Monterey Bay Aquarium
Seafood Watch®

Farmed Arctic Char

Salvelinus alpinus

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Canada, Iceland, U.S.

Land-based flow-through and recirculating aquaculture systems

November 6, 2014
Valerie Ethier, Independent contractor

Disclaimer
Seafood Watch® strives to have all Seafood Reports reviewed for accuracy and completeness by external scientists with expertise in ecology, fisheries science and aquaculture. Scientific review, however, does not constitute an endorsement of the Seafood Watch® program or its recommendations on the part of the reviewing scientists. Seafood Watch® is solely responsible for the conclusions reached in this report.

Final Seafood Recommendation

Arctic Char (*Salvelinus alpinus*)
Canada/US
Land-Based Facilities

Criterion	Score (0-10)	Rank	Critical?
C1 Data	5.00	YELLOW	
C2 Effluent	7.00	GREEN	NO
C3 Habitat	7.84	GREEN	NO
C4 Chemicals	6.00	YELLOW	NO
C5 Feed	5.52	YELLOW	NO
C6 Escapes	6.00	YELLOW	NO
C7 Disease	8.00	GREEN	NO
C8 Source	10.00	GREEN	
9X Wildlife mortalities	0.00	GREEN	NO
10X Introduced species escape	-1.60	GREEN	
Total	**53.76**		
Final score	**6.72**		

OVERALL RANKING

Final Score	6.72
Initial rank	GREEN
Red criteria	0
Interim rank	GREEN
Critical Criteria?	NO

FINAL RANK
GREEN

Scoring note – scores range from zero to ten where zero indicates very poor performance and ten indicates the aquaculture operations have no significant impact.

Summary
Arctic char raised in land-based facilities in Canada and the US receive a final score of 6.72 out of 10, and with no red criteria, the final recommendation is a green "Best Choice."

Final Seafood Recommendation

Arctic Char (*Salvelinus alpinus*)
Iceland
Land-Based Facilities

Criterion	Score (0-10)	Rank	Critical?
C1 Data	5.28	YELLOW	
C2 Effluent	6.00	YELLOW	NO
C3 Habitat	7.84	GREEN	NO
C4 Chemicals	6.00	YELLOW	NO
C5 Feed	6.10	YELLOW	NO
C6 Escapes	5.00	YELLOW	NO
C7 Disease	8.00	GREEN	NO
C8 Source	10.00	GREEN	
C9X Wildlife mortalities	0.00	GREEN	NO
C10X Introduced species escape	0.00	GREEN	
Total	**54.22**		
Final score	**6.78**		

OVERALL RANKING

Final Score	6.78
Initial rank	GREEN
Red criteria	0
Interim rank	GREEN
Critical Criteria?	NO

FINAL RANK
GREEN

Scoring note – scores range from zero to ten where zero indicates very poor performance and ten indicates the aquaculture operations have no significant impact.

Summary
Arctic char raised in land-based facilities in Iceland receive a final score of 6.78 out of 10, and with no red criteria, the final recommendation is a green “Best Choice.”

About Seafood Watch®

Monterey Bay Aquarium's Seafood Watch® program evaluates the ecological sustainability of wild-caught and farmed seafood commonly found in the United States marketplace. Seafood Watch® defines sustainable seafood as originating from sources, whether wild-caught or farmed, which can maintain or increase production in the long-term without jeopardizing the structure or function of affected ecosystems. Seafood Watch® makes its science-based recommendations available to the public in the form of regional pocket guides that can be downloaded from www.seafoodwatch.org. The program's goals are to raise awareness of important ocean conservation issues and empower seafood consumers and businesses to make choices for healthy oceans.

Each sustainability recommendation on the regional pocket guides is supported by a Seafood Report. Each report synthesizes and analyzes the most current ecological, fisheries and ecosystem science on a species, then evaluates this information against the program's conservation ethic to arrive at a recommendation of "Best Choices", "Good Alternatives" or "Avoid". The detailed evaluation methodology is available upon request. In producing the Seafood Reports, Seafood Watch® seeks out research published in academic, peer-reviewed journals whenever possible. Other sources of information include government technical publications, fishery management plans and supporting documents, and other scientific reviews of ecological sustainability. Seafood Watch® Research Analysts also communicate regularly with ecologists, fisheries and aquaculture scientists, and members of industry and conservation organizations when evaluating fisheries and aquaculture practices. Capture fisheries and aquaculture practices are highly dynamic; as the scientific information on each species changes, Seafood Watch®'s sustainability recommendations and the underlying Seafood Reports will be updated to reflect these changes.

Parties interested in capture fisheries, aquaculture practices and the sustainability of ocean ecosystems are welcome to use Seafood Reports in any way they find useful. For more information about Seafood Watch® and Seafood Reports, please contact the Seafood Watch® program at Monterey Bay Aquarium by calling 1-877-229-9990.

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Seafood Watch® and Seafood Reports are made possible through a grant from the David and Lucile Packard Foundation.

Guiding Principles

Seafood Watch™ defines sustainable seafood as originating from sources, whether fished[1] or farmed, that can maintain or increase production in the long-term without jeopardizing the structure or function of affected ecosystems.

The following **guiding principles** illustrate the qualities that aquaculture must possess to be considered sustainable by the Seafood Watch program:

Seafood Watch will:

- Support data transparency and therefore aquaculture producers or industries that make information and data on production practices and their impacts available to relevant stakeholders.
- Promote aquaculture production that minimizes or avoids the discharge of wastes at the farm level in combination with an effective management or regulatory system to control the location, scale and cumulative impacts of the industry's waste discharges beyond the immediate vicinity of the farm.
- Promote aquaculture production at locations, scales and intensities that cumulatively maintain the functionality of ecologically valuable habitats without unreasonably penalizing historic habitat damage.
- Promote aquaculture production that by design, management or regulation avoids the use and discharge of chemicals toxic to aquatic life, and/or effectively controls the frequency, risk of environmental impact and risk to human health of their use.
- Within the typically limited data availability, use understandable quantitative and relative indicators to recognize the global impacts of feed production and the efficiency of conversion of feed ingredients to farmed seafood.
- Promote aquaculture operations that pose no substantial risk of deleterious effects to wild fish or shellfish populations through competition, habitat damage, genetic introgression, hybridization, spawning disruption, changes in trophic structure or other impacts associated with the escape of farmed fish or other unintentionally introduced species.
- Promote aquaculture operations that pose no substantial risk of deleterious effects to wild populations through the amplification and retransmission of pathogens or parasites.
- Promote the use of eggs, larvae, or juvenile fish produced in hatcheries using domesticated broodstocks thereby avoiding the need for wild capture.
- Recognize that energy use varies greatly among different production systems and can be a major impact category for some aquaculture operations, and also recognize that improving

1 "Fish" is used throughout this document to refer to finfish, shellfish and other invertebrates.

practices for some criteria may lead to more energy intensive production systems (e.g., promoting more energy intensive closed recirculation systems).

Once a score and rank has been assigned to each criterion, an overall seafood recommendation is developed on additional evaluation guidelines. Criteria ranks and the overall recommendation are color-coded to correspond to the categories on the Seafood Watch pocket guide:

Best Choices/Green: Are well managed and caught or farmed in environmentally friendly ways.

Good Alternatives/Yellow: Buy, but be aware there are concerns with how they're caught or farmed.

Avoid/Red: Take a pass on these. These items are overfished or caught or farmed in ways that harm other marine life or the environment.

Executive Summary

Arctic char (*Salvelinus alpinus*) aquaculture production is practiced in a number of countries, including Austria, Canada, Iceland, Ireland, Italy, Norway, Sweden, the United Kingdom and the United States. This Seafood Watch assessment covers production in Iceland, Canada and the U.S. as these are the dominant sources of farmed Arctic char on the North American markets.

In 2012, Iceland produced 3,260 metric tons (mt) of Arctic char; with 2013 production projected at 3,400 mt. Iceland is the main supplier of char to the US marketplace. Official statistics are unavailable for Canadian and US Arctic char production, but are on a much smaller scale of approximately 500 mt annually.

Arctic char in Iceland is produced in about 15 land-based flow-through freshwater farms, with the majority occurring at three farms owned by the company Samherji. Production capacity of these three farms is 3000 tons (92% of 2012 production). Farms are located throughout Iceland near areas of the sea with high currents and quick water turnover rates, with the largest farms either on or very near the coast.

Production techniques for char in Canada and the US are also land-based in fresh water, and include some farms practicing flow-through systems and some using high levels of recirculation tanks in locations throughout the continent. In Canada, char farms are found in Yukon Territory, Nova Scotia, New Brunswick, Newfoundland, Quebec and Manitoba. US production of market-sized fish is from one farm in Wisconsin, which sources eggs from a hatchery in Washington State.

Arctic char farming results in low concerns for effluent impact. In Iceland, flow-through farms discharge their (freshwater) effluent into coastal waters where high currents are shown to prevent the accumulation or concentration of wastes. In Canada and the US, Arctic char farms use either recirculating systems where wastewater can be filtered, treated and reused a number of times, or they use flow-through systems where wastewater is discharged into settling ponds or into other treatment mechanisms. There is evidence of increased nutrients in surrounding waterways of some flow-through operations, but other systems are approaching zero discharge and require further additions of water only to replenish losses from evaporation. There is a range of effluent impacts at the farm level, but on average there is low concern from discharged nutrients.

In Canada and the United States, a feed with 45% protein, an industry feed conversion ratio (FCR) of 1.2, and an 18.9% protein content of the harvested fish indicates that 56.16 kilograms of nitrogenous waste is calculated to be produced per ton of char. Typical farms in this region are currently operating at partial recirculation with a trend towards increasing recirculation levels and decreasing discharge volumes. As such, 50% of nitrogenous waste is considered to be discharged as effluent, for a total of 28.08 kg of nitrogen and a Factor 2.1 score of 7 out of 10. The content and enforcement of effluent regulations and management in Canada and the US are considered to be moderately effective and result in a Factor 2.2 score of 7 out of 10. Overall, Arctic char farming in Canada and the US scores for waste discharge, production system and regulatory effectiveness combine for a Criterion 2 - Effluent score of a moderate 6 out of 10.

With respect to Iceland, a feed with 40% protein, an industry FCR of 1.25, and an 18.9% protein content of the harvested char indicates that 49.76 kilograms of nitrogenous waste is calculated to be produced per ton of char. In contrast to North America, char aquaculture facilities in Iceland operate as flow-through with no recirculation, indicating that 100% of this nitrogenous waste is discharged as effluent, resulting in Factor 2.1 score of 5 out of 10. The content and enforcement of Icelandic aquaculture regulations regarding effluents and their impacts is considered 'moderate,' resulting in Factor 2.2 score of 7.65 out of 10. Overall, the scores Arctic char farming in Iceland receive for waste discharge, production system and regulatory effectiveness combine for Criterion 2 - Effluent score of a moderate 6 out of 10.

Arctic char farming in Iceland, Canada, and the United States is shown to maintain habitat functionality and avoid the conversion and loss of ecosystem services. Farms have been operating for extended periods of time with no adverse habitat effects, or have been established on previously converted lands (e.g., agricultural farms or pre-existing industrial buildings). As such, char aquaculture results in minimal habitat impacts and receives a Factor 3.1 score of 9 out of 10. The content and enforcement of habitat regulations in all three countries is shown to be moderate for the size and scope of the industry, resulting in a Factor 3.2 score of a moderate 5.53 out of 10. The numerical score for Criterion 3 – Habitat is 7.84 out of 10.

Historically, disease has not been a significant issue in char aquaculture and, as such, the industry has a demonstrably low need to treat fish with chemotherapeutants. Chemicals are infrequently used in the production of Arctic char in any of the three assessment countries. Vaccines are administered and reduce the need for use of therapeutants through prevention of disease. While there is not a significant volume of published scientific literature available on chemical use in char farming, personal communications with industry experts confirmed that no antibiotics are utilized in production (one Canadian producer reported use of oxytetracycline once in the past five years). While farm records are not available and specific data are limited, the species has a demonstrably low need for chemical use and chemical treatments are not used over multiple production cycles. Therefore, the numerical score for Criterion 4 – Chemical Use is 6 out of 10.

Arctic char have a high dietary protein requirement, and their culture is reliant upon the supply of external feed. Fish in: Fish out (FIFO) ratios are 1.55 in the US/Canada and 0.85 in Iceland, with both calculations being driven by the fish oil content and the use of byproducts for fish oil in feeds. In the US/Canada, there is a net protein loss of 48.2%, while Iceland shows a net protein loss of 52.4%. Both scores are categorized by reliance on crop ingredients that are considered edible by humans as opposed to nonedible byproducts from fish, animals or crops.

Overall, Feed Criterion scores for all three countries are ‘moderate,’ with US and Canada receiving 5.52 out of 10 and Iceland receiving 6.10 out of 10.

