Monterey Bay Aquarium Seafood Watch®

Farmed Salmon Recommendations: 2021

Summary of updates to recommendations

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Introduction

Throughout 2020 and 2021, Seafood Watch conducted scheduled updates of five farmed salmon assessments, and they were collectively published on December 6, 2021. These assessments cover the geographies that dominate both global farmed salmon production and farmed salmon currently on the US market: Norway, Chile, Scotland, British Columbia, and Atlantic North America (Maine, US and Atlantic Canadian provinces)[1], and are of marine net pen production.

Scope of ratings

While earlier publications of these assessments did include some sub-national ratings, the majority produced a single rating for the scope of the assessment. With better data availability in recent years, these updates contain many multi-rating assessments. The scope of these ratings are most commonly at a 'production area' or 'production region'. This approach maintains our objective of assessing an industry's cumulative impact to the ecosystem in which it is sited while also allowing for a more granular understanding of how production may differ from region to region.

Scope of this document

This document is intended to provide a scoring summary for each assessment[2], an overview of driving factors, and a review of what's changed since the last-published assessment. It is arranged by assessment unit (i.e. major location). It includes annual production tonnage for the most recent year of complete data; in some cases, production tonnage is not reported with complete alignment to the unit of ratings within an assessment, so best estimates are given here. Seafood Watch currently recognizes salmon certified by the Aquaculture Stewardship

[1] The Seafood Watch assessments of farmed Atlantic salmon from the Faroe Islands and farmed Chinook salmon from New Zealand were last published in 2018 in 2020 respectively, and therefore not included in these updates. Both countries are globally-important producers of their respective species.

[2] Scoring note: Criterion scores and the final score range from 0 to 10, where 0 indicates very poor performance and 10 indicates no environmental impact. Criteria 8X, 9X, and 10X are exceptional criteria, where 0 indicates no impact and a deduction of -10 reflects a very significant impact. Final scores of ≥6.67 = Green, 3.34-6.66 = Yellow, and ≤3.33 = Red. Two or more Red criteria or one Critical criterion (indicated by black) result in a Red final result.

Council (ASC) as being equivalent to at least a Good Alternative, so tonnage of ASC certified production is also included.

For the full reports, please visit www.SeafoodWatch.org.

Norway

Species	Atlantic salmon (*Salmo salar*)	Production	1,377,185 mt (2020)
Region(s)	Production Areas 1 to 13	US imports	52,000 mt (2019)
Production system	Marine net pens	ASC certified	768,000 mt (2019)

	Production Areas and scores												
Criterion	1	2	3	4	5	6	7	8	9	10	11	12	13
C1 Data	7.05	7.05	7.05	7.05	7.05	7.05	7.05	7.05	7.05	7.05	7.05	7.05	7.05
C2 Effluent	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00
C3 Habitat	6.93	6.93	6.93	6.93	6.93	6.93	6.93	6.93	6.93	6.93	6.93	6.93	6.93
C4 Chemicals	4.00	6.00	2.00	2.00	4.00	6.00	4.00	4.00	4.00	4.00	4.00	4.00	6.00
C5 Feed	3.80	3.80	3.80	3.80	3.80	3.80	3.80	3.80	3.80	3.80	3.80	3.80	3.80
C6 Escapes	4.00	6.00	0.00	1.00	3.00	4.00	3.00	1.00	0.00	0.00	0.00	5.00	4.00
C7 Disease	4.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00	2.00	2.00	4.00	4.00	4.00
C8X Source of stock	-5.00	-5.00	-1.00	-1.00	-3.00	-1.00	-1.00	-1.00	0.00	0.00	0.00	0.00	0.00
C9X Wildlife mortalities	-4.00	-4.00	-4.00	-4.00	-4.00	-4.00	-4.00	-4.00	-4.00	-4.00	-4.00	-4.00	-4.00
C10X Introductions	-2.00	-3.00	-1.20	-1.20	-3.00	-1.20	-1.20	-1.20	-1.20	-1.20	-1.20	-1.20	-1.20
Total	24.78	23.78	19.58	20.58	20.78	27.58	24.58	24.58	24.58	24.58	26.58	31.58	32.58
Final score (0-10)	**3.54**	**3.40**	**2.80**	**2.94**	**2.97**	**3.94**	**3.51**	**3.51**	**3.51**	**3.51**	**3.80**	**4.51**	**4.65**
Red/Critical criteria	0/0	1/1	3/2	3/2	2/1	1/1	2/1	2/1	2/1	2/1	1/1	0/0	0/0
Final Rating	Y	R	R	R	R	R	R	R	R	R	R	Y	Y

Summary

The Norwegian salmon industry is data-rich, with government and research agencies monitoring impacts in the environment, particularly to wild salmonids, and publishing annual reports and/or regularly updated statistics on many aspects of production, often on a site-by-site basis. This data availability allowed for the analysis of many impact areas at the scope of each of the country's 13 Production Areas (PA). For some, the data showed differing levels of environmental performance. The rating for ten PAs is an Avoid, and for three – the southernmost and the two northernmost – it is a Good Alternative.

Driving Factors

Across PAs, the criteria which limited performance were Chemical Use, Escapes, and Disease.

