Rainbow Trout

Oncorhynchus mykiss

Colombia

Raceways and Net Pens

Aquaculture Standard Version A3.2

December 19, 2018

Seafood Watch Consulting Researchers

Disclaimer

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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 Watch Assessment. Each assessment 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." This ethic is operationalized in the Seafood Watch standards, available on our website here. In producing the assessments, 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 assessments 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 Watch assessments in any way they find useful.

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 farms must possess to be considered sustainable by the Seafood Watch program. Sustainable aquaculture farms and collective industries, by design, management and/or regulation, address the impacts of individual farms and the cumulative impacts of multiple farms at the local or regional scale by:

1. **Having robust and up-to-date information on production practices and their impacts available for analysis;**
   Poor data quality or availability limits the ability to understand and assess the environmental impacts of aquaculture production and subsequently for seafood purchasers to make informed choices. Robust and up-to-date information on production practices and their impacts should be available for analysis.
2. **Not allowing effluent discharges to exceed, or contribute to exceeding, the carrying capacity of receiving waters at the local or regional level;**
   Aquaculture farms 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.
3. **Being located at sites, scales and intensities that maintain the functionality of ecologically valuable habitats;**
   The siting of aquaculture farms does not result in the loss of critical ecosystem services at the local, regional, or ecosystem level.
4. **Limiting the type, frequency of use, total use, or discharge of chemicals to levels representing a low risk of impact to non-target organisms;**
   Aquaculture farms avoid the discharge of chemicals toxic to aquatic life or limit the type, frequency or total volume of use to ensure a low risk of impact to non-target organisms.
5. **Sourcing sustainable feed ingredients and converting them efficiently with net edible nutrition gains;**
   Producing feeds and their constituent ingredients has complex global ecological impacts, and the efficiency of conversion can result in net food gains or dramatic net losses of nutrients. Aquaculture operations source only sustainable feed ingredients or those of low value for human consumption (e.g. by-products of other food production), and convert them efficiently and responsibly.
6. **Preventing population-level impacts to wild species or other ecosystem-level impacts from farm escapes;**
   Aquaculture farms, by limiting escapes or the nature of escapees, prevent competition, reductions in genetic fitness, predation, habitat damage, spawning disruption, and other impacts on wild fish and ecosystems that may result from the escape of native, non-native and/or genetically distinct farmed species.

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

7. **Preventing population-level impacts to wild species through the amplification and retransmission, or increased virulence of pathogens or parasites;**
   Aquaculture farms pose no substantial risk of deleterious effects to wild populations through the amplification and retransmission of pathogens or parasites, or the increased virulence of naturally occurring pathogens.
8. **Using eggs, larvae, or juvenile fish produced from farm-raised broodstocks thereby avoiding the need for wild capture;**
   Aquaculture farms use eggs, larvae, or juvenile fish produced from farm-raised broodstocks thereby avoiding the need for wild capture, or where farm-raised broodstocks are not yet available, ensure that the harvest of wild broodstock does not have population-level impacts on affected species. Wild-caught juveniles may be used from passive inflow, or natural settlement.
9. **Preventing population-level impacts to predators or other species of wildlife attracted to farm sites;**
   Aquaculture operations use non-lethal exclusion devices or deterrents, prevent accidental mortality of wildlife, and use lethal control only as a last resort, thereby ensuring any mortalities do not have population-level impacts on affected species.
10. **Avoiding the potential for the accidental introduction of secondary species or pathogens resulting from the shipment of animals;**
    Aquaculture farms avoid the international or trans-waterbody movements of live animals, or ensure that either the source or destination of movements is biosecure in order to avoid the introduction of unintended pathogens, parasites and invasive species to the natural environment.

Once a score and rating has been assigned to each criterion, an overall seafood recommendation is developed on additional evaluation guidelines. Criteria ratings 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.