In Canada and the United States, partial recirculation and water treatment technology, screens, and secondary capture devices mitigate the risk of escapes. Additionally, at several of the facilities in North America, any escapes that do occur are expected to experience direct mortality as a result of either post-facility water treatment and/or lethally high water temperatures—the Factor 6.1a Escape Risk score for Canada and the US is 8.64 out of 10. In Iceland, the majority of facilities operate as flow-through with screens and secondary capture devices, however, no direct mortality of escapes is expected. The Factor 6.1a Escape Risk score for Iceland is 6 out of 10. For all three countries, char are native species that have been hatchery raised for four or more generations. Any escapes that do occur are expected to compete with wild native populations for food and habitat, and act as additional predation pressure on wild native populations. The Factor 6.1b Invasiveness score is 5 out of 10 for all three countries—when factors 6.1a and 6.1b are combined, the numerical score for Criterion 6 – Escapes is 6 out of 10 for Canada and the United States, and 5 out of 10 for Iceland.

To date, char aquaculture has not had significant issues with disease. While Arctic char are known to be vulnerable to a number of bacterial and viral diseases, aquaculture production in Canada, Iceland and the US are closely managed to prevent outbreaks and do not report any recent pathogen problems that present risk for wild populations. There have been no reported cases of any amplification of pathogen or parasite levels in wild fish populations surrounding farms in any of the three production countries, but this may be due to limited direct monitoring or focused studies. Based on the production systems for char, there is considered to be a potential connection between the farm-to-wild population in terms of pathogen transfer, but as the reported disease problems on the farms are low, temporary or infrequent, Arctic char aquaculture in Canada, Iceland and the US all receive a moderate score of 8 out of 10 for Criterion 7 – Disease, indicating a low risk of impact to wild populations.

All farm stock are produced in hatcheries from captive broodstock. As such, the industry is completely independent from wild stocks for broodstock and juvenile sourcing and there is no subsequent impact on wild populations. The score for Criterion 8 – Source of Stock is 10 out of 10.

Land-based production facilities are either indoors or utilize shade netting and other passive deterrents (e.g., fencing) to prevent any lethal interaction with wildlife. Therefore there are not considered to be any direct or accidental mortality of wildlife associated with char production. As such, the score for Exceptional Criterion 9X – Wildlife and Predator Mortality is a penalty of zero (out of -10).

In Canada and the United States, Arctic char aquaculture relies on the trans-waterbody shipment of eggs, which has the potential to unintentionally introduce species other than the principal farmed species. The biosecurity of both the source and destination of eggs is ‘moderate,’ and while no incidents of unintentionally introduced species are known, the risk persists and results in an Exceptional Criterion 10X score of -1.6 out of -10 for Canada and the US. In Iceland, there is no trans-waterbody shipment of eggs and, as such, no deduction is applied (i.e., score of 0 out of -10).

Overall, Arctic char aquaculture in land-based production systems in all assessed countries represents a ‘low-‘ risk of environmental impacts; Canada and the US score 6.72 out of 10 and Iceland scores 6.78 out of 10. With no red criteria, farmed Arctic char receives a ’Green – Best Choice’ ranking for all three assessed regions.

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Introduction

Scope of the analysis and ensuing recommendation

Species
Arctic char *(Salvelinus alpinus)*

Geographic coverage
This assessment focuses on Arctic char production in Canada (Yukon Territory, Nova Scotia, New Brunswick, Newfoundland, Quebec and Manitoba), the US (Wisconsin) and Iceland. Production in Iceland is evaluated separately from Canada and the US due to the differences in geography, technology used, feed and management.

Production Methods
Arctic char production facilities in Iceland are land-based flow-through tanks (where water makes one pass through the system before being discharged), while those in Canada and the US are land-based tanks with some operating as flow-through and others as recirculating systems (where water can be reused a number of times after being passed through filtration, oxygenation and denitrification technologies).

Species Overview

A member of the salmonid family, Arctic char is a carnivorous freshwater finfish species native to northern streams and lakes in North America, Asia, Europe, Iceland and Greenland. There are two distinct subgroups within Arctic char; one, anadromous (or sea-run) and the other, freshwater (or landlocked) groups. The species has been targeted for commercial and subsistence fishing for many years, and although the first attempts to fertilize and hatch eggs were in the early 1900s, on-growing farming efforts began in the 1960s in Iceland (IMFA 2010). Arctic char aquaculture research in Canada began in the late 1970s, with commercial production beginning in the mid-1980s. Research focused on culture conditions, growth requirements and performance in different production systems (DFO 2006, DFO 2013a).

Growth of the Arctic char aquaculture industry has been slow but gradual since the mid-1980s. Although selective breeding for consistently favorable production traits has been difficult due to complex genetic makeup, programs exist in Canada, Iceland and Sweden and are showing similar success to other salmonids (Thorarensen pers. comm.). Despite Arctic char's similarity with other cultured salmonids, aquaculturists have learned that some Atlantic salmon and trout culture techniques are not suitable for Arctic char (i.e., net pen rearing facilities). Greater success has been demonstrated in land-based facilities, however, one net pen farm exists in Iceland and shows similar growth rates to tank raised fish (Thorarensen pers. comm.) Research has shown that Arctic char has better results when raised in smaller and more densely stocked habitats, such as circular tanks. Therefore, almost all Arctic char aquaculture facilities are land-based systems.

Production statistics

In 2010, reported global aquaculture production of Arctic char was approximately 3200 metric tons (FAO 2011). The main farmed Arctic char producing countries are Iceland, Sweden, Norway and Canada, with some production also occurring in Austria, Ireland, Italy, the United Kingdom and the United States (Arctic Rose Inc. 2011, Boyer 2012, FAO 2011). Projected production for 2013 in Iceland is 3400 metric tons (Rúnarsson 2013). The industry is small enough that no official production statistics currently exist for Canada or the US, but unofficial data indicate production of ~500 metric tons (Arctic Rose Inc. 2011).

Import and export sources and statistics

No official import or export data exist for Arctic char (NMFS 2013). US production is destined for domestic markets and both Iceland and Canada export farmed char to the US (Pigott pers. comm.). Despite substantial production in Norway, very few exports to the US have been registered from Norway; between 1995 and 2012, only 42 kilograms of Arctic char were shipped (in 1999-2000) and no imports from Sweden could be found (Øvreberg pers. comm.). Based on the small size of the Canadian and US char industries, the majority of farmed char on the US market is likely of Icelandic origin. The largest distributor in the US imports about 800 metric tons of char from Iceland annually (IIIM 2013).

Common and market names

Arctic char is also known as char (or charr), common char, alpine trout, alpine char and sometimes sea trout. Product from the one US farm (AquaTerra Farms) is being marketed as Wisconsin ivory char.

Product forms

Arctic char is sold frozen or fresh as fillets (boneless, skinless or skin-on, bone-in) or whole (dressed). A small amount of smoked char meat is available.

Analysis

Scoring guide

- With the exception of the exceptional criteria (9X and 10X), all scores result in a zero to ten final score for the criterion and the overall final rank. A zero score indicates poor performance, while a score of ten indicates high performance. In contrast, the two exceptional factors result in negative scores from zero to minus ten, and in these cases zero indicates no negative impact.
- The full Seafood Watch Aquaculture Criteria that the following scores relate to are available here http://www.seafoodwatch.org/cr/cr_seafoodwatch/content/media/mba_seafoodwatch_aquaculturecriteramethodology.pdf
- The full data values and scoring calculations are available in Annex 1.

Criterion 1: Data quality and availability

Impact, unit of sustainability and principle

- *Impact: poor data quality and availability limits the ability to assess and understand the impacts of aquaculture production. It also does not enable informed choices for seafood purchasers, nor enable businesses to be held accountable for their impacts.*
- *Sustainability unit: the ability to make a robust sustainability assessment.*
- *Principle: robust and up-to-date information on production practices and their impacts is available to relevant stakeholders.*

Criterion 1 Summary

Canada/US

Data Category	Relevance (Y/N)	Data Quality	Score (0-10)
Industry or production statistics	Yes	5	5
Effluent	Yes	5	5
Locations/habitats	Yes	5	5
Predators and wildlife	Yes	5	5
Chemical use	Yes	5	5
Feed	Yes	5	5
Escapes, animal movements	Yes	5	5
Disease	Yes	5	5
Source of stock	Yes	5	5
Other – (e.g., GHG emissions)	No	Not relevant	n/a
Total			**45**

C1 Data Final Score	**5.0**	**YELLOW**

Iceland

Data Category	Relevance (Y/N)	Data Quality	Score (0-10)
Industry or production statistics	Yes	7.5	7.5
Effluent	Yes	5	5
Locations/habitats	Yes	5	5
Predators and wildlife	Yes	5	5
Chemical use	Yes	5	5
Feed	Yes	5	5
Escapes, animal movements	Yes	5	5
Disease	Yes	5	5
Source of stock	Yes	5	5
Other – (e.g., GHG emissions)	No	Not relevant	n/a
Total			**47.5**

C1 Data Final Score	**5.28**	**YELLOW**

Brief Summary

Overall, data availability for Arctic char aquaculture in Iceland, Canada, and the United States are 'moderate.' With respect to Canada and the US, the small size of the industry indicates that there is not a significant amount of governmental or scientific study for many of the categories assessed in this Seafood Watch report—production and industry statistics are notably lacking. The numerical score for Criterion 1 – Data is 4.72 out of 10 for Canada and the U.S. Regarding Iceland: while a significant amount of data on production statistics, use of feed, discharges, and water usage are published, all of these materials are available only in Icelandic with no English translations available. The numerical score for Criterion 1 – Data is 5.28 out of 10 for Iceland.

Justification of Ranking

Canada and United States

The Arctic char aquaculture industry in Canada began in the late 1980s and has been attempted in a few different states in the US since. However, the industry remains small and official statistics and data are difficult to find for certain criteria and some are not being collected at a national level (Arctic Rose Inc. 2011). Individual producers were very helpful and filled most of the data gaps where they were able; this along with the concentrated nature of the industry improved data quality (Lee pers. comm., Lucas pers. comm., Pigott pers. comm). The two largest producers are in Canada; Sustainable Blue (~180 mT annually) and Icy Waters (~150 mT annually) represent two thirds of current North American Arctic char production. While data from other smaller producers was taken into consideration for this assessment, the features of the two large farms characterize the majority of production and results were weighted accordingly. Feed formulations are often considered proprietary information and commercial manufacturers are reluctant to provide details for all assessment points, even to producers. As such, most information was available for the assessment, but was not independent of government data nor was it verified data, and results in scores of 5 of 10 for all criterion resulting in an overall data score of 5 of 10.

Iceland

Iceland is the world's largest farmed Arctic char producer. Government and independent agencies such as the Ministry of Fisheries and Agriculture, Ministry of Environment, Holar University College and Matis Ltd. (a food and biotech research and development company) provided many useful details for understanding the ecological impact of the industry. In addition, the main production company, Samherji, has been very transparent and willing to fill in remaining data gaps (Smáradóttir pers. comm.). Again, as the information is not government or independently verified data, the data quality score is moderate (5 out of 10); the only exemption is industry/production statistics, which result in a score of 7.5 out of 10. The Environmental Agency of Iceland inspects fish farms and regularly publishes reports, including production statistics, use of feed, discharges, water usage, electricity, oil etc., but are all in Icelandic with no English translations available. For the purposes of this report there are little data available regarding the impact on surrounding ecosystems from farm effluent discharge in English. Overall, Iceland receives a moderate data score of 5.28.

Criterion 2: Effluents

Impact, unit of sustainability and principle

- *Impact: aquaculture species, production systems and management methods vary in the amount of waste produced and discharged per unit of production. The combined discharge of farms, groups of farms or industries contributes to local and regional nutrient loads.*
- *Sustainability unit: the carrying or assimilative capacity of the local and regional receiving waters beyond the farm or its allowable zone of effect.*
- *Principle: aquaculture operations minimize or avoid the production and discharge of wastes at the farm level in combination with an effective management or regulatory system to control the location, scale and cumulative impacts of the industry's waste discharges beyond the immediate vicinity of the farm.*

Criterion 2 Summary

Canada/US

Effluent Risk Based Assessment

Effluent parameters	Value	Score	
F2.1a Biological waste (nitrogen) production per of fish (kg N ton-1)	56.16		
F2.1b Waste discharged from farm (%)	50		
F2 .1 Waste discharge score (0-10)		7	
F2.2a Content of regulations (0-5)	3.5		
F2.2b Enforcement of regulations (0-5)	5		
F2.2 Regulatory or management effectiveness score (0-10)		7	
C2 Effluent Final Score		**7.00**	**GREEN**
Critical?	NO		

Iceland

Effluent Risk Based Assessment

Effluent parameters	Value	Score	
F2.1a Biological waste (nitrogen) production per of fish (kg N ton-1)	49.76		
F2.1b Waste discharged from farm (%)	100		
F2 .1 Waste discharge score (0-10)		5	
F2.2a Content of regulations (0-5)	4.25		
F2.2b Enforcement of regulations (0-5)	4.5		
F2.2 Regulatory or management effectiveness score (0-10)		7.65	
C2 Effluent Final Score		**6.00**	**YELLOW**
Critical?	NO		

Brief Summary

In Canada and the United States, a feed with 45% protein, an industry feed conversion ratio (FCR) of 1.2, and an 18.9% protein content of the harvested fish indicates that 56.16 kilograms of nitrogenous waste per ton of char is calculated to be produced. Typical farms in this region are currently operating as partial recirculation, with a trend towards increasing recirculation levels and decreasing discharge volumes. As such, 50% of nitrogenous waste is considered to be discharged as effluent, for a total of 28.08 kg of nitrogen and a Factor 2.1 score of 7 out of 10. The content and enforcement of effluent regulations and management in Canada and the US are considered to be ‘moderately effective’ and result in a Factor 2.2 score of 7 out of 10. Overall, Arctic char farming in Canada and the US receive combined scores for waste discharge, production system and regulatory effectiveness of a ‘moderate’ Criterion 2 - Effluent score of 7 out of 10.