Chemical Use

Antimicrobial use across the industry is consistently very low and chemical pesticide use to treat sea lice has declined substantially in recent years, though this has been driven by observed sea lice resistance to pesticides and the need to find alternative treatments. In many PAs, however, the use of chemical pesticide treatments is still more than once per site per year. The Institute of Marine Science's (IMR) most recent annual risk assessment considers the use of chemical sea lice treatments and the use of copper-based net antifoulants in PAs 3 and 4 to be a high risk of impact to the environment. These data result in a red score for Chemical Use for PAs 3 and 4.

Escapes

Salmon continue to escape from Norwegian farms in both large-scale events and in small-scale trickle losses, and the primary concern for impact is the interbreeding of escapees with wild Atlantic salmon whose populations, broadly, are suffering. River monitoring data show only 33% of wild populations in Norway have good or very good genetic status; 27% have poor or very poor status and 30% have moderate status. For a given river system, the impact (or risk of impact) is driven by the occurrence of escaped farmed salmon in the spawning grounds and the robustness of the wild stocks against new genetic introgression. Data show differences in performance and risk between PAs. For PAs 3, 4, and 8-11, high numbers of farm escapees on the spawning grounds and high vulnerability to further genetic change in wild populations result in a critical conservation concern. For PAs 5 and 7, high numbers of escapees on the spawning grounds and a moderate vulnerability to further genetic change results in a high concern. PAs 1, 2, 6, 12, and 13 have a combination of moderate or low numbers of farm escapees on the spawning grounds and a moderate to strong resilience against further genetic change.

Disease

Bacterial diseases are low in Norwegian salmon farming, but viral diseases present a greater challenge. Sea lice, however, are the most impactful to both farmed fish and, through farm-to-wild transmission, to wild salmon and sea trout. The greatest risk to wild Atlantic salmon is during the spring out-migration of smolts; for sea trout, who remain in coastal waters for much of the year, their temporal susceptibility to lice pressure is generally high. Extensive data show sea lice numbers on farms and wild fish vary considerably throughout the year and from area to area. In 2017, the Norwegian government ratified a new regulation, commonly referred to as the traffic-light system, in which farmed salmon production tonnage within each PA is governed by a single indicator on salmon lice-induced mortality in migrating juvenile wild salmonids. These results guide our interpretation of the data, and show that for PAs 2-7, there is a high risk of population-level impacts to wild salmon or sea trout due to high farm-to-wild lice transmission and the vulnerable nature of their populations; this results in a critical conservation concern. PAs 8-10 have impacts which likely limit recovery of wild salmonid populations as a result of sea lice transmission, and PAs 1, 12, and 13 experience lower on-farm sea lice numbers and/or overlap in timing of lice discharge and the presence of wild salmon or sea trout, but wild fish are still likely to experience some mortality.

What's changed?

All prior Norwegian salmon assessments were scoped at the national industry level. However, more years of very high data availability of site- and Production Area-specific farm performance and wild fish monitoring have allowed this update to consider each PA individually. This has resulted in a rating for each PA in the country, including three that are Good Alternative. The higher granularity data allowed for an improvement in the score for Chemical Use in most Production Areas, but the assessment's driving factors remain generally the same, with the Escapes and Disease criteria limiting overall performance.

Chile

Species	Atlantic salmon (*Salmo salar*) Coho salmon (*Oncorhynchus kisutch*)	**Production**	787,131 mt (2020) 204,740 mt (2020)
Region(s)	Region X (Los Lagos) Region XI (Aysen) Region XII (Magallanes)	**US imports**	192,000 mt (2019) 142 mt (2019)
Production system	Marine net pens	**ASC certified**	267,000 mt (2019) 183,000 mt (2019)

Species, production regions and scores						
	Atlantic Salmon			Coho Salmon		
Criterion	Region X	Region XI	Region XII	Region X	Region XI	Region XII
C1 Data	6.59	6.59	6.59	6.59	6.59	6.59
C2 Effluent	4.00	4.00	2.00	4.00	4.00	2.00
C3 Habitat	6.93	6.93	6.93	6.93	6.93	6.93
C4 Chemicals	Critical	Critical	6	6	6	8
C5 Feed	3.41	3.41	3.41	3.41	3.41	3.41
C6 Escapes	4	4	4	1	1	1
C7 Disease	4	4	4	4	4	4
C8X Source of stock	0	0	0	0	0	0
C9X Wildlife mortalities	-4.00	-4.00	-4.00	-4.00	-4.00	-4.00
C10X Introductions	-0.2	-0.2	-0.2	0	0	0
Total	24.73	24.73	28.73	27.93	27.93	27.93
Final score (0-10)	**3.53**	**3.53**	**4.10**	**3.99**	**3.99**	**3.99**
Red/Critical criteria	1/1	1/1	1/0	1/1	1/1	2/1
Final Rating	**Red**	**Red**	**Yellow**	**Red**	**Red**	**Red**

Summary

Data availability for the Chilean salmon industry has increased in recent years, but the monitoring and reporting on farm performance and/or environmental impact can lag behind other major salmon producing countries, particularly for site-specific information. For some criteria, the improved data availability allowed for analysis of each species being farmed at the scope of each of the country's Regions. For some, the data showed differing levels of environmental performance. For Atlantic salmon, the rating for Regions X and XI is an Avoid and for southernmost Region XII is a Good Alternative. For coho salmon, the rating for all regions is an Avoid.

