human activities can be much more difficult to rebuild that it was to reduce it, because of predation mechanisms. This is covered in a new publication (Falkegård et al. 2023). In this publication, we conclude that there is little evidence that predation alone has been an underlying mechanism for driving salmon populations below conservation limits. However, depending on the predator's response to salmon abundance, predation may keep decimated populations from recovering, even when the actual causes of decline have been removed.

Catches and pre-fishery abundance

In 2023, the total reported catch in sea and river fisheries was 109 000 Atlantic salmon, equaling 389 metric tons. In addition, 27 000 salmon (124 metric tons) were reported caught and released (24% 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 2**). The pre-fishery abundance was more than halved from 1983-1986 to 2019-2022. The pre-fishery abundance was estimated at about 458 000 wild salmon in 2022. Both the pre-fishery abundance and catches were among the lowest ever recorded in 2022 (based on the time series starting in 1980), but higher than the year before.

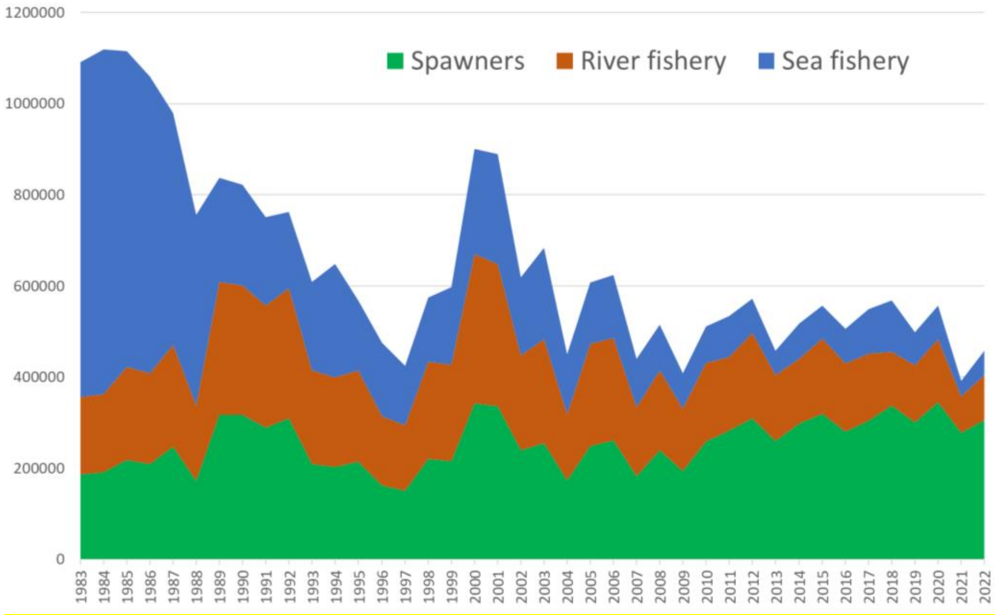

Figure 2. *Estimated number of wild salmon returning from the ocean towards Norwegian rivers each year, divided in number of fish caught in the sea fisheries, number of fish caught in the rivers during angling, and the number of fish left for spawning in the rivers during the period 1983-2022.*

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 large Tana watercourse has had a marked decline in the pre-fishery abundance, in contrast to the rest of Northern Norway, with a 75% 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 human 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, in agreement with data from 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 increased compared to these poorest years, but remained relatively low, with a survival of only 1-4% for salmon that left the River Imsa during 2009-2020. However, for the salmon that left in 2021, the survival increased (7% until return as one-sea-winter fish in 2022) and this was the highest survival recorded in more than 20 years. 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 244 salmon rivers for the period 2019-2022. 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 2019-2022 were attained, or likely attained, for 91% of the populations (**figure 3**). This is among the best results regarding attainment of the management targets since the first evaluation was done in 2009 (**figure 3**). The number and proportion of populations reaching their management targets have increased markedly from 2006-2009 to 2019-2022 (**figure 3**). The increase in proportion of populations reaching their spawning targets is largely due to stricter regulations of fisheries causing reduced exploitation rates.