With respect to Iceland, a feed with 40% protein, an industry FCR of 1.25, and an 18.9% protein content of the harvested char indicate that 49.76 kilograms of nitrogenous waste per ton of char are calculated to be produced. In contrast to North America, char aquaculture facilities in Iceland operate as flow-through with no recirculation, indicating that 100% of this nitrogenous waste is discharged as effluent, resulting in Factor 2.1 score of 5 out of 10. The content and enforcement of Icelandic aquaculture regulations regarding effluents and their impacts is considered ‘moderate,’ resulting in Factor 2.2 score of 6.8 out of 10. Overall, Arctic char farming in Iceland received a ‘moderate’ score of 6 out of 10 for Criterion 2 – Effluent, for waste discharge, production system and regulatory effectiveness.

Justification of Ranking

Canada and United States

Effluent volume and impact data for Arctic char in Canada and the US is difficult to locate due to the industry being dispersed among many states and provinces, many with decentralized management and regulation; however, producers and other experts have been very cooperative during the assessment process and provided data for all points of the assessment. Due to the fact that it is not independently verified, the Effluent Data score is 5 and the Risk Based Assessment option is used for Canada and the US.

<u>F2.1a Biological waste production per ton of fish</u>

Arctic char are a salmonid species and, similar to other carnivorous fish species, have high dietary protein requirements. Typical on-growing diets contain between 38% and 48% crude protein (BioMar 2013, Lee pers. comm., Smáradóttir pers. comm.). The feed used in Canada and the US contains 45% protein and the industry achieves an average FCR of 1.2 (Lee pers. comm., Lucas pers. comm., Pigott pers. comm.). Harvested Arctic char contain 18.9% protein, and when these values are input into the Seafood Watch calculations (shown in Appendix 1), 56.16 kilograms of nitrogen waste are calculated to be produced per metric ton of char biomass produced.

F2.1b Production system discharge score

Char aquaculture systems in Canada and the US range from traditional flow-through to complete recirculation (zero discharge). Effluent treatment characteristics vary from farm to farm. In some flow-through systems, effluent is filtered and treated prior to being discharged into settling ponds (for further treatment) or natural waterways. Other farms will reuse water in several areas of the farm before/after treatment and prior to discharge (i.e., partial recirculation systems) while others continue to recirculate water through the system, only replenishing to compensate for loss due to evaporation and wet solids (i.e., full recirculating system). Filtered solids that are collected are disposed of properly (i.e., used as agricultural fertilizer or disposed of with other organic wastes if use for fertilizer is not permitted in the region) (Lee pers. comm., Lucas pers. comm., Pigott pers. comm.).

Eventual wastewater disposal is farm dependent; Sustainable Blue (a farm in Nova Scotia producing ~180 metric tons of char annually) is nearly full recirculation and discharges a small amount to a tertiary water treatment facility, while Icy Waters (a Yukon farm with annual production of ~150 metric tons) is flow-through and uses settling ponds and marshland to treat water before it returns to natural wetlands downstream of the farm (Lee pers. comm., Lucas pers. comm.). Icy Waters previously used drum filters to remove solids from discharge water, but testing indicated higher concentrations of dissolved nutrients using this method than found when settling ponds are used (Lucas pers. comm.). Public comments during Icy Waters' reapplication for a water license with the Yukon Water Board indicate that there may be increased algal growth in the creeks and lake into which the farm releases effluent (Johnston pers. comm., Sharp pers. comm.). Analysis performed by the Yukon Water Board and the farm were considered during the farm's water license renewal, and it was determined that Icy Waters does not substantially alter the water quality or quantity it uses and the license was granted with an agreed upon reduction in total phosphorus release over the next five years (Yukon Water Board 2013).

This report does not cover farm-level data for all production facilities in Canada and the US, however, production systems raising Arctic char are moving toward higher levels of recirculation, and the typical farm is currently operating as a partial recirculation system (Vandenberg pers. comm.). Arctic char in Canada and the US receive a system discharge score of 0.5 (between flow-through with treatment and full recirculation) indicating that 50% of waste from fish is released from the immediate farm site as effluent. Subsequently, 28.08 kg N per ton of fish produced is calculated to be discharged as effluent from farms in Canada and the United States. This effluent discharge corresponds to a score of 7 out of 10 for Factor 2.1.

F2.2 Management of farm-level and cumulative impacts

The Arctic char industry in Canada and the US is dispersed among a number of provinces, territories and states and is subject to regulation and management by several different authorities. All farms contacted for this assessment are in compliance with current federal and regional legislation as well as permit conditions regarding monitoring and effluent discharges, which are discussed below.

In New Brunswick, Arctic char aquaculture is governed both by the Environmental Management Program for Land Based Finfish Aquaculture in New Brunswick (best management practices, monitoring and reporting, discharge thresholds) and the Department of Environment and Local Government Certificate of Approval to Operate (which includes conditions regarding number of fish and/or biomass, rate of water withdrawal and total phosphorus and/or total nitrogen concentration at point of discharge into a watercourse or after a set mixing zone) (GNB 2013). Environmental impact assessments are required for any new facility using $\geq$50 m^3 of water per day.

In the Yukon Territory, the Yukon Water Board (YWB) governs decisions regarding water use and discharge permits and is subject to regular review. When considering license renewal, YWB takes into account a number of acts and regulations, including the Waters Act, Waters Regulation, public register for the application, the Board's typical license requirements, and the Yukon Environmental and Socio-economic Assessment Act Evaluation Report (Yukon Water Board 2013). Site-specific control measures in both major production regions (Yukon and New Brunswick) are designed for aquaculture, set according to the ecological status of the receiving water body and include discharge limits. Monitoring data demonstrates minor non-compliance by Icy Waters (the only char production facility in the Territory) with regards to phosphorus releases after water flow was restricted by upstream construction; production volumes were subsequently decreased in order to achieve compliance.

Both the content and enforcement of effluent regulations and management in Canada and the US are considered to be moderately effective and result in a Factor 2.2 score of 7 out of 10. Overall, Arctic char farming in Canada and the US scores a 'moderate' final Effluent score of 7 out of 10 for waste discharge, production system and regulatory effectiveness.

Iceland

The data score for the effluent category in Iceland is a moderate 5, due to the lack of information available (in English) regarding potential impacts from farm discharge, resulting in the use of the Effluent Risk Based Assessment. Discharge data are collected and available in Icelandic from the governing bodies, however, as it is not available in English, the data could not be used for this assessment (Thorarensen pers. comm.).

<u>F2.1a Biological waste production per ton of fish</u>

The feed used in Iceland contains 40% protein and the industry achieves an average FCR of 1.25 (Smáradóttir pers. comm.). Harvested Arctic char contain 18.9% protein, which indicates that 49.76 kilograms of nitrogen waste are calculated to be produced per metric ton of char.

<u>F2.1b Production system discharge score</u>

Icelandic char production utilizes long established traditional flow-through production systems. Most operations source intake water from wells, while a small number of facilities source intake waters from streams. This water passes through the farms only once and does not recirculate prior to release. Farms discharging into the sea are intentionally sited in locations with high current activity (Smáradóttir pers. comm., Thorarinsdottir pers. comm.). Any facility discharging effluent into freshwater is required to properly filter particulate wastes. Although the farms intake freshwater, the majority of farms release effluent into the ocean and, thus, are not required to filter wastewater. As such, a basic production System Discharge score of 1.0 is assigned, indicating that 100% of wastes produced by farms are discharged.

F2.2 Management of farm-level and cumulative impacts

Several federal, regional and community authorities are charged with the management of aquaculture in Iceland (Haug et al. 2009, Fiskistofa n.d., TIAA 2009). The current underlying management system, the Act of Aquaculture (No. 71/2008), was implemented in 2008 and lays down the requirements for establishing aquaculture farms in Iceland. Other relevant acts include Act No. 106/2000 on environmental impact assessments and Act No. 55/1998 concerning treatment, production and distribution of marine products. Any freshwater fish farm producing more than 20 metric tons annually is required to have both an environmental and an operational license issued by the Ministry of the Environment and Ministry of Fisheries and Agriculture (Directorate of Fisheries); any farm below this threshold is managed by a local health and environmental community committee (Haug et al. 2009). Environmental licenses contain specific criteria regarding discharge of pollutants, harmful chemicals, and distribution of suspended solids, along with other local and regional environmental issues (TIAA 2009).

Although effluent filtering and/or treatment is not required for land-based farms discharging to the sea, outlets must be at least 5 meters below the mean low spring tide level, or 20 meters out to sea from the low spring tide line (Jonsson 2000). License applications contain a detailed description of the production, pollution risk and control, farm location, the local environment and other relevant issues. Based on the license draft and consultation with the local Health Inspection Authority, the Nature Conservation Agency, the Planning Agency and the Directorate of Freshwater Fisheries, a farm may be required to undertake an environmental impact assessment. Licensing requirements also set a monitoring schedule, and test for compliance (Jonsson 2000). Monitoring is set according to facility size and does not necessarily cover all phases of production, but enforcement by the environmental agencies and food agencies along with the local health inspection authorities control is considered effective. Management and regulation face regular review and the Icelandic system will be updated in 2015 (Thorarensen pers. comm.). Iceland receives a score of 7.65 out of 10 for Regulatory or management effectiveness.

Final score for the Effluent Criterion

Overall, Arctic char farming in Iceland scores ‘moderate’ for waste discharge, production system and regulatory effectiveness and receives the Criterion 2 –Effluent score of 6 out of 10.

Criterion 3: Habitat

Impact, unit of sustainability and principle

- *Impact: Aquaculture farms can be located in a wide variety of aquatic and terrestrial habitat types and have greatly varying levels of impact to both pristine and previously modified habitats and to the critical "ecosystem services" they provide.*
- *Sustainability unit: The ability to maintain the critical ecosystem services relevant to the habitat type.*
- *Principle: aquaculture operations are located at sites, scales and intensities that cumulatively maintain the functionality of ecologically valuable habitats.*

Criterion 3 Summary

Canada/Iceland/US

Habitat parameters	Value	Score	
F3.1 Habitat conversion and function		9.00	
F3.2a Content of habitat regulations	3.25		
F3.2b Enforcement of habitat regulations	4.25		
F3.2 Regulatory or management effectiveness score		5.53	
C3 Habitat Final Score		**7.84**	**GREEN**
Critical?	NO		

Brief Summary

Arctic char farming in Iceland, Canada, and the United States is shown to maintain habitat functionality and avoid the conversion and loss of ecosystem services. Farms have either been operating for extended periods of time with no adverse habitat effects, or alternatively have been established on previously converted lands (e.g., agricultural farms or pre-existing industrial buildings). As such, char aquaculture results in minimal habitat impacts and receives a Factor 3.1 score of 9 out of 10. The content and enforcement of habitat regulations in all three countries is shown to be 'moderate' for the size and scope of the industry, resulting in a Factor 3.2 score of 5.53 out of 10. The numerical score for Criterion 3 – Habitat is 7.84 out of 10.

Justification of Ranking

Factor 3.1. Habitat conversion and function

The majority of land-based production facilities (covering ~1-1.5 hectares each) used for the culture of Arctic char of Canada and the US are either long established (>10 years) as fish farms (producing other species) or were established on previously converted land (e.g., agricultural/ terrestrial farms) (Lee pers. comm., Lucas pers. comm., Pigott pers. comm.). When possible, producers upgrade older aquaculture farms, implementing new technologies to meet current standards rather than converting additional land for aquaculture production (Lee pers. comm.).

AquaTerra Farms (Wisconsin) and Sustainable Blue (Nova Scotia) are both located in historic agricultural land, while Ridgeland Aqua Farms (Manitoba) is located on a converted pig barn (Green 2013, Lee pers. comm., Pigott pers. comm.). Ecosystem function was not lost due to habitat conversion (as defined by the Seafood Watch criteria) for the development of Arctic char farms in North America.

Siting of farms in Iceland was based initially on proximity to coastal areas with high water current and good access to high quality fresh water (Smáradóttir pers. comm.). Additionally, growth in the Arctic char industry has been achieved mostly through intensification rather than through an increase in physical footprints. Three farms (situated on about 2.7 ha) owned by Samherji have a combined capacity of 3000 metric tons per year, which represented over 90% of Iceland's production in 2012 (IMFA 2010, Smáradóttir pers. comm.).