Driving Factors

For Atlantic salmon, the criteria which limited performance were Effluent and Chemical Use. For coho salmon, the criteria which limited performance were Effluent and Escapes.

Effluent

The available evidence from Chile (and elsewhere) shows significant impacts in the water column from salmon farm effluents are unlikely, but seabed impacts can be substantial. In Regions X and XI, monitoring data show generally good performance on the primary metric of benthic impact – the aerobic or anaerobic nature of the seabed near net pens – but farms in Region XII do not perform as well. Data from both the most recent year available (2020) and the time series of 2012-2020 show that less than half of Region XII benthic impact measurements were satisfactory. Some important gaps exist in understanding the carrying capacity of Chile's fjords and channels and the corresponding impact of nutrient discharge from salmon sites cumulatively, so these results (particularly considering the expansion of production in Region XII) are concerning. The score for Regions X and XI is yellow, but the score for Region XII is red.

Chemical Use

The open nature of the net pen production system provides no barrier to infection from environmental pathogens and parasites that may subsequently require treatment by chemicals including antimicrobials and pesticides. For Chilean salmon production, the bacterial pathogen *Piscirickettsia salmonis* causing salmon rickettsial septicemia/syndrome (SRS), and to a lesser extent *Renibacterium salmoninarum* causing bacterial kidney disease (BKD), drives very high use of antimicrobials. The sea louse *Caligus rogercresseyi* drives very high use of chemical pesticides. The data show high variation between species and Region both in total and relative terms.

Atlantic salmon require substantially more chemical treatment than coho salmon, and Regions X and XI require more than Region XII. The relative antimicrobial use of Atlantic salmon in Regions X, XI, and XII in 2020 was calculated to be 588.2 g/mt, 543.9 g/mt, and 99.5 g/mt respectively, with an approximate treatment frequency of 3.1 treatments per site per year in Region X, 2.9 in Region XI, and 0.5 in Region XII. The relative antimicrobial use of coho salmon in Regions X, XI, and XII in 2020 was 29.3 g/mt, 27.1 g/mt, and 5.0 g/mt respectively, with a treatment frequency per site per year of 1.0 in Regions X and XI, and 0.2 for the small amount of coho production in Region XII.

Nearly all antimicrobial use is of florfenicol. The direct ecological impacts of antimicrobials to the receiving environments remain unclear, but of high concern is the potential development of antimicrobial resistance and the possible passage of mobile resistance genes to human pathogens. Although only used in veterinary applications, florfenicol is listed by the World Health Organization (WHO) as highly-important for human medicine due to the concern for its mobile resistance “floR” gene to confer resistance in a variety of bacterial populations to other antimicrobials. Determining the drivers and scale of these processes are challenging and this is an active area of research in Chile. It is important to note a contrasting paradigm that suggests resistance genes initially enter aquatic environments primarily from human and terrestrial sources, but research shows salmon farms can play a role in the persistence and further development of resistance concerns.

Some recent studies indicate phenotypic resistance (technically the loss of susceptibility) in the primary target of antimicrobials in Chile (the bacterial pathogen *P. salmonis*) is not developing or is uncommon, and there is no evidence of clinical treatment failures in production due to resistance. However, the government’s resistance surveillance program shows approximately 50% of the isolates of *P. salmonis* from Atlantic salmon farms tested in 2020 had reduced susceptibility to florfenicol (and approximately 17% to oxytetracycline, an important drug for the industry in years past) in laboratory in-vitro trials. The research on the mechanisms underlying the acquisition and dissemination of acquired antimicrobial resistance by varied bacterial populations continues to evolve, and there is no conclusive link to antimicrobial use in aquaculture. Yet, there is inevitably a high concern that the widespread, repetitive, and prolonged use of antimicrobials in Chilean salmon farms (particularly Atlantic salmon farms) has resulted in bacterial populations evolving and adapting to the two most commonly used drugs.

Pesticide use for Atlantic salmon in Chile is also high and increasing, reflecting the ongoing struggle to control parasitic sea lice. Nearly 20 mt active ingredient of pesticide was used in 2019, plus over 3,200 mt of hydrogen peroxide, with pesticide use predominantly occurring in

Regions X and XI due to the low sea lice numbers to date in Region XII. The impact of these pharmaceuticals on the marine environment remains largely uncertain, particularly with regard to repetitive treatments at a single site or from coordinated treatments in a single waterbody. Widespread resistance has previously developed in Chile and is likely to recur with the repeated use of a limited number of available treatments. With a minimal presence of sea lice on coho salmon, they are not administered chemical pesticide treatments.

Overall, pesticide use for Atlantic salmon in Regions X and XI is high, and of greater concern is the ongoing repetitive use of a single antimicrobial in multiple treatments per site per year. This use pattern drives its potential contribution to the pool of resistant genes in the environment, so chemical use for Atlantic salmon in Regions X and XI is a critical conservation concern. For Atlantic salmon in Region XII, where antimicrobial and pesticide use (and therefore contribution to the concern for resistance persistence and development) are currently lower, the chemical use score is yellow. It is important to note, however, that strong management at both the farm and regional scales will be important in keeping chemical use in Region XII from increasing.