Final Seafood Recommendations

Rainbow Trout (*Oncorhynchus mykiss*)
Colombia – Farmed
Raceway Production

Criterion	Score	Rank	Critical?
C1 Data	5.68	YELLOW	
C2 Effluent	3.00	RED	NO
C3 Habitat	6.13	YELLOW	NO
C4 Chemicals	3.00	RED	NO
C5 Feed	6.52	YELLOW	NO
C6 Escapes	7.00	GREEN	NO
C7 Disease	4.00	YELLOW	NO
C8X Source	0.00	GREEN	NO
C9X Wildlife mortalities	-2.00	GREEN	NO
C10X Secondary species escape	-1.00	GREEN	
Total	**32.34**		
Final score (0-10)	**4.62**		

OVERALL RANKING

Final Score	4.62
Initial rank	YELLOW
Red criteria	2
Interim rank	RED
Critical Criteria?	NO

FINAL RANK

RED

Scoring note – scores range from 0 to 10, where 0 indicates very poor performance and 10 indicates the aquaculture operations have no significant impact. Criteria 8X, 9X, and 10X are exceptional criteria, where 0 indicates no impact and a deduction of -10 reflects a very significant impact. Two or more Red criteria result in a Red final result.

Summary

The final numerical score for rainbow trout grown in raceways in Colombia is 4.62 out of 10, and with two red criteria (Criterion 2 - Effluent and Criterion 4 - Chemicals) the final recommendation is Red “Avoid”.

Rainbow Trout (*Oncorhynchus mykiss*)
Colombia – Farmed
Net Pen Production

Criterion	**Score**	**Rank**	**Critical?**
C1 Data	5.00	YELLOW	
C2 Effluent	2.00	RED	NO
C3 Habitat	5.47	YELLOW	NO
C4 Chemicals	2.00	RED	NO
C5 Feed	6.38	YELLOW	NO
C6 Escapes	5.00	YELLOW	NO
C7 Disease	4.00	YELLOW	NO
C8X Source	0.00	GREEN	NO
C9X Wildlife mortalities	-6.00	YELLOW	NO
C10X Secondary species escape	-1.00	GREEN	
Total	**22.85**		
Final score (0-10)	**3.26**		

OVERALL RANKING

Final Score	3.26
Initial rank	RED
Red criteria	2
Interim rank	RED
Critical Criteria?	NO

FINAL RANK
RED

Summary
The final numerical score for rainbow trout grown in net pens in Colombia is 3.26 out of 10, and with two red criteria (Criterion 2 -Effluent and Criterion 4 - Chemicals) the final recommendation is Red “Avoid”.

Executive Summary:

Note: where appropriate, sections of this report contain two separate scores for raceway and netpen operations, while other scores are shared. Two final scores and recommendations are presented for this report.

This Seafood Watch assessment involves criteria covering impacts associated with: effluent, habitats, wildlife and predator interactions, chemical use, feed production, escapes, introduction of non-native organisms (other than the farmed species), disease, the source stock, and general data availability.

The rainbow trout (*Oncorhynchus mykiss*) is a freshwater fish species native to the Pacific West coast of North America, from Kuskokwim River, Alaska, south to Baja California. The life history and characteristics of rainbow trout make them highly desirable for sportfishing and aquaculture activities, resulting in a longstanding history of introductions worldwide, including to Colombia in 1939. Trout production in Colombia totals 6,700 MT per annum in freshwater raceways and net pens, which accounts for approximately 7% of Colombia's aquaculture production. Trout exports from Colombia originate from five companies, four of which operate raceways and one of which uses net pens. The production systems assessed in this report represent only a segment of Colombia's trout farming industry, but 100% of products available to US consumers. Some rainbow trout have a marine component to their life cycle; these fish are known as "steelhead" or "steelhead trout." Although steelhead trout are farmed in many parts of the world, the farm sites assessed in this report are freshwater-only systems. Therefore, the ensuing recommendation covers only *O. mykiss* farmed in freshwater systems, known as rainbow trout.