Siting for char farms in all countries evaluated in this assessment has been conducted so as to avoid the conversion of high-value, sensitive ecosystems. While the use of previously built infrastructure protects and maintains habitat functionality, char aquaculture is considered to have minimal impacts on habitat functionality. As such, Canada, Iceland and the US all receive a score of 9 out of 10 for Factor 3.1 Habitat conversion and function.

Factor 3.2. Habitat and farm siting management effectiveness (appropriate to the scale of the industry)

Regulations and management governing land-based farm siting score 'moderate' relative to the high score all countries received for the habitat conversion factor. Canada, Iceland and the US all have strong aquaculture regulatory frameworks; however, most legislation focuses on marine aquaculture in net pens or cages, or on shellfish farming in tidal habitats. Part of the reason for this is that management and regulations lag behind the growth of inland aquaculture, and the recent advancement in the associated technology.

<u>Canada and United States</u>

Char farms in Canada and the US are located in a number of provinces, territories and states, resulting in regulation and management by several different authorities. All farms contacted for this assessment are in compliance with current federal and regional legislation as well as with permit conditions regarding siting allowances. In Canada, the Department of Fisheries and Oceans (DFO) and various provincial regulatory bodies address the growth and siting of the aquaculture industry (DFO 2013b). Many provinces have aquaculture growth strategies, which may need to be updated to include land-based farms. As a relatively small industry, cumulative impacts from land-based aquaculture have not been identified as a current concern, but should be considered for future revisions. Not all aquaculture projects are subject to environmental assessments under recent updates to the Canadian Environmental Assessment Act, although it is unclear as to whether land-based facilities will be managed differently than other marine or freshwater projects (Canadian Environmental Assessment Agency (CEAA) 2013). According to section 19(a) of the Canadian Environmental Act, all projects undergoing an environmental impact assessment (EIA) must include a review of cumulative impacts. The CEAA maintains an online, publicly available database of all ongoing and completed environmental assessments.

While undergoing the siting process, proposed aquaculture farms must consider cumulative impacts of neighboring industries and avoid high-value habitats (DFO 2006).

Both federal and state regulations govern land-based aquaculture in the US (NRAC 2010, WDNR 2013). All permit applications are assessed on a case-by-case basis and the process is designed to protect surrounding ecosystems from potential impacts (WDNR 2013). Similar to regulations in Canada, those in the US are designed mainly for marine aquaculture farms. Land-based aquaculture in Wisconsin is not expected to grow significantly and reduces concern for potential cumulative impacts (Weeks 2013). AquaTerra Farms produces below the threshold to be controlled under the Clean Water Act's (CWA) National Pollutant Discharge Elimination System (NPDES), but waterbodies in the US are subject to discharge limitations known as total maximum daily load (TMDL). TMDL is a calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards, and an allocation of that load among the various sources of that pollutant.

<u>Iceland</u>

The Icelandic Ministry for the Environment is authorized to set regulations for site selection and potential habitat impact is taken into consideration during the application process for farm licensing. If there is concern of significant effects on the surrounding ecosystem, an environmental impact assessment may be required prior to license approval (Jonsson 2000). The Aquaculture Act no. 71 was implemented July 1st 2008 and aims to manage aquaculture development in a sustainable manner (IMFA 2008). No English translation of the act could be located, but it has been confirmed that updates dealing with scale and future growth have been made to the governance of Arctic char farms due to the size and expansion of the industry (Thorarensen pers. comm.). In addition to the Aquaculture Act, the Planning and Building Act, the Environmental Impact Assessment Act and the Nature Conservation Act may also regulate siting and habitat impacts of fish farms in Iceland.

Although the regulations surrounding farm siting and habitat protection are complex and not always transparent, they appear to be adequate for the size of the Arctic char industry in each country. If unanticipated growth is seen in any country, this factor will need to be reevaluated, but current habitat regulation and management for all three countries receives a 'moderate' score of 4.88 out of 10.

Final score for the Habitat Criterion

Overall, Arctic char aquaculture has not reduced ecosystem functionality in Canada, Iceland or the US and, in combination with generally suitable habitat management, results in a moderately-high Habitat criterion score of 7.84 out of 10.

Criterion 4: Evidence or Risk of Chemical Use

Impact, unit of sustainability and principle

- *Impact: Improper use of chemical treatments impacts non-target organisms and leads to production losses and human health concerns due to the development of chemical-resistant organisms.*
- *Sustainability unit: non-target organisms in the local or regional environment, presence of pathogens or parasites resistant to important treatments*
- *Principle: aquaculture operations by design, management or regulation avoid the discharge of chemicals toxic to aquatic life, and/or effectively control the frequency, risk of environmental impact and risk to human health of their use.*

Criterion 4 Summary

Canada/Iceland/US

Chemical Use parameters	Score	
C4 Chemical Use Score	**6.00**	
C4 Chemical Use Final Score	**6.00**	**YELLOW**
Critical?	NO	

Brief Summary

Historically, disease has not been a significant issue in char aquaculture and, as such, the industry has a demonstrably low need to treat fish with chemotherapeutants. Chemicals are very infrequently used in the production of Arctic char in any of the three assessment countries. Vaccines are administered and reduce the need for the use of therapeutants through prevention of disease. While there is not a significant volume of published scientific literature available on chemical use in char farming, personal communications with industry experts confirmed that no antibiotics are utilized in production (one Canadian producer reported use of oxytetracycline once in the past five years). While farm records are not available and specific data are limited, the species has a demonstrably low need for chemical use and chemical treatments are not used over multiple production cycles. Therefore, the numerical score for Criterion 4 – Chemical Use is 6 out of 10.

Justification of Ranking

Disease in Arctic char aquaculture is not a significant production challenge and, as such, the industry uses very little (if any) in the way of chemotherapeutants (Lee pers. comm., Lucas pers. comm., Pigott pers. comm., Smáradóttir pers. comm.). Broodstock and eggs brought in for culture are specific-pathogen free. Vaccinations are used in some Canadian and Icelandic production, but this method does not lead to the discharge of any chemicals, as individual fish are injected. Many producers pursue and use alternative methods to prevent or treat disease in place of chemical treatments. Instead of the prophylactic use of antibiotics, the manager of Icy Waters uses garlic powder, during times of stress, to increase fish immunity (Lucas pers. comm.). One producer reported the use of oxytetracycline for an uncharacteristic outbreak of furunculosis, however, it was the first time in five years, under veterinary prescription, and a last resort method to maintain the health and welfare of the fish. This appears to be an isolated incident, as both Icelandic and US producers interviewed reported no chemical use during Arctic char production (Matís ltd. 2012, Pigott pers. comm., Smáradóttir pers. comm.).

Personal communication with producers in all three countries confirmed that vaccinations do not result in the discharge of active chemicals (Lee pers. comm., Lucas pers. comm., Pigott pers. comm., Smáradóttir pers. comm.). Additionally, it was confirmed that no other chemical treatments have been used over the most recent multiple production cycles (Lee pers. comm., Lucas pers. comm., Pigott pers. comm., Smáradóttir pers. comm.). Given that farm records are not publically available and that there has been little scientific study in this area, this assessment considers specific data to be limited, however, the species has a demonstrably low need for chemical use. As such, Arctic char aquaculture receives a score of 6 out of 10 for Criterion 4 – Chemical Use.

Criterion 5: Feed

Impact, unit of sustainability and principle

- *Impact: feed consumption, feed type, ingredients used and the net nutritional gains or losses vary dramatically between farmed species and production systems. Producing feeds and their ingredients has complex global ecological impacts, and their efficiency of conversion can result in net food gains, or dramatic net losses of nutrients. Feed use is considered to be one of the defining factors of aquaculture sustainability.*
- *Sustainability unit: the amount and sustainability of wild fish caught for feeding to farmed fish, the global impacts of harvesting or cultivating feed ingredients, and the net nutritional gains or losses from the farming operation.*
- *Principle: aquaculture operations source only sustainable feed ingredients, convert them efficiently and responsibly, and minimize and utilize the nonedible portion of farmed fish.*

Criterion 5 Summary

Canada/US

Feed parameters	Value	Score	
F5.1a Fish In: Fish Out ratio (FIFO)	1.54	6.16	
F5.1b Source fishery sustainability score		-4.00	
F5.1: Wild Fish Use		5.55	
F5.2a Protein IN	30.46		
F5.2b Protein OUT	15.78		
F5.2: Net Protein Gain or Loss (%)	-48.2	5	
F5.3: Feed Footprint (hectares)	10.74	6	
C5 Feed Final Score		**5.52**	**YELLOW**
Critical?	NO		

Iceland

Feed parameters	Value	Score	
F5.1a Fish In: Fish Out ratio (FIFO)	0.85	7.87	
F5.1b Source fishery sustainability score		-2.00	
F5.1: Wild Fish Use		7.70	
F5.2a Protein IN	29.99		
F5.2b Protein OUT	12.66		
F5.2: Net Protein Gain or Loss (%)	-57.8	4	
F5.3: Feed Footprint (hectares)	13.13	5	
C5 Feed Final Score		**6.10**	**YELLOW**
Critical?	NO		

Brief Summary

Arctic char have a high dietary protein requirement and their culture is reliant upon the supply of external feed. Fish in: Fish out ratios are 1.55 in the US/Canada and 0.85 in Iceland with both calculations being driven by the fish oil content and the use of byproducts for fish oil in feeds. In the US/Canada, there is a net protein loss of 48.2%, while Iceland shows a net protein loss of 52.4%. Both scores are categorized by reliance on crop ingredients that are considered edible by humans as opposed to nonedible byproducts from fish, animals or crops. Overall, Feed Criterion scores for all three countries are 'moderate,' with US and Canada receiving 5.52 out of 10 and Iceland receiving 6.10 out of 10.

Justification of Ranking

Dietary requirements of Arctic char are similar to those of other salmonid species, especially Atlantic salmon and rainbow trout (Vandenberg pers. comm.). Protein needs have been experimentally demonstrated between 33% and 38% (minimum) and are between 38% and 45% in practice along with 18%–22% crude lipid content for on-growing purposes (Árnason et al. 2013). Several sources are used to fulfill these dietary needs, including fishmeal, fish oil, terrestrial crop proteins and oils (i.e., soybean meal, soy protein concentrate, wheat gluten meal, rapeseed/canola products and corn protein concentrate) and terrestrial animal proteins (i.e., poultry byproduct meal). Arctic char feeds are commercially manufactured and contents differ by company and by country. Feed formulations are often considered proprietary and, as such, it can be very difficult to obtain the specific data points required to complete the feed calculations in this assessment. Producers have been very helpful during this process and Samherji (the largest producer in Iceland) and Dr. Thorarensen (of Holar University College) were able to disclose feed formulations and sourcing.

Factor 5.1. Wild Fish Use

Canada and United States

<u>F5.1a Fish in: Fish out (FIFO)</u>

Canadian and US producers source from a variety of feed companies, primarily EWOS and Skretting (and subsidiary BioOregon), and also Corey AquaFeeds and Taplow Feeds (Lee pers. comm., Lucas pers. comm., Pigott pers. comm.). Current commercial char FCRs reported by researchers and producers range from 1.1 to 1.3 feed conversion ratio, with Sustainable Blue noting that they have achieved a low FCR of 0.95. Scoring for this criterion uses an average FCR of 1.2 and fishmeal and fish oil contents of 25% and 8% respectively (Johnston pers. comm., Lee pers. comm., Lucas pers. comm., Pigott pers. comm., Vandenberg pers. comm.). Producers have been working along with feed manufacturers to increase the proportion of fishmeal and oil from byproducts and trimmings (both from fisheries and agriculture), however, any data from feed companies is confidential to producers. Although the amount in each batch of feed will vary, the byproduct inclusion values from recent sustainability reports for major feed companies EWOS and Skretting were applied for North American feed (26% of fishmeal and 20% of fish oil are sourced from byproducts; Cermaq 2012, Skretting Norway 2012). The fish in: fish out (FIFO) ratio that results from the combination of these reported values is 1.54 and is driven by fish oil (i.e. 1.54 kg of wild fish are necessary to produce the fish oil required to grow one kg of farmed char). This FIFO value corresponds to an initial FIFO score of 6.16.

F5.1b Sustainability of the source of wild fish (SSWF)

The second factor considered in the wild fish use score is the sustainability of the source of wild fish (SSWF), which adjusts the FIFO score based on the relative sustainability of the fisheries from which the feed ingredients are sourced. Similar to feed formulations, source fisheries can be difficult to obtain as each batch of feed is manufactured using the most economically efficient source of fishmeal and fish oil. Since a large amount of Arctic char feed is sourced from EWOS and Skretting, the summaries of their 2012 fisheries were used to inform this factor. Table 2 outlines the species and origin fisheries of the major sources for both EWOS and Skretting along with the percentage of raw ingredients each provided (Cermaq 2012, Skretting Norway 2012).

FishSource is a database maintained by the Sustainable Fisheries Partnership (SFP) that evalutes the relative sustainability of a given fishery. The FishSource management and fish stock scores are also presented in Table 2, along with averages weighted by proportion of sourced fishmeal and fish oil (excluding the percentage from byproduct/trimmings; SFP 2013).