For coho salmon, the frequency of antimicrobial use is approximately once per site per year in Regions X and XI, and with no pesticide use, this results in a yellow score. For coho salmon in Region XII (if production were to continue), very low antimicrobial use and no pesticide use result in a green score.

Escapes

Salmon continue to escape from Chilean salmon farms in both large-scale events and in small-scale trickle losses. The potential impact of escaped fish varies substantially depending on a variety of factors. Several species of salmonids, including Atlantic and coho salmon – all of which are not native to Chile – were intentionally stocked throughout the country at several points throughout the 1900s, and some have established robust populations. Atlantic salmon, which in addition to being stocked have repeatedly escaped from farms in large numbers for several decades, have shown to be highly unlikely to establish in the wild. In contrast, the evidence of the establishment and increasing range of coho salmon is now clear in the far south of Chile. Recent research has added new records of established populations of coho in the Beagle Chanel and in the Cape Horn Biosphere Reserve. In government-conducted research fishing between 2016 and 2019, coho accounted for 8.4% of all fish caught, and their relative contribution to total catch increased with southward fishing effort through Regions X, XI, and XII. Genetic profiling is used to assign rainbow trout caught in the wild as wild spawned or as direct farm escapes, but these techniques are still in development for coho salmon. It is therefore not yet known if these captures of coho and their apparent establishments and/or range expansion are due to previous stocking efforts or, as some recent authors have suggested, due to more recent aquaculture escapes. Southern Chile has unique ecosystems with high degrees of endemism and some vulnerable and endangered fish species, and with coho salmon's highly piscivorous nature, the potential impact is high. Coho are known to have the ability to migrate long distances, so without better data, it is possible that farm escapes from each region are contributing to coho's apparent range expansion and potential impact. Therefore, Escapes for coho in all regions is a critical conservation concern.

What's changed?

The Chilean salmon assessment has always considered Atlantic and coho salmon separately, and while some improvements have been realized by the industry, more years of regional data availability for some criteria – particularly Effluent and Chemical Use – have allowed this update to consider each Region individually. This has resulted in multiple ratings, including one that is Good Alternative. For Atlantic salmon, Chemical Use remains the most important driving factor, but poor benthic impact performance in Region XII has lowered the Effluent score to red (in this region). For coho salmon, Escapes remains the driving factor, and with continued escape events and recent information indicating an expansion of their range, it is now considered an area of critical conservation concern. Without reason to consider benthic impacts differently than Atlantic salmon sites, the Effluent score in Region XII is also now red. Due to continued decreases in antimicrobial use, the Chemical Use score for coho salmon increased, and due to better data availability, the increase in score can recognize different performance levels between Regions.

Scotland

Species	Atlantic salmon (*Salmo salar*)	**Production**	203,881 mt (2019)
Region(s)	Northwest (Highland) Southwest Western Isles (Eilean Siar, O. Hebrides) Orkney Isles Shetland Isles	**US imports**	25,000 mt (2019)
Production system	Marine net pens	**ASC certified**	15,000 mt (2019)

	Production regions and scores				
Criterion	Northwest	Southwest	Western Isles	Orkney Isles	Shetland Isles
C1 Data	6.82	6.82	6.82	6.82	6.82
C2 Effluent	5.00	5.00	5.00	5.00	5.00
C3 Habitat	6.93	6.93	6.93	6.93	6.93
C4 Chemicals	2.00	2.00	2.00	7.00	2.00
C5 Feed	4.35	4.35	4.35	4.35	4.35
C6 Escapes	0.00	0.00	0.00	4.00	3.00
C7 Disease	0.00	0.00	0.00	6.00	0.00
C8X Source of stock	-5.00	-5.00	-5.00	0.00	0.00
C9X Wildlife mortalities	-2.00	-2.00	-4.00	-2.00	-2.00
C10X Introductions	-6.00	-6.00	-6.00	-1.80	-1.80
Total	12.10	12.10	10.10	36.30	24.30
Final score (0-10)	**1.73**	**1.73**	**1.44**	**5.19**	**3.47**
Red/Critical criteria	3/1	3/1	3/1	0/0	3/0
Final Rating	**Red**	**Red**	**Red**	**Yellow**	**Red**

Summary

The Scottish salmon industry is data-rich, with government and research agencies publishing annual reports and/or regularly updated statistics on many aspects of production, often on a site-by-site basis. This data availability allowed for the analysis of many impact areas for each of the country's five regions of production. For some, the data showed differing levels of

environmental performance. The rating for four regions is an Avoid, and for one – the Orkney Isles – it is a Good Alternative.

Driving Factors

Across production regions, the criteria which limited performance were Chemical Use, Escapes and Disease.