Criterion 1 – Data Quality and Availability
As an important farmed species globally, a wealth of general science and published literature exists on rainbow trout, and on some of the impacts of raceway and net pen farming systems. However, various gaps exist in this body of data specific to Colombian production. The Colombian government, as well as the Food and Agriculture Organization of the United Nations (FAO), have both published several helpful reports on the status of Colombian aquaculture, as well as potential environmental impacts and strategies for mitigation. Colombian aquaculture experts, industry members, and the aquaculture industry organization (FEDEACUA) were contacted to obtain specific data on farm operations and feed companies, but substantial gaps remain. The availability of data for raceway operations is slightly higher than for net pens, primarily due to direct communication with two of the raceway farms. For these reasons, the final score for Criterion 1 – Data is 5.7 out of 10 for raceways, and 5 out of 10 for net pens.

Criterion 2 – Effluent
Data availability for both raceways and net pens regarding effluent monitoring and data collection is low, requiring use of the risk-based assessment. For raceways, the nitrogen waste

produced is calculated to be 67.9 kg N per ton of trout, based on an eFCR of 1.35 and 43% protein in feeds. For net pens, an eFCR of 1.5 and feed protein content of 43% result in a calculated 78.2 kg of waste N per ton of production. The overall waste discharge score (Factor 2.1) for raceways is 4 out of 10 and for net pens is 3 out of 10.

Regarding the industry's effluent management and regulation, the content of regulations (Factor 2.2a) for both systems receives a score of 2 out of 5 due to management measures that do not appear to set specific thresholds for aquaculture. The enforcement of those regulations (Factor 2.2b) scores 2 out of 5 for raceways due to little evidence of enforcement, and 2 out of 5 for net pens, due to limited data availability and evidence of potential contribution to eutrophication in Lake Tota. The overall management effectiveness scores (Factor 2.2) for raceways and net pens are both 1.6 out of 10. The final score for Criterion 2 – Effluent (combining Factors 2.1 and 2.2) for raceway operations in Colombia is 3 out of 10 and for net pen operations, is 2 out of 10.

Criterion 3 – Habitat

Colombia is a hydrologically rich country and contains many watershed areas with high biodiversity. In the case of raceways, there is evidence that many of the farms are sited appropriately outside of protected areas without incurring environmental degradation to the immediate surrounding environment. The net pen company that is exporting to the US is located in a lake that is considered to be high value conservation habitat and has been demonstrably eutrophic, though the role of net pen aquaculture in the continuation of the eutrophic status is not currently clear in comparison to other anthropogenic impacts. These factors result in a habitat conversion (Factor 3.1) score of 8 out of 10 for raceway and 7 out of 10 for net pen production. Government agencies recognize the need for protection of these areas; however, due to excess complexity and frequently changing responsibilities and regulations that are enacted very recently, there is a history of inefficiency in regulation and implementation as it relates to trout aquaculture in raceways and in net pens. This results in a management effectiveness score (Factor 3.2) of 2.4 out of 10 for both raceways and net pens. Combining the scores for both factors in Criterion 3 – Habitat results in a score of 6.1 out of 10 for raceways and 5.5 out of 10 for net pens.

Criterion 4 – Chemicals

Based on information from FEDEACUA and from two of the five exporting farms, the use of chemical treatments and prophylactics in Colombian trout production appears to be generally low, however several antibiotics listed as highly important to human medicine by the World Health Organization (WHO) are allowed by the Colombian government. Although data are only available from two of the four Colombian raceway operations exporting trout to the US, there is evidence of low chemical use in general, as well as reduction for potential effects on non-target organisms due to the use of settling ponds. However, due to a lack of chemical use data from the other farms, as well as the allowance and confirmed use of a highly important antimicrobial, Criterion 4 – Chemical Use scores 3 out of 10 for raceways. For net pen operations, there is also a lack of data for the use of chemicals; however, given the openness of the system, there is a greater risk of affecting non-target organisms if harmful chemicals are used. Combined with the allowance for use of a highly important antimicrobial and evidence of US FDA import rejections due to unspecified veterinary drug residues, this results in a Criterion 4 – Chemical Use score of 2 out of 10 for net pens.