Table 1. 2012 Reduction fishery sources and FishSource scores for Skretting and EWOS feed.

Company	Species and fishery origin	Fishmeal %	Fish oil %	FishSource scores 1	2	3	4	5
Skretting	Anchoveta – Peruvian northern-central stock	36.2	45.4	6	10	10	8.3	8
	Capelin – Icelandic	9.8	0	6	10	10	6	-
	Capelin – Barents Sea	8.3	10	8	10	10	6	6
	European sprat – North Sea	7.9	11.9	6	5.7	10	6	6
	Boar fish – NE Atlantic	3.1	0	6	-	-	6	6
	Lesser sand-eel – North Sea	1.8	0.8	6	10	6	6	6
	Atlantic herring – Icelandic summer-spawning	1.3	4	6	10	8.6	9.9	8.9
	Atlantic herring – Norwegian spring-spawning	1.1	0	8.4	10	9.9	8.9	7.7
	Blue whiting – Northeast Atlantic	0.9	0	8.9	10	6	10	10
	Norway pout – North Sea	0	0.8	6	10	10	8.5	6
	Gulf menhaden – Gulf of Mexico	0	9	6	6	6	10	10
	(Byproduct/trimmings)	28.2	15	-	-	-	-	-
	Total & Weighted Average	**98.6**	**96.9**	**6.3**	**9.0**	**9.4**	**7.7**	**7.1**
EWOS	Anchoveta (Peru)	52		6	10	10	8.3	8
	Anchoveta (Chile - III & IV)			6	5.4	10	6.8	9.3
	Anchoveta (Chile - V-X)			6	10	10	6	6
	Anchoveta (Chile - XV-I-II)			6	0.4	6	6	6
	Capelin – Norway, Iceland	9		7	10	10	6	6
	Sand Eaal – Denmark, Norway	2		6	10	6	6	6
	Sprat – Denmark	5		6	5.7	10	6	6
	Menhaden – USA	4		6	6	6	10	10
	(Byproduct/trimmings)	24		-	-	-	-	-
	Total & Weighted Average	**96**		**6.1**	**6.9**	**8.9**	**6.8**	**7.2**

The weighted average FishSource scores demonstrate that, in general, source fisheries of fishmeal and fish oil used in Arctic char commercial diets (and especially the most significant sources) are from relatively sustainable fisheries. Although there are a few exceptions, the majority of fisheries have FishSource scores of greater than or equal to 6, with at least one score equal to or greater than 8.

With respect to the SSWF adjustment, on a scale from 0 to -10 (with 0 being the best performance, indicative of the most sustainable fisheries), both major feed manufacturers receive a high SSWF score of -2. When this adjustment is applied to the FIFO score of 6.16, Arctic char aquaculture in Canada and the US receives a 'moderate' Factor 5.1 Wild Fish Use score of 5.55 out of 10.

Iceland

F5.1a Fish in: Fish out (FIFO)

Feed source data and formulations for Arctic char production in Iceland differ from that in North America and were made readily available for the purpose of this assessment by Ms. Smáradóttir (Samherji) and Dr. Thorarensen (Holar University College). The average FCR is reported as 1.25, and feed contains 20% fishmeal and 19.5% fish oil with 65% of raw marine ingredients sourced from processing byproducts (Smáradóttir pers. comm.). The fish in: fish out (FIFO) ratio that results from the combination of these reported values is 0.85 and is driven by fish oil (i.e., 0.85 kg of wild fish are necessary to produce the fish oil required to grow one kg of farmed char). This FIFO value corresponds to an initial FIFO score of 7.87.

Fish oil in Iceland is sourced mainly from capelin and herring (Smáradóttir pers. comm.), both of which have a higher than average oil yield (13.5%–14% whole fat content, yielding ~100g from 1kg of fish, or a 10% fish oil yield). This higher oil yield makes a significant difference to the amount of wild fish required to produce a kilogram of farmed fish.

F5.1b Sustainability of the source of wild fish (SSWF)

Laxá Feed Mill Ltd. is the major feed manufacturer in Iceland and sources from fisheries in Icelandic waters. The main source fisheries are capelin and herring caught in fishing area FAO-27 (Smáradóttir pers. comm.). All FishSource scores for both fisheries are above 6 with at least one score greater than 8 (SFP 2013). As such, feed used for Arctic char aquaculture in Iceland receives a SSWF score of -2.

With a FIFO score of 7.87 and a SSWF score of -2, Arctic char aquaculture in Iceland scores a high 7.70 out of 10 for Factor 5.1 Wild fish use.

Factor 5.2. Net Protein Gain or Loss

Canada and United States

Commercial Arctic char feed in Canada and the US contains approximately 45% crude protein (Lee pers. comm., Lucas pers. comm., Pigott pers. comm.). Protein in formulated feeds is derived primarily from fishmeal, corn protein concentrate, soya bean meal and poultry byproduct meal (Lee pers. comm., Vandenberg pers. comm.). Seafood Watch encourages the use of ingredients that are unfit for human consumption: ingredients that are considered in this assessment to be fit for human consumption, include the portion of fishmeal and fish oil not from byproducts and the protein in edible crop ingredients (corn protein concentrate and soya bean meal).

Detailed commercial feed formulations are not available for Arctic char feed, however, researchers stated that feeds are modeled on Atlantic salmon feeds (Vandenberg pers. comm.).

The British Columbia Seafood Watch report and a review paper by Sarker et al. represent the most recent Canadian salmon feed data (Bridson 2014, Sarker et al. 2013). Data from BC feed companies show that a large amount of the total protein (an average of 71.4%) comes from nonedible land animal byproducts, largely poultry and feather meals, which are high in protein (Bridson 2014), however, values for Arctic char production cannot be assumed to be the same as Atlantic salmon.

As is stated in F5.1, the fishmeal content of feeds used for Arctic char production is 25%, and consists of 26% byproducts. Therefore, it is calculated that 18.5% of the feed is fishmeal from whole fish, and 6.5% of the feed is fishmeal from fish byproducts. Using the assumption that fishmeal is 60% protein, it is calculated that 11.1% of the protein in the feed is from whole fish, and 3.9% is protein from fish byproducts. It is further calculated that 25% of the total feed is protein from whole fish, while 9% of the total feed is protein from fish byproducts. Therefore, the total amount of protein from marine ingredients is 34%.

Subtracting the 34% marine ingredients from the total percentage of ingredients in feed (100%) leaves 66% of the protein in the feed to be provided by crop ingredients (corn protein concentrate and soya bean meal) and land animal ingredients (poultry byproduct meal). Both crop ingredients are considered to be edible, while the poultry byproduct meal is not. Because inclusion levels of these remaining ingredients are not provided, it is assumed that each is included equally (22% of protein from corn protein concentrate, 22% soya bean meal, and 22% poultry byproduct meal). Based on these findings, the total amount of protein from nonedible sources (fishmeal from marine byproducts and poultry byproduct meal) is 31%, and the remaining 69% of protein is from edible sources (fishmeal from whole fish, corn protein concentrate and soya bean meal). Because it has been assumed that both crop ingredients are included at equal levels, it is calculated that 44% of protein in the feed is from edible crop ingredients. The remaining 25% is fishmeal protein from whole fish.

The protein content of farmed Arctic char is 18.9% and edible yield obtained is estimated at 67% (Árnason et al. 2013). Approximately half of the nonedible byproducts from harvested char are used either directly (feed) or indirectly (as compost/fertilizer) for other food production (Lee pers. comm., Lucas pers. comm., Pigott pers. comm.). Byproducts from harvested fish go to further offset the protein in/protein out equation and improves the resulting score.

Accounting for all input sources and outputs of protein from Arctic char production in Canada and the US, the net protein loss is -48.2% and results in a score of 5 out of 10.

Iceland

At the time of this report, feed for Arctic char aquaculture in Iceland does not contain any terrestrial animal ingredients, meaning that crude protein is derived entirely from fishmeal and terrestrial crop products. Crude protein levels for Iceland feed are reported between 38% and 42% (Smáradóttir pers. comm.). The average of these values (40%) has been used for calculations in this assessment. Protein in feed is split 50/50 between crop and fishmeal, with fishery byproducts accounting for 65% of the fishmeal portion (Brussel 2013). It is calculated that 20% of feed protein is from nonedible sources, while 70% is from edible crop sources. Some crop ingredients in feed are sourced from byproducts (Thorarensen pers. comm.), however, since the exact proportion is not known, for the purpose of the assessment it is assumed that all crop protein is from edible sources. As stated above, the whole fish protein content of Arctic char is 18.9% and edible yield is 67% (Árnason et al. 2013). It is not known whether any nonedible byproducts from harvested, farmed Arctic char are used for other food production.

Icelandic char production does not include the use of terrestrial animal byproducts, but use of edible crop protein sources results in a protein loss (-57.8%) and a moderate score of 4 out of 10.

Factor 5.3. Feed Footprint

Canada and the United States
The total amount of marine ingredients in feed (fishmeal + fish oil) is 33%. In order to determine the inclusion levels of crop and land animal ingredients, the percentage of protein in feed from land animal products is calculated (9.9%) which dictates a total inclusion level of land animal products in feed to be 16.5%. The total amount of crop feed ingredients in the feed is calculated as the remaining value after addition of marine ingredients (33%) and land animal ingredients (16.5%). This remainder is 50.5%.

These calculations result in a footprint of 10.74 hectares per ton of Arctic char produced, and a final F5.3 score of 6 of 10.

Iceland
There are no terrestrial animal products used for Arctic char feed in Iceland. Inclusion levels of aquatic feed ingredients are 39.5% (i.e., the combined total of fishmeal and fish oil) and 60.5% (i.e., the remainder of the feed) for crop feed ingredients. This results in a feed footprint of 13.13 hectares per ton of production and a score of 5 out of 10 for F5.3.

Final score for the Feed Criterion

The combination of final scores for F5.1 Wild Fish Use, F5.2 Protein Use and F5.3 Feed Footprint results in a final Criterion 5 score of 5.52 of 10 for production in Canada and the US.

The combination of final scores for F5.1 Wild Fish Use, F5.2 Protein Use and F5.3 Feed Footprint results in a final Criterion 5 score of 6.10 of 10 for production in Iceland.

Criterion 6: Escapes

Impact, unit of sustainability and principle

- *Impact: competition, genetic loss, predation, habitat damage, spawning disruption, and other impacts on wild fish and ecosystems resulting from the escape of native, non-native and/or genetically distinct fish or other unintended species from aquaculture operations.*
- *Sustainability unit: affected ecosystems and/or associated wild populations.*
- *Principle: aquaculture operations pose no substantial risk of deleterious effects to wild populations associated with the escape of farmed fish or other unintentionally introduced species.*

Criterion 6 Summary

Canada/US

Escape parameters	Value	Score	
F6.1 Escape Risk		8.64	
F6.1a Recapture and mortality (%)	66		
F6.1b Invasiveness		5	
C6 Escape Final Score		**6.00**	**YELLOW**
Critical?	NO		

Iceland

Escape parameters	Value	Score	
F6.1 Escape Risk		6.00	
F6.1a Recapture and mortality (%)	0		
F6.1b Invasiveness		5	
C6 Escape Final Score		**5.00**	**YELLOW**
Critical?	NO		

Brief Summary

In Canada and the United States, partial recirculation and water treatment technology, screens, and secondary capture devices mitigate the risk of escapes. Additionally, at several of the facilities in North America, any escapes that do occur are expected to experience direct mortality as a result of either post-facility water treatment and/or lethally high water temperatures—the Factor 6.1a Escape Risk score for Canada and the US is 8.64 out of 10. In Iceland, the majority of facilities operate as flow-through with screens and secondary capture devices, however, no direct mortality of escapes is expected. The Factor 6.1a Escape Risk score for Iceland is 6 out of 10. For all three countries, char are native species that have been hatchery raised for four or more generations. Any escapes that do occur are expected to compete with wild native populations for food and habitat, act as additional predation pressure on wild native populations and potentially disturb breeding behavior. The Factor 6.1b Invasiveness score is 3 out of 10 for all three countries—when Factors 6.1a and 6.1b combine, the numerical score for Criterion 6 – Escapes is 6 out of 10 for Canada and the United States and 5 out of 10 for Iceland.

Justification of Ranking

Factor 6.1a. Escape risk

Canada and the United States

Arctic char aquaculture in Canada and the US uses land-based production systems operating either as flow-through or (more commonly) recirculation. Some farms have water outlets that eventually discharge into natural water bodies, but others have water treatment technology, screens and/or secondary capture devices. For example, the small amount of water that leaves Sustainable Blue goes into a tertiary water treatment facility and thus negates the possibility of survival of any escapees (no escape events have occurred to date, Lee pers. comm.). Icy Waters utilizes a system of three settling ponds to remove solids from effluent and has had only one individual Arctic char make it into the first pond in the last decade (Lucas pers. comm.). However, there have been no official assessments of escapes or examinations of whether or not escapees are breeding and/or becoming established (Johnston pers. comm., Sharp pers. comm). AquaTerra Farms reports that in the event of an escape, the escaped fish would not survive, as Arctic char require much lower water temperatures than that of the river they would be discharged into. As there is no possibility of escapee survival in two of the three char farms assessed (one due to post-facility treatment of water and the other due to high surrounding water temperatures), the recapture/mortality score is set at 0.66 (indicating 66% of escapees would suffer direct mortality before impacting surrounding environments). The risk of escape occurring is scored as 6 (an intermediate score between full recirculation [8] and flow-through [4]), which, when adjusted by the 66% mortality, results in a Factor 6.1a Escape Risk score of 8.64 out of 10.