Chemical Use

Scotland's antimicrobial use is low, but there has been a recent increase; the number of sites treated, for example, increased from five in 2015 to 55 in 2019. While this is a concerning trend, the current use is considerably less than one treatment per site per year on average across Scotland. From a regional perspective, the Orkney Isles and the Southwest region have the lowest antimicrobial use in Scotland. For the use of chemical pesticides to treat sea lice, the total number of treatments per year has generally declined over the last ten years, but the industry still uses over three treatments per site on average each year, or over five treatments per 18-month growout cycle. A recent review by the Scottish Environmental Protection Agency concluded that the existing impact standard was not adequately protecting marine life, and sea lice's resistance to a common treatment is widespread, further indicating its overuse. New regulations have been adopted but their efficacy in preventing cumulative impacts from coordinated multiple treatments per year is as-yet unknown. With very low prevalence of sea lice on the farms in the Orkney Isles, these farms have a much lower reliance on pesticides; they administer treatment less than once per site per year. For the Northwest, Southwest, Western Isles and Shetland Isles, their pattern of chemical use results in a red score. For the Orkney Isles, the demonstrably low need for chemical use results in a green score.

Escapes

Though less common than in decades past, large escape events – where several thousand fish are reported lost from marine net pens – occur annually in Scotland. Undetected or unreported trickle losses may also be cumulatively substantial. The survival to maturity of escapees and therefore their potential to spawn with wild salmon is likely to be highly variable depending on the size, location, and time of year of escape. Quantifying the impacts to wild salmon populations is complex, but in contrast to the extensive monitoring and research efforts in other salmon-farming regions like Norway and Atlantic North America (US and Atlantic Canada), monitoring of escapee presence on spawning grounds and studies on genetic introgression are limited in Scotland. The research that does exist shows evidence of farm-origin genetic material within wild Scottish salmon populations; notably, though, some observed introgression may have come from deliberate stocking attempts. Ultimately, there is great cause for concern for the health of native salmon populations – many of which are threatened or endangered – based on the impacts demonstrated through comprehensive research and monitoring efforts in other regions and agreement amongst international experts that a risk of population-level impacts could occur in Scotland without highly effective fish containment going forward. There are some notable regional variations; for example, the Orkney Isles have not reported an escape event since 2012 and both the Orkney and Shetland Isles do not have local wild salmon populations. Escapes here could migrate to rivers in other areas, but the risk is lower. For the Orkney Isles, the result is a yellow score. For the Shetland Isles, while having better fish containment in the most recent five years, still do report escapes and the result is a red score. For the Southwest, Northwest and Western Isles, there continue to be substantial escapes in areas that have vulnerable wild salmon populations, and without data to demonstrate a low rate of introgression or impact, Escapes is a critical conservation concern for these regions.

Disease

Bacterial and viral pathogens infect farmed salmon in Scotland and negatively impact production. Their beyond-farm impact appears low yet remains uncertain (possibly due to the challenges of detecting diseased wild fish). In contrast, parasitic sea lice, whose numbers have been shown to be elevated in the environment around salmon farms and to impact wild salmon and sea trout individuals, are recognized as a concern by the Scottish government and by their Salmon Interactions Working Group. While sea lice are not considered to be responsible for the long-term declines in wild salmon and sea trout (and there are many ongoing non-aquaculture pressures on the populations), there is a concern that the added pressure of sea lice transmission from salmon farms is a significant impactor on the health and recovery of wild salmonid populations.

In contrast to Norway, which has long term comprehensive monitoring and modelling of lice on farms and on wild salmon and sea trout, there is very little monitoring of sea lice on wild fish in Scotland. While the available research in Scotland indicates the mortality of sea trout due to sea lice has declined since the late 1990s and is now perhaps in the range of 10-20% per annum, the Scottish government still defers to examples from Norway, where sea lice are considered to have the greatest negative impact on wild salmon and sea trout and are regarded as an expanding population threat. Though there is an absence of clear evidence on the impacts in Scotland and evidence in Norway cannot be fully representative of the situation in Scotland, there is an overall high cause for concern. The net pen production system is open to the environment, the (recommended) lice limits that were established for the protection of wild fish are commonly exceeded, wild salmon and sea trout have a generally high susceptibility to lice, and there is an apparent high potential for population impacts, especially to discreet wild sea trout populations due to their longer coastal residences in areas with increased sea lice infection pressures. With consideration of the vulnerable conservation status of both Atlantic salmon and sea trout in Scotland, the final score for the Northwest, Southwest, Western Isles, and Shetland Isles is red. In contrast, with data indicating very low lice prevalence on farms in the Orkney Isles region and no rivers in Orkney which host native spawning populations, the cause for concern is lower; as such, there is a yellow score for the Orkney Isles.

What's changed?

A longer time series of regional data allowed the assessment to increase the granularity of its ratings; each of the five regions now has its own rating, though the Orkney Isles remains the only region with a yellow final outcome. For the Northwest, Southwest, and Western Isles, continued escapes, a lack of dedicated monitoring and research efforts to understand their impacts, and the vulnerability of wild salmon populations has reduced the Escapes score to a critical conservation concern. In addition, the Source of Stock criterion in the Seafood Watch Aquaculture Standard now includes the sourcing of wild-caught cleaner fish. The Northwest, Southwest, and Western Isles all use wild-caught cleaner fish to control sea lice, and while voluntary fishery control measures exist and there is a movement to make them mandatory, there are no substantive stock assessments and the fishery is considered – at best – to be of unknown sustainability. This has reduced the Source of Stock score to yellow for the Northwest, Southwest, and Western Isles. With more years of successful fish containment, the Escapes score for the Orkney Isles increased; together with the absence of spawning populations in Orkney rivers – which limits the overall risk that farm escapees breed with wild fish – the overall Escapes score is now yellow. For all regions but the Western Isles, continued low mortality of wildlife species as a result of their interaction with farm equipment has increased the score to green for Wildlife Mortalities.