Criterion 5 – Feed

Most feeds for rainbow trout farms in Colombia are produced by four feed companies, but specific data on the ingredients used and their sources are only available from two of them. Data on the efficiency of feed use on farms are also limited, but typical feed conversion ratios (FCR) of 1.35 for trout in raceways and 1.50 for net pens are used. Average fishmeal and fish oil inclusion levels in trout feeds are estimated to be 20.0% and 6.3% respectively. Information from two feed companies indicates 100% byproducts sourcing for fish oil, and an estimated 50% byproducts use for fish meal. This leads to a Forage Fish Efficiency Ratio (FFER) of 0.60 for raceways and 0.67 for net pens. From first principles, this means 0.60 or 0.67 MT of wild fish would need to be caught to supply the fishmeal used to grow one MT of farmed trout in Colombia. Information regarding the sustainability of the fishery sources of marine ingredients is very limited. The net protein loss for raceway and net pen production is calculated to be approximately 43% and 48% respectively, and the global area required to produce the ingredients needed for one MT of trout is 9.9 ha and 11.0 ha for raceways and net pens respectively. The numerical scores for Factors 5.1, 5.2 and 5.3 combine to give a final score for Criterion 5 – Feed of 6.5 out of 10 for raceways, and 6.4 out of 10 for net pens.

Criterion 6 – Escapes

Due to the use of multiple settling ponds and redundancy in containment screens, the risk of escapes from raceway systems in Colombia is considered low. In net pen farming systems, the single net barrier and exposure to the open environment increases the risk of escape and makes recapture difficult. In Colombia, 70 years of rainbow trout introductions for sport fishing mean it is already present in many of the freshwater streams, rivers, and lakes in which aquaculture activities take place. The species was been classified in Colombia as "introduced and invasive" in 2008, but in 2015 it was reclassified as "domesticated." Studies in other regions indicate the species exerts competitive and predatory pressure on native species; however, several studies within Colombia indicate that the previously stocked rainbow trout stocks dwindled after the stocking ceased in 2008. This indicates that rainbow trout may not be as strong a concern for competitive and genetic interactions in Colombian waterways. Nevertheless, given the established nature of trout prior to aquaculture in Colombia, the impact of further escapes from farms is uncertain. Overall, the risk of escape and the risk of impact combine to give final scores for Criterion 6 – Escapes of 7 out of 10 and 5 out of 10 for raceways and net pens respectively.

Criterion 7 – Disease; Pathogen and Parasite Interactions

Currently, there is minimal disease reporting in Colombia, but though many common trout diseases are not generally considered to be present (likely due to import restrictions on ova suppliers), *Flavobacterium* is a common bacterial disease that appears at hatcheries in

Colombia and is a concern for wild fish. Two farms exporting trout to the US shared their biosecurity plans for the purposes of this assessment, but raceways and net pens are open systems that have an inherent risk of disease transmission and amplification. With limited data availability, the risk-based assessment was used for both raceways and net pens, and the final numerical score for Criterion 7 – Disease is 4 out of 10 for both systems.

Criterion 8X – Source of Stock

The large Colombian farms exporting trout to the US use imported juveniles and ova from domesticated broodstock in US trout hatcheries. Therefore, both net pens and raceways in Colombia are independent from wild broodstock or seed. The final score for Criterion 8X-Source of Stock is a deduction of 0 out of –10.

Criterion 9X – Wildlife and Predator Mortalities

Trout raceways in Colombia use full enclosures to exclude wildlife and reduce interactions, and wildlife mortality is considered limited to exceptional circumstances. Net pens are sited in Lake Tota, which is home to two populations of endangered bird species; however, the extent of measures taken to prevent wildlife interactions is uncertain (for example top nets do not appear to be used), as is the extent to which these and other birds interact with the farm. Regulations in Colombia regarding interactions with wildlife at aquaculture facilities are minimal, and there is no clear enforcement. Overall, the final score for Criterion 9X- Predator and Wildlife Mortalities is a deduction of –2 out of –10 for raceways and –6 out of 10 for net pens in Lake Tota.