Iceland

Iceland’s land-based char farms operate as flow-through systems. Double security barriers are used to reduce the risk of escapes. The country’s largest producer (Samherji) reports that they have not experienced any escape events (company data from Smáradóttir pers. comm.), but given that effluent from farms is released directly into the ocean, evidence of escapes is expected to be difficult to collect. No material could be found regarding procedures for recapture in the event of an escape and, as such, no recapture or mortality adjustment is applied. Considering the lack of specific evidence on escapes in Iceland, the escape risk score is based upon the production system characteristics as defined in the Seafood Watch Criteria. Icelandic char aquaculture facilities are flow-through tank systems with multiple escape prevention methods and are considered moderate risk systems. Iceland’s Arctic char industry receives a Factor 6.1a Escape Risk score of 6 out of 10.

Factor 6.1b. Invasiveness

The invasiveness profile of a species is informed by two parts: the first part is scored for either native species (based on potential genetic differences from wild populations) or non-native species (based on species potential for establishment), and the second part is scored according to the escapees' potential to cause ecosystem impacts regardless of native or non-native status.

Part A: Native species

Arctic char are native in Canada, the United States, and Iceland. Production fish from hatcheries are at least five generations (in Canada and the US) and ten generations (in Iceland) removed from the wild (Lucas pers. comm., Smáradóttir pers. comm.). Breeding programs are aimed at improving genetic management and selecting for characteristics to enhance production success in captivity, such as heat and disease resistance. As the farm stock have been hatchery raised for more than four generations, Factor 6.1b Part A receives a score of 1 out of 5 for all three countries.

Part C

As noted for the escape risk factor, the likelihood of escape events in all countries depends on the type of system being used. Along with this, the risk of impact a species poses is assessed based on life history characteristics. If any char were to escape, theoretically they could compete with wild native populations for food and habitat, act as additional predation pressure on wild native populations and may disturb breeding behavior. As such, Factor 6.1b Part C scores 4 out of 5.

When Parts A and C combine, the final Factor 6.1b Invasiveness score is 5 out of 10 for Arctic char in Canada, Iceland and the US.

Final score for the Escapes Criterion

The final score for the escapes criterion combines the escape risk with the invasiveness of the species should it escape. Overall, the two escape factors combine for a moderate Escape score of 6 out of 10 for Canada/the US and 5 out of 10 for Iceland.

Criterion 7: Disease; pathogen and parasite interactions

Impact, unit of sustainability and principle

- *Impact: amplification of local pathogens and parasites on fish farms and their retransmission to local wild species that share the same water body.*
- *Sustainability unit: wild populations susceptible to elevated levels of pathogens and parasites.*
- *Principle: aquaculture operations pose no substantial risk of deleterious effects to wild populations through the amplification and retransmission of pathogens or parasites.*

Criterion 7 Summary

Canada/Iceland/US

Pathogen and parasite parameters	Score	
C7 Biosecurity	8.00	
C7 Disease; pathogen and parasite Final Score	**8.00**	**YELLOW**
Critical?	**NO**	

Brief Summary

To date, char aquaculture has not had significant issues with disease. While Arctic char is known to be vulnerable to a number of bacterial and viral diseases, aquaculture production in Canada, Iceland and the US are closely managed to prevent outbreaks, and do not report any recent pathogen problems that present risk for wild populations. There have been no reported cases of any amplification of pathogen or parasite levels in wild fish populations surrounding farms in any of the three production countries, but this may be due to limited direct monitoring or focused studies. Based on the production systems for char, there is considered to be a potential connection between the farm to wild population in terms of pathogen transfer, but as the reported disease problems on the farms are low, temporary or infrequent, Arctic char aquaculture in Canada, Iceland and the US all receive a score of 8 out of 10 for Criterion 7 – Disease, indicating a low risk of impact to wild populations.

Justification of Ranking

Intensive aquaculture production is vulnerable to pathogens and parasites due to a number of factors, including high animal densities and periods of increased stress levels. Land-based facilities have an increased ability to monitor and manage biosecurity and health measures of production animals, as waterflows are monitored, controlled and can be treated prior to entering the culture environment. Production fish can also be isolated and treated in land-based facilities with relative ease, in the event of a disease occurrence. Arctic char are known to be susceptible to a number of diseases in the wild, including infectious pancreatic necrosis virus (IPNV), infectious hematopoietic necrosis virus (IHNV), viral hemorrhagic septicemia virus

(VHSV), furunculosis, bacterial kidney disease (BKD), vibrosis, saplogeniasis, proliferative kidney disease (PKD), metazoan parasites (tapeworms and roundworms), gyrodactylid monogenean parasites (flukes) and sea lice (Johnston 2008).

Interviews with producers indicate no pathogen problems over at least the past five production cycles with the exception of one Canadian outbreak of furunculosis and periodic signs of saprolegnia on eggs or broodstock (Lee pers. comm., Lucas pers. comm.). No disease problems have been reported by producers in the US or Iceland (Pigott pers. comm, Smáradóttir pers. comm.).

As noted previously in this report, production systems vary from farm to farm, but the primary concern with this criterion is potential harmful disease interactions with wild populations, including the amplification and retransmission of disease agents. There have been no reported cases of any amplification of pathogen or parasite levels in wild fish populations surrounding farms in any of the three production countries, but this may be due to limited direct monitoring or focused studies. Based on the production systems for char, there is considered to be a potential connection between the farm to wild population in terms of pathogen transfer, but as the reported disease problems on the farms are low, temporary or infrequent, Arctic char aquaculture in Canada, Iceland and the US all receive a score of 8 out of 10 for Criterion 7 – Disease, as there is a low risk of impact to wild populations.

Criterion 8: Source of Stock – independence from wild fisheries

Impact, unit of sustainability and principle

- *Impact: the removal of fish from wild populations for on-growing to harvest size in farms*
- *Sustainability unit: wild fish populations*
- *Principle: aquaculture operations use eggs, larvae, or juvenile fish produced from farm-raised broodstocks thereby avoiding the need for wild capture*

Criterion 8 Summary

Canada/Iceland/US

Source of stock parameters	Score	
C8 % of production from hatchery-raised broodstock or natural (passive) settlement	100	
C8 Source of stock Final Score	**10.00**	**GREEN**

Brief Summary
All farm stock are produced in hatcheries from captive broodstock. As such, the industry is completely independent from wild stocks for broodstock and juvenile sourcing and there is no subsequent impact on wild populations. The score for Criterion 8 – Source of Stock is 10 out of 10.

Justification of Ranking
All Arctic char aquaculture production is sourced from eyed eggs produced in hatcheries with egg production based on captive broodstock (Lee pers. comm., Lucas pers. comm., Pigott pers. comm., Smáradóttir pers. comm.). Breeding programs are aimed at improving genetic management and selecting for characteristics to enhance production success in captivity, such as heat and disease resistance. Icy Waters is a major eyed egg supplier in North America and last brought broodstock in from the wild in 1995, while the stock of char at Coastal Zones Research Institute have not received eggs or fish from the wild since the mid-1980s (Dumas, pers. comm., Lucas pers. comm.). Arctic char has been raised in captivity in Iceland for 10 generations (Smáradóttir pers. comm.). Canada, Iceland and the US do not increase pressure on wild populations for broodstock or juvenile sourcing and as such, the score for Criterion 8 – Source of Stock is 10 out of 10.

Exceptional Criterion 9X: Wildlife and predator mortalities

A measure of the effects of deliberate or accidental mortality on the populations of affected species of predators or other wildlife.

This is an "exceptional" criterion that may not apply in many circumstances. It generates a negative score that is deducted from the overall final score. A score of zero means there is no impact.

Criterion 9X Summary

Canada/Iceland/US

Wildlife and predator mortality parameters	Score	
C9X Wildlife and predator mortality Final Score	0.00	GREEN
Critical?	NO	

Justification of Ranking
Land-based production facilities are either indoors or utilize shade netting and other passive deterrents (e.g., fencing) to prevent any lethal interaction with wildlife (Lee pers. comm., Lucas pers. comm., Pigott pers. comm., Smáradóttir pers. comm.). Therefore, there are not considered to be any direct or accidental mortality of wildlife associated with char production. As such, the score for Exceptional Criterion 9X – Wildlife and Predator Mortality is a penalty of zero (out of -10).

<u>Exceptional Criterion 10X: Escape of unintentionally introduced species</u>

A measure of the escape risk (introduction to the wild) of alien species <u>other than the principle farmed species</u> unintentionally transported during live animal shipments.

This is an "exceptional" criterion that may not apply in many circumstances. It generates a negative score that is deducted from the overall final score.

Exceptional Criterion 10X Summary

Canada/US

Escape of unintentionally introduced species parameters	Score	
C10Xa International or trans-waterbody live animal shipments (%)	2.00	
C10Xb Biosecurity of source/destination	8.00	
C10X Escape of unintentionally introduced species Final Score	**-1.6**	**GREEN**

Iceland

Escape of unintentionally introduced species parameters	Score	
C10Xa International or trans-waterbody live animal shipments (%)	10.00	
C10X Escape of unintentionally introduced species Final Score	**0.00**	**GREEN**

Brief Summary

In Canada and the United States, Arctic char aquaculture relies on the trans-waterbody shipment of eggs, which has the potential to unintentionally introduce species other than the principal farmed species. The biosecurity of both the source and destination of eggs is moderate, and while no incidents of unintentionally introduced species are known, the risk persists and results in an Exceptional Criterion 10X score of -1.6 out of -10 for Canada and the US. In Iceland, there is no trans-waterbody shipment of eggs and as such no deduction is applied (i.e. score of 0 out of -10).

Justification of Ranking

Factor 10Xa International or trans-waterbody live animal shipments

Canada and United States

A large proportion of Arctic char aquaculture in Canada and the US is based on domestic hatchery production, however, for many facilities this represents movement between ecologically distinct bodies of water. Icy Waters in the Yukon is a major supplier of eyed Arctic char eggs for North American farms, with some production also supplied by Troutlodge in Washington (Pigott pers. comm., Lucas pers. comm.). Sustainable Blue in Nova Scotia has also recently started importing eggs from hatcheries in Iceland (Lee pers. comm.). Most regulatory agencies only allow the regional/national/ international movement of certified disease free, eyed eggs (Johnston pers. comm.). As the movement of char only focuses on eggs, the disinfection of eggs before shipment is an effective method to reduce the risk of transporting unintended organisms. Since there are no official production statistics available for Canada or the US, it is assumed that the majority of production (approximately 80%) is based on international or trans-waterbody movements, resulting in a score of 2 out of 10 for Exceptional Criterion 10Xa.

Iceland
Production of Arctic char in Iceland is entirely dependent on domestic hatchery sources (Smáradóttir pers. comm.). No trans-waterbody or international live animal movements occur. As such, Iceland scores 10 out of 10 for Exceptional Criterion 10Xa and results in no deduction for Exceptional Criterion 10X – Escape of Unintentionally Introduced Species.

Factor 10Xb Biosecurity of source/destination
The hatchery facility at Icy Waters operates as a flow-through system with biosecurity measures in place (i.e., egg disinfection prior to shipping, Lucas pers. comm.). Hatcheries in Iceland are flow-through as well, with water sourced from boreholes deep below the farms and no exposure to wild salmonid populations (Smáradóttir pers. comm.). Hatcheries receive a score of 8 out 10 as the source of animal movements, as they are flow-through systems with biosecurity plans in place and eggs are screened and disinfected before import. Import permits (regarding source facilities) and health certificates (i.e., screening for known diseases and proper water treatment) are required for live animal shipping, further protecting the destination facility (Extension 2013). The destination for animal movements is scored the same as the initial escape risk factor for Canadian and US production facilities, 8 of 10.

All production areas have strict regulations about live animal movements, and sourcing and biosecurity of farms result in a small overall potential for the escape of unintentionally introduced species. When C10Xa and C10Xb combine, a deduction of -1.6 out of -10 is applied for Exceptional Criterion 10X with respect to the US and Canada. As Iceland does not require any live animal shipments, the C10X for Iceland is 0 out of -10.

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References

AquaTerra Farms (2013) AquaTerra Farms – Our Fish. Available from: http://aquaterrafish.com/products

Arctic Rose Inc. (2011) International Workshop Arctic Charr Aquaculture 2011: Assessing Status – Identifying Opportunity. Final Report – Aquaculture Collaborative Research And Development Program Of Fisheries And Oceans Canada. Available from: http://www.irzc.umcs.ca/flash_content/Dossier%20PDF/Publications/ACRDP_Final_Report.pdf

Árnason J, Sigurgeirsson O, Jóhannsdóttir J, Ólafsdóttir A, Ginindza J (2013) Protein requirements of Arctic charr. Matís – Food Research, Innovation & Safety. Report no. 15-13.