British Columbia, Canada

Species	Atlantic salmon (*Salmo salar*)	**Production**	86,000 mt (2019)
Region(s)	All areas collectively	**US imports**	60,700 mt (2019, incl. wild)
Production system	Marine net pens	**ASC certified**	16,000 mt (2019)

Criterion	Score	Rating
C1 Data	7.50	Green
C2 Effluent	5.00	Yellow
C3 Habitat	6.93	Green
C4 Chemicals	2.00	Red
C5 Feed	4.09	Yellow
C6 Escapes	5.00	Yellow
C7 Disease	0.00	Red
C8X Source of stock	0.00	Green
C9X Wildlife mortalities	-2.00	Green
C10X Introduction of secondary species	-3.20	Green
Total	25.32	
Final score (0-10)	3.62	
Final Score	**3.62**	
Red/Critical criteria	2/0	
Final Rating	**Red**	

Summary

The BC salmon industry is data-rich, with government and research agencies publishing annual reports and/or regularly updated statistics on many aspects of production; for some – such as chemical use and fish health – these are available on a site-by-site basis. There is an increasingly intense focus on monitoring impacts in the environment, particularly to wild salmonids, and several academic papers are published each year which analyze the data. A key component of this research is the variability in conclusions, illustrating the difficulty in robustly understanding how on-farm phenomena like pathogens and parasite infections impact wild salmon. This variability was mirrored in the polarity of comments received during peer/external review of this assessment. Overall, the data showed that analysis of production in BC should be conducted collectively. The rating for all BC Atlantic salmon production is an Avoid.

Driving Factors

The criteria which limited performance were Chemical Use and Disease.

Chemical Use

Approximately half of active sites in BC are treated with antimicrobials each year. A simple averaging indicates a three-year average of 1.3 antimicrobial treatments per site per year from 2018 to 2020, but the median treatment number per treated site was three. This indicates that while many sites are not treated, those that are treated have multiple treatments per year. Two antimicrobial types are used – oxytetracycline and florfenicol – both of which are listed as highly important for human medicine by the World Health Organization. The use of chemical pesticides to treat sea lice is currently less than once per year per site. The impacts of their use in BC are not yet fully understood, but the available evidence indicates that significant impacts are likely to be constrained to an area commonly accepted as an "allowable zone of effect", similar to that impacted by organic enrichment. While increased tolerance (i.e., resistance) to chemical pesticides has been slow to develop in BC compared to other regions and the industry uses a variety of alternatives, reduced efficacy of one treatment type is increasingly being reported. It is an area of concern to follow. Driven by the use of highly important antimicrobials more than once per year per site on average, the result is a red score for Chemical Use.

Disease

Many species of Pacific salmon are in decline over large geographical areas, including areas with and without salmon farms or salmon farming industries. As such, it is clear that pathogens or parasites from salmon farms have not caused the widespread decline, but given the importance of wild salmon (considered essential to life by Indigenous communities in BC), any substantial contributions to their declines or inhibitions of their recovery must be considered. The consequences of pathogen infection are highly variable depending on the individual, the strain of the pathogen, and the circumstances, driving the challenge of studying their impacts effectively in wild populations. The government-conducted risk assessments (for the risk of nine pathogens from farms in the Discovery Islands impacting the abundance or diversity of Fraser River sockeye salmon) are important studies with which to frame the components to be considered, yet despite their findings that all nine viral and bacterial pathogens had a "minimal" risk of impact when considered individually, the limitations in their scope are apparent: for each, they assessed the risk of just that single pathogen to a single wild salmon species from a single river in a single salmon farming area. The combined risk of more than one pathogen or the risk to other populations in other regions were not considered. Recent research continues to develop rapidly and is making many associations between on-farm viruses and wild salmon, yet with few robust conclusions on demonstrable impacts. This challenge of drawing conclusions is perhaps best illustrated by a 2021 publication from the Strategic Salmon Health Initiative that notes (emphasis added here) "the risk of disease transmission from farmed to wild fish has increased, with potential to contribute to declines in wild fish populations, but the probability and magnitude of this transmission has not been determined". It therefore currently remains largely impossible to clearly differentiate between the speculation that viruses are driving or significantly contributing to the declines of wild salmon, and the contrasting position reflected in the DFO risk assessments and other recent studies that bacterial and viral pathogens from Atlantic salmon farms are of minimal concern to wild salmon in BC.

With regard to parasitic sea lice, the large amount of data available indicates high geographic and temporal variability in lice levels on farms in most regions. There are substantial outbreaks (e.g., average lice levels above the three-lice treatment threshold) in one or more reporting regions in most of the last five years, and frequent high lice levels in some regions. The regulations allow lice to increase to high levels on farms (above the treatment threshold) without breaching the conditions of license. The numbers of lice observed on out-migrating juvenile wild salmon are also highly variable both geographically and temporally. The tolerance of juvenile Pacific salmon to sea lice infection varies considerably by species and particularly by size. For some, even low abundances of lice on very small juvenile salmon may cause mortality or sublethal effects on physiology and behavior, but susceptibility in young fish changes rapidly with age, and therefore their risk of being impacted by on-farm lice changes substantially during the four-month outmigration period. Therefore, the prevalence and intensity of lice seen on wild fish does not necessarily imply mortality or significant impact to individual fish, yet given the high regional and temporal variability, it is likely that there will be substantial mortality in some areas in some years. Sub-lethal impacts and increased risk of predation may also be important. Similar to bacterial and viral pathogens, the ongoing controversy regarding the impacts of sea lice highlights the lack of conclusive outcomes to date.