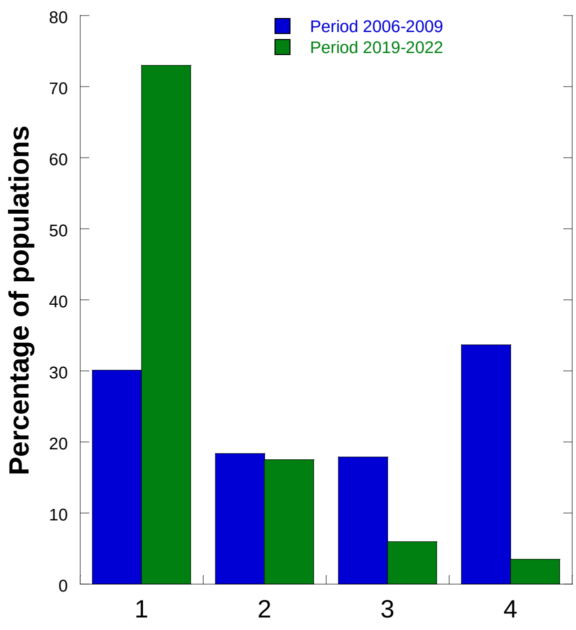

Figure 3*. Proportion (%) of the evaluated salmon rivers in category 1: the management target is attained, category 2: there is a risk that the management target is not attained, category 3: the management target is likely not attained, and category 4: the management target is far from being attained. Data are given for the periods 2006-2009 (first assessment) and 2019-2022.*

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 recent 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 4**). When the drift net fishery was banned from 1989, the exploitation was reduced. The sea fisheries have been further reduced after the 1990s. In 2022, 12% 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 2022, 22% 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 2022 (**figure 4**). On average, 47% of the salmon entering the rivers were killed in fisheries until 2005, whereas in 2022, 25% 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.

Reduced exploitation has resulted in an increased number of salmon spawning in the rivers during the last years (**figure 2**). 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, to around 60% from 2018 and onwards, and 67% in 2021.

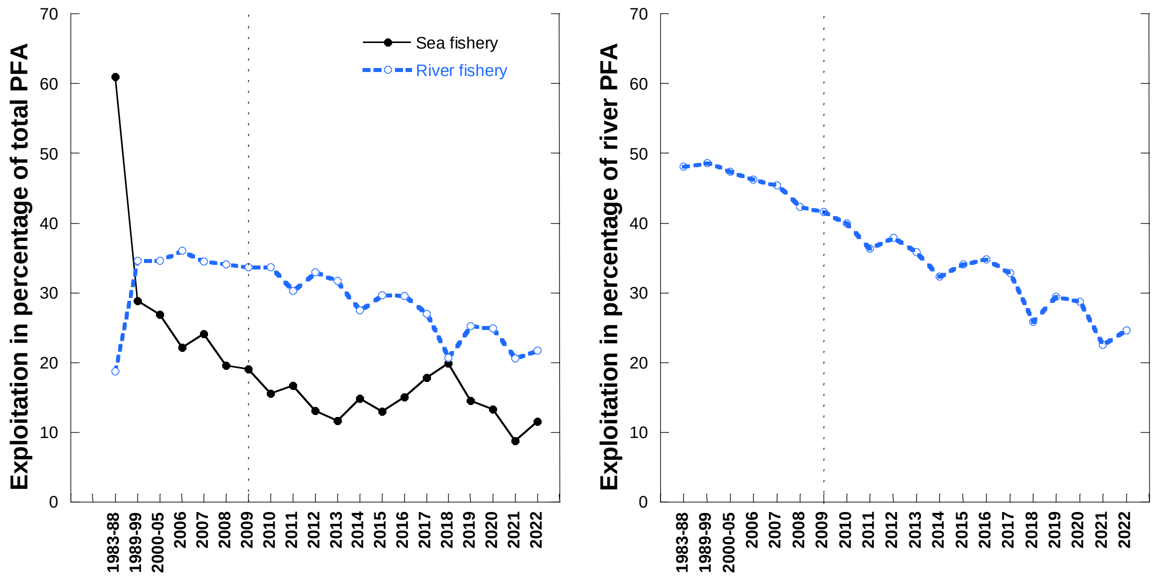

Figure 4. *Left graph: Exploitation of salmon given as percentage of the pre-fishery abundance (Total PFA, in numbers) for the periods 1983-88, 1989-99 and 2000-05 (averages) and thereafter as annual values. Right graph: Exploitation of salmon in the rivers given as the proportion of salmon entering 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.*

Scientific publications from the Norwegian Scientific Advisory Committee for Atlantic Salmon

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