BioMar (2013) Fish species and data sheets – Arctic Char. Available from: http://www.biomar.com/en/BioMar-Denmark/Species--products/Fish-species/Fjeldorred/

Boyer J (2012) Arctic char aquaculture development and profitable commercialisation. Fisheries and Aquaculture News. Available from: http://www.mapaq.gouv.qc.ca/SiteCollectionDocuments/Journal_Peche_Impact/2012/Pecheimpact_1209A.pdf

Bridson P (2014) Monterey Bay Aquarium Seafood Watch Program – British Columbia Atlantic salmon (*Salmo salar*). Available from: http://www.seafoodwatch.org/cr/cr_seafoodwatch/content/media/MBA_SeafoodWatch_FarmedBCSalmon_Report.pdf

Brussel (2013) Ice Fresh Farmed Arctic Char *Salvelinus alpinus* – Samherji detailed data sheet.

Canadian Aquaculture Industry Alliance (CAIA) (2012) Canadian Farmed Arctic Char. Available from: http://www.aquaculture.ca/files/species-arctic-charr.php

Canadian Environmental Assessment Act (CEAA) (2013) Overview – Canadian Environmental Assessment Act, 2012. Available from: http://www.ceaa-acee.gc.ca/default.asp?lang=en&n=16254939-1

Cermaq (2012) Cermaq Annual Report 2012. Available from: http://www.report2012.cermaq.com/sustainability#

Extension (2013) Canada Will Begin Enforcement of New Aquatic Animal Import Regulations as of December 10, 2012. Available from: https://www.extension.org/pages/65626/canada-will-begin-enforcement-of-new-aquatic-animal-import-regulations-as-of-december-10-2012#.U-U3zkiTFaE

Fisheries and Oceans Canada (DFO) (2006) Arctic Char. Available from: http://web.archive.org/web/20120419195216/http://www.dfo-mpo.gc.ca/aquaculture/finfish-poissons/char-omble-eng.htm

Fisheries and Oceans Canada (DFO) (2013a) Arctic Char. Available from: http://www.dfo-mpo.gc.ca/aquaculture/sector-secteur/species-especes/arctic-char-omble-chevalier-eng.htm

Fisheries and Oceans Canada (DFO) (2013b) Legislation and Regulation. Available from: http://www.dfo-mpo.gc.ca/aquaculture/management-gestion/regs-eng.htm

Fiskistofa (no date) The Icelandic Directorate of Fisheries – Responsibilities and main tasks. Available from: http://www.fiskistofa.is/media/utgefid_efni/DOF.pdf

Food and Agriculture Organization of the United Nations (FAO) (2011) Fishstat J. FAO Fisheries Department, Fishery Information, Data and Statistics Unit. 2000: Universal software for fishery statistical time series. Version 2.0. Available from: http://www.fao.org/fishery/statistics/software/fishstatj/en (Data sources: Global Aquaculture Production – Quantity and Value (1950—2010))

Government of New Brunswick (GNB) (2013) Environmental Management Program for Land Based Finfish Aquaculture in New Brunswick - Version 1.0. Available from: www2.gnb.ca/content/dam/gnb/Departments/env/pdf/MarineAquaculture-AquacoleMarin/EnvironmentalManagementProgramLandBasedFinfish.pdf

Green M (2013) Arctic char being raised in pig barns in Manitoba. CBC Manitoba Scene. Available from: http://www.cbc.ca/manitoba/scene/homepage-promo/2013/04/07/arctic-char-raised-in-pig-barns-in-manitoba/index.html

Haug L, Paulsen H, Eriksson L-O, Rúnarsson G (2009) Nordic policy and management related to freshwater aquaculture. Available from: http://www.bioforsk.no/ikbViewer/Content/55626/Haug%20Nordic%20Policy%20management%20related%20to%20freshwater%20aquaculturea.pdf

Icelandic Ministry of Fisheries and Agriculture (IMFA) (2008) Laws and Regulations. Available from: http://www.fisheries.is/aquaculture/laws-and-regulations/

Icelandic Ministry of Fisheries and Agriculture (IMFA) (2010) Iceland Fisheries – Aquaculture Arctic Char. Available from: http://www.fisheries.is/aquaculture/species/arctic-charr/

Icelandic Industry and Innovation Ministry (IIIM) (2013) Ministry of Fisheries and Agriculture meeting with the largest retailer in the United States for char. Available from: http://www.atvinnuvegaraduneyti.is/sjavarutvegs-og-landbunadarmal/frettir/nr/7805

Jonsson GS (2000) Licensing, monitoring and regulation of aquaculture in Iceland. Journal of Applied Ichthyology. (4-5):172–6.

Johnston G (2008) Arctic Charr Aquaculture. John Wiley & Sons. Oxford, UK. 288 pp.

Marine Harvest (2009) Marine Harvest Sustainability Report 2009. Available from: http://marineharvest.com/Global/Sustainability/Sustainability%20Report%202009%20Final.pdf

Matís ltd (2012) Icelandic Arctic Charr. Available from: http://www.matis.is/iceland-arctic-charr/

Miles RD, Jacob JP (2011) Fishmeal: Understanding why this Feed Ingredient is so Valuable in Poultry Diets. Animal Sciences Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Available from: http://edis.ifas.ufl.edu/ps043

National Marine Fisheries Service (NMFS) (2013) Cumulative trade data by product. Fisheries Statistics Division, Office of Science and Technology, National Marine Fisheries Service, U.S. Department of Commerce, Silver Spring, MD. http://www.st.nmfs.noaa.gov/commercial-fisheries/foreign-trade/applications/trade-by-product

North Central Regional Aquaculture Center (NCRAC) (2010) Wisconsin – Aquaculture contacts, transport regulations, and approved aquatic species. Available from: http://www.ncrac.org/Info/StateImportRegs/wisconsin.htm#Environmental

Sæther B-S, Siikavuopio SI, Lysne H, Thorarensen H & Brännäs E (No date) Sustainable aquaculture of Arctic charr - NorthCharr Status of Arctic charr farming in Iceland, Norway and Sweden Available from: http://www.northcharr.eu/downloads/Arctic_charr_farming_in_NPP_region.pdf

Sarker, P., Bureau, D., Hua, K., Drew, M., Forster, I., Were, K., Hicks, B., Vandenberg, G. 2013. Sustainability issues related to feeding salmonids: a Canadian perspective. Reviews in Aquaculture (2013) 5, 1–21

Skretting Norway (2012) Sustainability Report 2012. Available from: http://www.nutreco.com/Global/Nutreco corporate/Publications/Sustainability/2012/Skretting Norway Sustainability Report 2012.pdf

Sustainable Fisheries Partnership (SFP) (2013) FishSource – Status and environmental performance of fisheries worldwide. Available from: http://www.fishsource.com/

The Icelandic Aquaculture Association (TIAA) (2009) Aquaculture in Iceland. Available from: http://lfh.is/documents/AquacultureinIcelanddes2009upps.pdf

Rúnarsson G (2013) Aquaculture in Iceland. The Icelandic Aquaculture Association. Available from: http://www.lfh.is/documents/China23042013.pdf

Washington Fish Growers Association (WFGA) (2007) Washington Finfish Aquaculture Tour. Available from: http://www.wfga.net/tour.php

Weeks C (2013) Regulation impacts on the commercial aquaculture in the North Central Region. Available from: https://secure.wisconsinaquaculture.com/Docs/567.pdf

Wisconsin Department of Natural Resources (WDNR) (2013) Environmental Permits for Wisconsin Fish Farms – PUB-FH-059 Available from: http://dnr.wi.gov/topic/fishing/documents/aquaculture/factsheet_fh_059.pdf

Yukon Water Board, 2013, Water Use Application MS11-041 (Renewal of Y-IN87-07L, as amended) Icy Waters Ltd. Available from: http://www.yukonwaterboard.ca/WATERLINE/

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Data points and all scoring calculations

This is a condensed version of the criteria and scoring sheet to provide access to all data points and calculations. See the Seafood Watch Aquaculture Criteria document for a full explanation of the criteria, calculations and scores. Yellow cells represent data entry points.

Canada/US

Criterion 1: Data quality and availability

Data Category	Relevance (Y/N)	Data Quality	Score (0-10)
Industry or production statistics	*Yes*	5	5
Effluent	Yes	5	5
Locations/habitats	Yes	5	5
Predators and wildlife	Yes	5	5
Chemical use	Yes	5	5
Feed	Yes	5	5
Escapes, animal movements	Yes	5	5
Disease	Yes	5	5
Source of stock	Yes	5	5
Other – (e.g. GHG emissions)	No	Not relevant	n/a
Total			**45**

C1 Data Final Score	5.00	YELLOW

Criterion 2: Effluents

Factor 2.1a - Biological waste production score

Protein content of feed (%)	45
eFCR	1.2
Fertilizer N input (kg N/ton fish)	0
Protein content of harvested fish (%)	18.9
N content factor (fixed)	*0.16*
N input per ton of fish produced (kg)	86.4
N in each ton of fish harvested (kg)	30.24
Waste N produced per ton of fish (kg)	**56.16**

Factor 2.1b - Production System discharge score

Basic production system score	0.5
Adjustment 1 (if applicable)	0
Adjustment 2 (if applicable)	0
Adjustment 3 (if applicable)	0
Discharge (Factor 2.1b) score	**0.5**

50 % of the waste produced by the fish is discharged from the farm

2.2 – Management of farm-level and cumulative impacts and appropriateness to the scale of the industry

Factor 2.2a - Regulatory or management effectiveness

Question	Scoring	Score
1 - Are effluent regulations or control measures present that are designed for, or are applicable to aquaculture?	Yes	1
2 - Are the control measures applied according to site-specific conditions and/or do they lead to site-specific effluent, biomass or other discharge limits?	Moderately	0.5
3 - Do the control measures address or relate to the cumulative impacts of multiple farms?	Moderately	0.5
4 - Are the limits considered scientifically robust and set according to the ecological status of the receiving water body?	Moderately	0.5
5 - Do the control measures cover or prescribe including peak biomass, harvest, sludge disposal, cleaning etc?	Yes	1
		3.5

Factor 2.2b - Enforcement level of effluent regulations or management

Question	Scoring	Score
1 - Are the enforcement organizations and/or resources identifiable and contactable, and appropriate to the scale of the industry?	Yes	1
2 - Does monitoring data or other available information demonstrate active enforcement of the control measures?	Yes	1
3 - Does enforcement cover the entire production cycle (i.e. are peak discharges such as peak biomass, harvest, sludge disposal, cleaning included)?	Yes	1
4 - Does enforcement demonstrably result in compliance with set limits?	Yes	1
5 - Is there evidence of robust penalties for infringements?	Yes	1
		5

F2.2 Score (2.2a*2.2b/2.5)	**7**

C2 Effluent Final Score	7.00	GREEN
	Critical?	NO

Criterion 3: Habitat

3.1. Habitat conversion and function

F3.1 Score	9

3.2 Habitat and farm siting management effectiveness (appropriate to the scale of the industry)

Factor 3.2a - Regulatory or management effectiveness

Question	Scoring	Score
1 - Is the farm location, siting and/or licensing process based on ecological principles, including an EIAs requirement for new sites?	Mostly	0.75
2 - Is the industry's total size and concentration based on its cumulative impacts and the maintenance of ecosystem function?	Partly	0.25
3 – Is the industry's ongoing and future expansion appropriate locations, and thereby preventing the future loss of ecosystem services?	Yes	1
4 - Are high-value habitats being avoided for aquaculture siting? (i.e. avoidance of areas critical to vulnerable wild populations; effective zoning, or compliance with international agreements such as the Ramsar treaty)	Yes	1
5 - Do control measures include requirements for the restoration of important or critical habitats or ecosystem services?	Partly	0.25
		3.25

Factor 3.2b - Siting regulatory or management enforcement

Question	Scoring	Score
1 - Are enforcement organizations or individuals identifiable and contactable, and are they appropriate to the scale of the industry?	Yes	1
2 - Does the farm siting or permitting process function according to the zoning or other ecosystem-based management plans articulated in the control measures?	Mostly	0.75
3 - Does the farm siting or permitting process take account of other farms and their cumulative impacts?	Moderately	0.5
4 - Is the enforcement process transparent - e.g. public availability of farm locations and sizes, EIA reports, zoning plans, etc?	Yes	1
5 - Is there evidence that the restrictions or limits defined in the control measures are being achieved?	Yes	1
		4.25

F3.2 Score (2.2a*2.2b/2.5)	5.53

C3 Habitat Final Score	7.84	GREEN

Critical?	NO

Criterion 4: Evidence or Risk of Chemical Use

Chemical Use parameters	Score	
C4 Chemical Use Score	6.00	
C4 Chemical Use Final Score	**6.00**	YELLOW
Critical?	NO	

Criterion 5: Feed

5.1. Wild Fish Use

Factor 5.1a - Fish In: Fish Out (FIFO)