The available data highlight the ongoing uncertainty in the cumulative impacts of pathogens and parasites from farms to wild salmon populations across BC, but given the broadly poor status of wild salmon populations, the uncertainties largely define the need for a precautionary approach. While the volumes of data and research on this topic are large and continually increasing, the complexities mean the impacts of salmon farming alone cannot be quantified robustly; as such, the Risk-Based Assessment method was used. Overall, the potential pathogen and parasite interactions between farmed and wild salmon in BC must be considered a high concern until further evidence indicates otherwise. With open production systems discharging viral, bacterial and parasitic pathogens into waterbodies shared with vulnerable and endangered wild salmon populations, the result is a red score for Disease.

What's changed?

Chemical Use continues to be a limiting factor in the assessment of farmed Atlantic salmon in British Columbia, and Disease continues to be a focal point of public discussion, on-farm practice, regulatory oversight, and research. Major research initiatives aimed at understanding the health status of farmed fish, the health status of wild fish, and the dynamics between the two have continued to produce large volumes of data. However, the published research has not (yet) provided a more conclusive understanding; rather, it continues to highlight the complexities of the subject and leave much room for interpretation, hypothesis, and further research. As a result, for the Disease criterion in the Seafood Watch Aquaculture Standard, the Risk-Based Assessment methodology was used. Briefly, Atlantic salmon farms in BC continue to experience pathogen and parasite infection, and the cumulative disease pressure they place on wild salmon populations, whose populations are largely vulnerable or endangered, is unknown. As such, the concern for impact is high until further evidence robustly indicates otherwise. With open production systems discharging viral, bacterial and parasitic pathogens into waterbodies shared with vulnerable and endangered wild salmon populations, the Disease score has decreased to red.

Atlantic North America (Maine, US & Atlantic Canada)

Species	Atlantic salmon (*Salmo salar*)	**Production**	67,300 mt (2018)
Region(s)	Maine, United States New Brunswick, Canada Newfoundland, Canada Nova Scotia, Canada	**US imports**	23,000 mt (2019) US production remains domestic
Production system	Marine net pens	**ASC certified**	16,000 mt (2019)

	Production regions and scores			
Criterion	Maine	New Brunswick	Newfoundland	Nova Scotia
C1 Data	5.91	5.91	5.91	5.91
C2 Effluent	4.00	4.00	4.00	4.00
C3 Habitat	6.93	6.93	6.93	6.93
C4 Chemicals	8.00	2.00	2.00	8.00
C5 Feed	5.25	5.25	5.25	5.25
C6 Escapes	4.00	3.00	3.00	4.00
C7 Disease	4.00	0.00	2.00	4.00
C8X Source of stock	0.00	0.00	0.00	0.00
C9X Wildlife mortalities	-2.00	-2.00	-2.00	-2.00
C10X Introductions	-0.80	-0.40	-0.60	-1.40
Total	35.29	24.69	26.49	34.69
Final score (0-10)	**5.04**	**3.53**	**3.78**	**4.96**
Red/Critical criteria	0/0	3/0	3/0	0/0
Final Rating	**Yellow**	**Red**	**Red**	**Yellow**

Summary

The Atlantic North American salmon industry is not as data-rich as most other salmon farming regions globally. Government agencies typically publish highly aggregated performance information, and the intensity of research in the region is less than is found in, for example, western Canada and Norway. As a result, many criteria were informed heavily by information from the region's dominant producing company. However, data availability did allow for the analysis of many impact areas for each of the country's four production regions, and for some, the data showed differing levels of environmental performance. The rating for two regions is an Avoid, and for two – Maine and Nova Scotia – it is a Good Alternative.

Driving Factors

The criteria which limited performance were Chemical Use, Escapes, and Disease.

Chemical Use

Antimicrobial use has declined since at least 2012, and data from the region's dominant producer (who operates approximately 80% of active sites) show only eight treatments were applied region-wide in 2020, equating to 0.12 treatments per site that year. There have been no antimicrobial treatments in Maine since 2017, and there were none in Nova Scotia in 2020. Even if the region's secondary producer differed in their reliance on antimicrobial treatment, the industry-wide average would still very likely be less than one treatment per site per year.

Accurately describing pesticide use is challenged by variable data availability in the most recent years, combined with rapid changes in production practices and pesticide use. Data show there has been no pesticide use in Maine since 2018 and none in Nova Scotia since at least 2016. In New Brunswick and Newfoundland, pesticide use was high through 2018 with multiple treatments per site per year on average. In 2018, half of Newfoundland's active sites received 10 or more pesticide treatments. Since then, pesticide use has declined substantially. Some in-feed treatments and some bath treatments do still occur to varying degrees in New Brunswick and in Newfoundland, though without robust data for the most recent years from all producers, clarity on exactly how many treatments of which types on which sites is difficult to obtain. The impacts on non-target organisms (including commercially important species such as lobster) of pesticide treatments are challenging to quantify, but are likely to have been considerable, at least in the immediate farm area during periods of high pesticide use. Resistance to treatment has also occurred in the region. There have been known cases of illegal pesticide use and detections of residues of chemicals not approved for use in Canada, although they are considered to represent exceptional cases at the typical farm level. The recent rapid decrease in pesticide use limits these concerns (particularly in areas where pesticide use has been minimal or has largely been eliminated in recent years).