Criterion 10X – Escape of Unintentionally Introduced Species

The Colombian farms exporting rainbow trout to the US are entirely dependent on the import of live trout in the form of eggs and juveniles from the US. The shipments originate from a highly biosecure hatchery, with little chance of unintentionally transferring live animals or pathogens due to multiple disease-free certifications and licensing requirements for import into Colombia. The destinations of the shipments (i.e., raceways and net pen farms in Colombia) are more open, therefore the biosecurity score is based on the more secure source. Overall, despite the dependence on shipments, the high biosecurity means there is only a minor deduction of –1 out of –10 for Criterion 10X – Escape of secondary species for both raceways and net pens.

Introduction:

Scope of the analysis and ensuing recommendation

Species: Rainbow trout (*Oncorhynchus mykiss)*
Geographic coverage: Colombia
Production Methods: Freshwater raceways and net pens

Species Overview:

Brief Overview of the Species

The rainbow trout (*Oncorhynchus mykiss*, previously called *Salmo gairdneri)* is a freshwater fish species historically native to the Pacific west coast of North America, from Kuskokwim River, Alaska, south to Baja California (Behnke 2010; USGS 2013). They typically inhabit cold-water lakes, rivers, and streams between 9 to 17°C (48 to 62°F), feeding opportunistically upon insects, eggs, aquatic crustaceans and fish (Crawford and Muir 2008) **(**Behnke 2010). Rainbow trout are a member of the family Salmonidae, which includes Pacific salmon, trout of the genus Oncorhynchus, Atlantic salmon, brown trout, char, whitefishes and grayling (ITIS 2016). The name *rainbow trout* refers to between three and seven distinct evolutionary subspecies (contested among taxonomists), including: anadromous steelhead trout, golden trout, several subspecies of redband trout, and populations native to the Gulf of California (Behnke 2010). They are silver in color, often with dark speckles and a pink to deep-red band along their lateral line (Murillo 2012).

The life history and characteristics of rainbow trout make them highly desirable for sportfishing and aquaculture activities. They are fast growing, predatory, and produce large eggs that can be readily collected and manipulated (FAO 2016). As a result, the species has a longstanding history of human-mediated biological invasions, making rainbow trout perhaps the most geographically widespread and best studied of the salmonid species worldwide (Crawford and Muir 2008). Endemic populations now persist on every continent except Antarctica (López-Macías et al. 2007).

Salmonids are not native to Colombia. The rainbow trout, known locally as *trucha arco iris,* was first introduced to the county's Andean streams, rivers and lakes in 1939, primarily to populate the region's watersheds with a species of higher economic value than native species (Esquivel et al. 2014) (Cruz-Casallas 2011) (CONPES 2014). These intentional introductions and regular stocking for sportfishing resulted in established trout populations throughout nearly all the country's high-elevation lakes, rivers, and tributaries (Alvis 2006) (Cruz-Casallas 2011) (Mora et al. 1992) (Pascual et al. 2007). The restocking programs in Colombia were terminated after 2008 (Merino et al. 2013).

Some rainbow trout have a migratory marine component to their life cycle; these fish are known as *steelhead* or *steelhead trout* and may be farmed in marine environments. Although steelhead trout are farmed in many parts of the world, the farm sites assessed in this report are freshwater-only systems. Therefore, the ensuing recommendation covers only *O. mykiss* farmed in freshwater systems, known as rainbow trout.

Production Systems

In Colombia, rainbow trout are farmed for both domestic and export markets. All trout farms in Colombia use either raceways or lake-based net pens and those producing for the export market have a larger production scale than many for the domestic market (MADR 2010).