Fishmeal inclusion level (%)	25
Fishmeal from byproducts (%)	26
% FM	18.5
Fish oil inclusion level (%)	8
Fish oil from byproducts (%)	20
% FO	6.4
Fishmeal yield (%)	22.5
Fish oil yield (%)	5
eFCR	1.2
FIFO fishmeal	0.99
FIFO fish oil	1.54
Greater of the 2 FIFO scores	1.54
FIFO Score	**6.16**

Factor 5.1b - Sustainability of the Source of Wild Fish (SSWF)

SSWF	-4
SSWF Factor	-0.61

F5.1 Wild Fish Use Score	**5.55**

5.2. Net protein Gain or Loss

Protein INPUTS	
Protein content of feed	45
eFCR	1.2
Feed protein from Nonedible sources (%)	31

Feed protein from EDIBLE CROP soruces (%)	44
Protein OUTPUTS	
Protein content of whole harvested fish (%)	18.9
Edible yield of harvested fish (%)	67
Nonedible byproducts from harvested fish used for other food production	50
Protein IN	30.46
Protein OUT	15.78
Net protein gain or loss (%)	-48.20
Critical?	NO
F5.2 Net protein Score	**5.00**

5.3. Feed Footprint

5.3a Ocean area of primary productivity appropriated by feed ingredients per ton of farmed seafood

Inclusion level of aquatic feed ingredients (%)	33
eFCR	1.2
Average Primary Productivity (C) required for aquatic feed ingredients (ton C/ton fish)	*69.7*
Average ocean productivity for continental shelf areas (ton C/ha)	*2.68*
Ocean area appropriated (ha/ton fish)	10.30

5.3b Land area appropriated by feed ingredients per ton of production

Inclusion level of crop feed ingredients (%)	50.5
Inclusion level of land animal products (%)	16.5
Conversion ratio of crop ingredients to land animal products	*2.88*
eFCR	1.2
Average yield of major feed ingredient crops (t/ha)	*2.64*
Land area appropriated (ha per ton of fish)	0.45

Value (Ocean + Land Area)	**10.74**

F5.3 Feed Footprint Score	**6.00**

C5 Feed Final Score	**5.52**	**YELLOW**
	Critical?	**NO**

Criterion 6: Escapes

6.1a. Escape Risk

Escape Risk	**6**

Recapture & Mortality Score (RMS)	
Estimated % recapture rate or direct mortality at the escape site	66
Recapture & Mortality Score	0.66
Factor 6.1a Escape Risk Score	**8.64**

6.1b. Invasiveness

Part A – Native species

Score	1

Part B – Non-Native species

Score	**0**

Part C – Native and Non-native species

Question	Score
Do escapees compete with wild native populations for food or habitat?	To some extent
Do escapees act as additional predation pressure on wild native populations?	To some extent
Do escapees compete with wild native populations for breeding partners or disturb breeding behavior of the same or other species?	No
Do escapees modify habitats to the detriment of other species (e.g. by feeding, foraging, settlement or other)?	No
Do escapees have some other impact on other native species or habitats?	No
	4

F 6.1b Score	**5**

Final C6 Score	**6.00**	**YELLOW**
	Critical?	**NO**

Criterion 7: Diseases

Pathogen and parasite parameters	Score	
C7 Biosecurity	8.00	
C7 Disease; pathogen and parasite Final Score	**8.00**	**GREEN**
Critical?	NO	

Criterion 8: Source of Stock

Source of stock parameters	Score	
C8 % of production from hatchery-raised broodstock or natural (passive) settlement	100	
C8 Source of stock Final Score	**10**	**GREEN**

Exceptional Factor 9X: Wildlife mortalities

Wildlife and predator mortality parameters	Score	
F9X Wildlife and predator mortality Final Score	**0.00**	**GREEN**
Critical?	NO	

Exceptional Factor 10X: Escape of unintentionally introduced species

Escape of unintentionally introduced species parameters	Score	
F10Xa International or trans-waterbody live animal shipments (%)	2.00	
F10Xb Biosecurity of source/destination	8.00	
C6 Escape of unintentionally introduced species Final Score	**-1.60**	**GREEN**

Iceland

Criterion 1: Data quality and availability

Data Category	Relevance (Y/N)	Data Quality	Score (0-10)
Industry or production statistics	*Yes*	7.5	7.5
Effluent	Yes	5	5
Locations/habitats	Yes	5	5
Predators and wildlife	Yes	5	5
Chemical use	Yes	5	5
Feed	Yes	5	5
Escapes, animal movements	Yes	5	5
Disease	Yes	5	5
Source of stock	Yes	5	5
Other – (e.g. GHG emissions)	No	Not relevant	n/a
Total			**47.5**

C1 Data Final Score	5.28	YELLOW

Criterion 2: Effluents

Factor 2.1a - Biological waste production score

Protein content of feed (%)	40
eFCR	1.25
Fertilizer N input (kg N/ton fish)	0
Protein content of harvested fish (%)	18.9
N content factor (fixed)	*0.16*
N input per ton of fish produced (kg)	80
N in each ton of fish harvested (kg)	30.24
Waste N produced per ton of fish (kg)	**49.76**

Factor 2.1b - Production System discharge score

Basic production system score	0.9
Adjustment 1 (if applicable)	0
Adjustment 2 (if applicable)	0
Adjustment 3 (if applicable)	0
Discharge (Factor 2.1b) score	**0.9**

9
0 % of the waste produced by the fish is discharged from the farm

2.2 – Management of farm-level and cumulative impacts and appropriateness to the scale of the industry

Factor 2.2a - Regulatory or management effectiveness

Question	Scoring	Score
1 - Are effluent regulations or control measures present that are designed for, or are applicable to aquaculture?	Yes	1
2 - Are the control measures applied according to site-specific conditions and/or do they lead to site-specific effluent, biomass or other discharge limits?	Yes	1
3 - Do the control measures address or relate to the cumulative impacts of multiple farms?	Mostly	0.75
4 - Are the limits considered scientifically robust and set according to the ecological status of the receiving water body?	Yes	1
5 - Do the control measures cover or prescribe including peak biomass, harvest, sludge disposal, cleaning etc?	Moderately	0.5
		4.25

Factor 2.2b - Enforcement level of effluent regulations or management

Question	Scoring	Score
1 - Are the enforcement organizations and/or resources identifiable and contactable, and appropriate to the scale of the industry?	Yes	1
2 - Does monitoring data or other available information demonstrate active enforcement of the control measures?	Yes	1
3 - Does enforcement cover the entire production cycle (i.e. are peak discharges such as peak biomass, harvest, sludge disposal, cleaning included)?	Mostly	0.75
4 - Does enforcement demonstrably result in compliance with set limits?	Yes	1
5 - Is there evidence of robust penalties for infringements?	Mostly	0.75
		4.5

F2.2 Score (2.2a*2.2b/2.5)	**7.65**

C2 Effluent Final Score	**6.00**	**YELLOW**
	Critical?	NO

Criterion 3: Habitat

3.1. Habitat conversion and function

F3.1 Score	**9**

3.2 Habitat and farm siting management effectiveness (appropriate to the scale of

the industry)

Factor 3.2a - Regulatory or management effectiveness

Question	Scoring	Score
1 - Is the farm location, siting and/or licensing process based on ecological principles, including an EIAs requirement for new sites?	Mostly	0.75
2 - Is the industry's total size and concentration based on its cumulative impacts and the maintenance of ecosystem function?	Mostly	0.75
3 – Is the industry's ongoing and future expansion appropriate locations, and thereby preventing the future loss of ecosystem services?	Mostly	0.75
4 - Are high-value habitats being avoided for aquaculture siting? (i.e. avoidance of areas critical to vulnerable wild populations; effective zoning, or compliance with international agreements such as the Ramsar treaty)	Mostly	0.75
5 - Do control measures include requirements for the restoration of important or critical habitats or ecosystem services?	Partly	0.25
		3.25

Factor 3.2b - Siting regulatory or management enforcement

Question	Scoring	Score
1 - Are enforcement organizations or individuals identifiable and contactable, and are they appropriate to the scale of the industry?	Yes	1
2 - Does the farm siting or permitting process function according to the zoning or other ecosystem-based management plans articulated in the control measures?	Mostly	0.75
3 - Does the farm siting or permitting process take account of other farms and their cumulative impacts?	Mostly	0.75
4 - Is the enforcement process transparent - e.g. public availability of farm locations and sizes, EIA reports, zoning plans, etc?	Mostly	0.75
5 - Is there evidence that the restrictions or limits defined in the control measures are being achieved?	Yes	1
		4.25

F3.2 Score (2.2a*2.2b/2.5)	**5.53**

C3 Habitat Final Score	**7.84**	**GREEN**
	Critical?	NO

Criterion 4: Evidence or Risk of Chemical Use

Chemical Use parameters	Score	
C4 Chemical Use Score	**6.00**	
C4 Chemical Use Final Score	**6.00**	**YELLOW**
Critical?	NO	

Criterion 5: Feed

5.1. Wild Fish Use

Factor 5.1a - Fish In: Fish Out (FIFO)

Fishmeal inclusion level (%)	20
Fishmeal from byproducts (%)	65
% FM	7
Fish oil inclusion level (%)	19.5
Fish oil from byproducts (%)	65
% FO	6.83
Fishmeal yield (%)	22.5
Fish oil yield (%)	10
eFCR	1.25
FIFO fishmeal	0.39
FIFO fish oil	0.85
Greater of the 2 FIFO scores	0.85
FIFO Score	**7.87**

Factor 5.1b - Sustainability of the Source of Wild Fish (SSWF)

SSWF	-2
SSWF Factor	-0.17

F5.1 Wild Fish Use Score	**7.70**

5.2. Net protein Gain or Loss

Protein INPUTS		
Protein content of feed		40
eFCR		1.25
Feed protein from Nonedible sources (%)		20
Feed protein from EDIBLE CROP soruces (%)		70
Protein OUTPUTS		
Protein content of whole harvested fish (%)		18.9
Edible yield of harvested fish (%)		67
Nonedible byproducts from harvested fish used for other food production		0
Protein IN		29.99
Protein OUT		12.663
Net protein gain or loss (%)		-57.78
	Critical?	NO
F5.2 Net protein Score	**4.00**	

5.3. Feed Footprint

5.3a Ocean area of primary productivity appropriated by feed ingredients per ton of farmed seafood

Inclusion level of aquatic feed ingredients (%)	39.5
eFCR	1.25
Average Primary Productivity (C) required for aquatic feed ingredients (ton C/ton fish)	*69.7*
Average ocean productivity for continental shelf areas (ton C/ha)	*2.68*
Ocean area appropriated (ha/ton fish)	12.84

5.3b Land area appropriated by feed ingredients per ton of production

Inclusion level of crop feed ingredients (%)	62
Inclusion level of land animal products (%)	0
Conversion ratio of crop ingedients to land animal products	*2.88*
eFCR	1.25
Average yield of major feed ingredient crops (t/ha)	*2.64*
Land area appropriated (ha per ton of fish)	0.29

Value (Ocean + Land Area)	**13.13**

F5.3 Feed Footprint Score	**5.00**

C5 Feed Final Score	**6.10**	**YELLOW**
	Critical?	**NO**

Criterion 6: Escapes

6.1a. Escape Risk

Escape Risk	**6**

Recapture & Mortality Score (RMS)	
Estimated % recapture rate or direct mortality at the escape site	0
Recapture & Mortality Score	0
Factor 6.1a Escape Risk Score	**6**

6.1b. Invasiveness

Part A – Native species

Score	1

Part B – Non-Native species

Score	**0**

Part C – Native and Non-native species

Question	Score
Do escapees compete with wild native populations for food or habitat?	To some extent
Do escapees act as additional predation pressure on wild native populations?	To some extent
Do escapees compete with wild native populations for breeding partners or disturb breeding behavior of the same or other species?	No
Do escapees modify habitats to the detriment of other species (e.g. by feeding, foraging, settlement or other)?	No
Do escapees have some other impact on other native species or habitats?	No
	4

F 6.1b Score	**5**

Final C6 Score	**5.00**	**YELLOW**
	Critical?	**NO**

Criterion 7: Diseases

Pathogen and parasite parameters	Score	
C7 Biosecurity	8.00	
C7 Disease; pathogen and parasite Final Score	**8.00**	**YELLOW**
Critical?	NO	

Criterion 8: Source of Stock

Source of stock parameters	Score	
C8 % of production from hatchery-raised broodstock or natural (passive) settlement	100	
C8 Source of stock Final Score	**10**	**GREEN**

Exceptional Factor 9X: Wildlife and predator mortalities

Wildlife and predator mortality parameters	Score	
F9X Wildlife and Predator Final Score	**0.00**	**GREEN**
Critical?	NO	

Exceptional Factor 10X: Escape of unintentionally introduced species

Escape of unintentionally introduced species parameters	Score	
F10Xa International or trans-waterbody live animal shipments (%)	10.00	
F10Xb Biosecurity of source/destination	0.00	
F10X Escape of unintentionally introduced species Final Score	**0.00**	**GREEN**