Overall, the data demonstrate that chemical treatments have been consistently used less than once per site per year in both Maine and Nova Scotia; for both of these regions, the final score is green. For New Brunswick and Newfoundland, with minor antimicrobial use, the uncertainty regarding ongoing pesticide use (including by the secondary producer), despite marked declines in the past few years, presents concern. The score for New Brunswick and Newfoundland is red.

Escapes

Best management practices to prevent escapes are in place in every region in Atlantic North America and they have been effective in reducing the number of escapes over time. However, net pen systems are inherently vulnerable to both large-scale and small-scale fish escapes, and data show that escapes do still occur in the Atlantic North American industry, albeit with important regional variation. Farms in Maine have not reported an escape since 2003, and farms in Nova Scotia have reported only 44 escaped fish in the past ten years. New Brunswick and Newfoundland have each reported many thousands of escaped fish over this time period. Escapees disperse rapidly and recapture at sea is unlikely, but a second recapture opportunity occurs in rivers. The number of escaped fish entering rivers in the four regions is highly variable by river and by year, and while the use of trapping or counting devices enables the recapture and removal of (potentially all) escapees in some rivers, there are many rivers without effective measures.

Farmed Atlantic salmon are genetically distinct from their wild counterparts, and hybridization between escaped and wild salmon and genetic introgression have been demonstrated, particularly after a large escape of mature fish in Newfoundland. Wild salmon populations in the North Atlantic have been in long-term decline and continue to decline in areas with and without salmon farms; nevertheless, several wild salmon populations in the vicinity of the salmon farming industry are of special concern, threatened, or endangered, and any contributions to their further decline or inhibitions of their recovery are a concern.

In all regions, the vulnerability of the net pen system to escape and the vulnerability of wild salmon populations are a concern. In Maine and Nova Scotia, the number of reported escapes has been very low over a long timeframe, and few escaped fish have been detected in rivers in both regions. The final score for both regions is yellow. In New Brunswick, escape numbers have been high and escapees are detected in rivers, and though capture devices in important rivers allow their removal, escapees could enter rivers in areas with vulnerable populations in the Inner Bay of Fundy. In Newfoundland, escape numbers have been high and while typical numbers of escapees in rivers are moderate, there are fewer opportunities for recapture and studies of specific escape events have demonstrated genetic introgression in many rivers. For New Brunswick and Newfoundland, the final score is red.

Disease

There is overall a lack of data to robustly understand the degree to which on-farm disease occurs in the Atlantic North American industry or to understand how diseases may transfer to and impact wild fish. It is known that while many disease management and monitoring measures are in place, the open net pen system remains vulnerable to both the introduction and discharge of pathogens and parasites and diseases do occur in the industry.

The limited available data in Atlantic North America indicate sea lice levels on farms are high in New Brunswick, including in some areas each year during the juvenile salmon outmigration period, but are likely low in Maine and Nova Scotia. Despite the welcome start of (minimal) data publication in Newfoundland, lice levels here remain largely unknown. Atlantic salmon are one of the most susceptible salmonid species to sea lice and sub-lethal impacts and increased risk of predation may also be important.

Given the status of wild salmon populations, the uncertainties driven by the lack of data largely define the need for a precautionary approach. For all regions, the potential impacts of viral or bacterial pathogens remains unknown, but in New Brunswick, average lice levels are often high in at least one Bay Management Area each year during out-migration, with likely very high levels in individual farms. In Newfoundland, lice levels remain largely uncertain, though the likely continued administration of pesticides indicate on-farm sea lice is a challenge. For New Brunswick and Newfoundland, the final score for Disease is red. For Nova Scotia and Maine, while data availability is also very poor, the pesticide use data indicate lice levels are low (and antimicrobial use data indicate bacterial diseases are low), but the open nature of the production systems results in a final score of yellow.

What's changed?

The Atlantic North America assessment previously considered Maine and the Canadian provinces separately, but more regional data has allowed each of the four sub-regions to be assessed individually. Importantly, though, this has not resulted in an improved Data score. Different datasets for different regions from different sources over different timescales makes obtaining robust clarity on performance in any one region difficult, and the Data score decreased. The Chemical Use score for Maine was previously red because of a sudden increase in antimicrobial use and pesticide use data that were not specific to each region; with a reduction in the use of antimicrobials (none since 2017) and Maine-specific data showing very low pesticide use in recent years, the Chemical Use score has improved markedly. These regional data showing low chemical use on farms in Nova Scotia has also significantly improved the score. The Chemical Use score for both regions is now green. Escapes and Disease continue to challenge all regions in the industry, but continued excellent fish containment and good river monitoring data in Maine maintain a yellow score, and similar performance and information for Nova Scotia has improved the score to yellow.