All of Colombia's rainbow trout farming activities take place at high elevation—between 6,200 and 10,500 ft above sea level—to meet the biological requirements (primarily water temperature and dissolved oxygen) of the species (Alvis 2006) (MADR 2010) (Merino et al. 2013). Trout production for export is located in four departments: Antioquia, Boyacá, Cauca, Cundinamarca, and Risaralda (Figure 1).

Figure 1. Colombian departments that support export trout production: Antioquia, Boyacá, Cauca, Cundinamarca, Risaralda

Typical raceways measure 1m x 10m x 1m, arranged in parallel fashion. Production cycles last between 9 and 12 months, depending on harvest size, with final feed conversion ratios of 1.3 to 1.5: 1 and 6% mortality (Merino et al. 2013).

Net pen farming is a more recent development in Colombia, and production for export occurs in Lake Tota in the department of Boyacá, with the processing operations located in the adjacent Cundinamarca. There is production in one other high-altitude lake (Lake Guamués in

Nariño); however, these fish are not currently being exported to the US. Net pen farms are sited near to shore and use floating metal or wooden collars, which provide an attachment point and support system for nets, as well as walkways for maintenance and husbandry activities. Individual cages typically measure 5m x 5m x 2.5m deep, stocking small trout (alevins) of 5 g and harvesting at 250 to 300 g in 7 months. Reported feed conversion ratios and mortality through the production cycle range from 1.2 to 1.5: 1 and up to 12%, respectively (Merino et al. 2013).

Production Statistics

As a region, Latin America makes a relatively small contribution to aquaculture production at the global scale. The totality of aquaculture production of all species from the region was 1.9 million metric tonnes (MT) in 2010, or 3.2% of the 60 million MT of global aquaculture production (Merino et al. 2013) (Bostock et al. 2010). Of this, Colombia specifically contributed ~83,000 MT—only 4.3% of the region's aquaculture production. For trout production in Latin America, specifically, Colombia has remained a steady producer in the region (Figure 1), leading production volumes in the early 2000s and now currently surpassed only by Peru and Mexico for freshwater production (FishStatJ 2018).

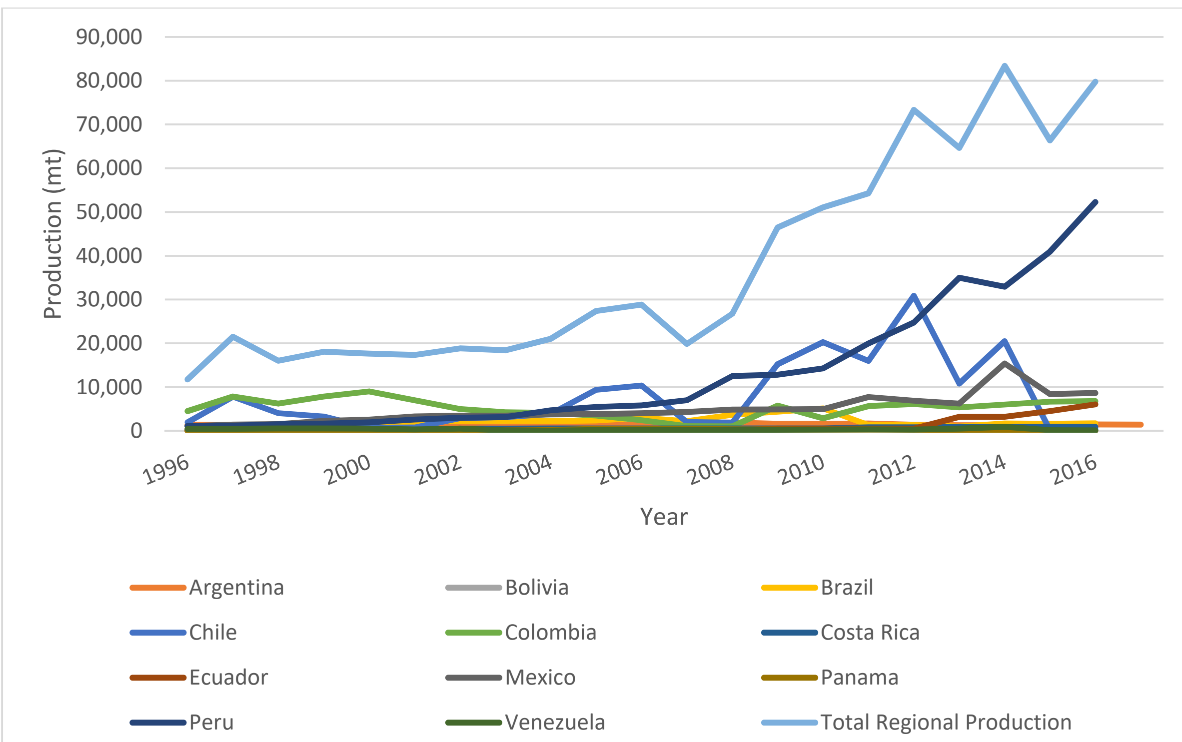

Figure 2. Rainbow trout production in Latin America by country. Note: steelhead trout produced in marine net pens in Chile is excluded from this figure. Source: (FishStatJ 2018)

Annual Colombian production of rainbow trout has increased at approximately 20% per year over the last 30 years, from 300 MT in 1985 to 6,700 MT in 2016 (Cruz-Casallas et al. 2011) (Sanabria 2012) (FishstatJ 2018); however, between 2000 and 2010, growth and the overall production of the industry were highly variable, primarily due to national civil conflict and issues with domestic price stability (MADR 2010b) (Cruz-Casallas et al. 2011). Five commercial-sized trout farms currently operate for export to the US, primarily in the departments of Antioquia, Boyacá, Cauca, Cundinamarca, and Risaralda (Merino et al. 2013) (Sanabria 2012) (pers. comm., FAO NASO; FEDEACUA 2017). Of the five companies, one uses net pens and four use raceways (outlined in Table 1). Trout accounts for nearly 7% of the aquaculture production in Colombia (other species include tilapia and cachama) (AUNAP 2013).

Table 1. Colombian trout facilities exporting to the United States

Facility Name	Location	System
Trout Co SAS	Cundinamarca, Boyacá, Colombia	Net pens in Lago de Tota.
Pescados Frescos de Colombia	Risaralda, Colombia (Caldas)	Raceways
Truchas Belmira SAS	Antioquia, Colombia	Raceways
Piscifactoría El Diviso	Cauca, Colombia	Raceways
Piscicola de Occidente	Antioquia, Colombia	Raceways

Import and Export Sources Statistics

Approximately half of Colombian trout production is exported (AUNAP 2014B) (Guerrero et al. 2015). US Rainbow trout imports (from all sources) have increased considerably in the last decade; in 2014, 9,562 MT of fresh and frozen rainbow trout, valued at USD 95 million was imported, 90% of which came from Chile, Canada, and Argentina (NOAA 2018). Prior to 2012, Colombian trout products accounted for roughly 2 to 4% of total trout imported to the US; varying between 150 to 300 MT per year (NOAA 2018), but with the enactment of the Trade Promotion Agreement (TPA) between the United States and Colombia in May of 2012 (which removed tariffs and duties that previously hindered trade between the nations), trout imports from Colombia have remained steady at roughly 700 to 800 MT per year, representing 6 to 8% of total trout imports to the US (International Trade Administration, NOAA 2018).

Also worth noting is the trade in trout eggs between the US and Colombia. In 2013, Colombia imported 82 M eyed-ova from the US, valued of USD 4.2 M (Esquivel et al. 2014) (see Criterion 10X).

Common and Market Names

Scientific Name	*Oncorhynchus mykiss*
Common Name	Rainbow trout

Rainbow trout are commonly sold as *steelhead* or *steelhead trout*, but as described above, this report's recommendation covers only freshwater-grown rainbow trout

Product Forms: whole fresh, fileted, butterflied and smoked (Merino et al. 2013).

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: having robust and up-to-date information on production practices and their impacts available for analysis.

Criterion 1 Summary – Raceways

Data Category	Data Quality	Score (0-10)
Industry or production statistics	7.5	7.5
Management	5	5
Effluent	5	5
Habitat	5	5
Chemical use	5	5
Feed	5	5
Escapes	5	5
Disease	2.5	2.5
Source of stock	10	10
Predators and wildlife	5	5
Introduced species	7.5	7.5
Other – (e.g. GHG emissions)	Not Applicable	n/a
Total		**62.5**

C1 Data Final Score (0-10)	**5.7**	**YELLOW**

Criterion 1 Summary – Net pens

Data Category	Data Quality	Score (0-10)
Industry or production statistics	7.5	7.5
Management	5	5
Effluent	5	5
Habitat	5	5
Chemical use	2.5	2.5
Feed	5	5
Escapes	2.5	2.5
Disease	2.5	2.5

Source of stock	10	10
Predators and wildlife	5	5
Introduced species	5	5
Other – (e.g. GHG emissions)	Not Applicable	n/a
Total		**55**

C1 Data Final Score (0-10)	**5**	**YELLOW**

Brief Summary:
As an important farmed species globally, a wealth of general science and published literature exists on rainbow trout, and on some of the impacts of raceway and net pen farming systems. However, various gaps exist in this body of data specific to Colombian production. The Colombian government, as well as the FAO have both published several helpful reports on the status of Colombian aquaculture, as well as potential environmental impacts and strategies for mitigation. Colombian aquaculture experts, industry members, and the aquaculture industry organization (FEDEACUA) were contacted to obtain specific data on farm operations and feed companies, but substantial gaps remain. The availability of data for raceway operations is slightly higher than for net pens, primarily due to direct communication with two of the raceway farms. For these reasons, the final score for Criterion 1 – Data is 5.7 out of 10 for raceways, and 5 out of 10 for net pens.

Justification of Ranking:

Industry Production Statistics
A wealth of data is available from the industry regarding production statistics for exported trout to the US. Colombian government entities, such as the National Authority for Aquaculture and Fisheries (Autoridad Nacional de Acuicultura Y Pesca; AUNAP[2]), as well as the aquaculture industry association (Federación Colombiana De Acuicultores Fedeacua; FEDEACUA[3]) have various publications available outlining the state of aquaculture in Colombia, as well as the challenges the industry needs to address. The information is restricted to the larger, exporting farms (which are the focus of this assessment), but numerous farms supply trout domestically that are not represented well in the data. This limits our understanding of the industry in Colombia as a whole, and the score for Industry or Production statistics is 7.5 out of 10 for both raceways and net pens.

Management and Regulations
The applicable laws in Colombia are readily available online via the federal government, and FEDEACUA has provided a comprehensive list on their website; however, they are quite complex when it comes to finding specific aspects applicable to aquaculture. The Colombian

[2] http://www.aunap.gov.co/
[3] http://www.fedeacua.org/

government and FEDACUA are both working to improve the quality of management regarding regulation surrounding aquaculture and its impacts, but many of these new regulations have yet to be implemented. At the farm-level, one company (El Diviso) is able to supply standard operating procedures (SOPs) and internal policies, and another company (Pisciola de Occidente) is able to provide a biosecurity protocol, but similar information is not available from any other farms. Regarding government monitoring or enforcement, there is no publicly available database for records of compliance (e.g., water quality monitoring). Furthermore, there is variable data availability from each department, which reduces the possibility of a comprehensive dataset. The data availability and quality for Management and Regulations scored 5 out of 10 for both raceways and net pens.

Effluent

SOPS and some raw water quality data from previous internal monitoring reports are available from one of the four raceway farms, as well as a recent inspection report (performed by NSF Food Safety Certification) for compliance with the Best Aquaculture Practices (BAP) standard from the same farm. Information about raw water quality from two annual effluent samplings, as well as clarification on the applicability of the various laws was available from another of the raceway farms. Detailed, farm-level information is not available for the other two raceway farms, nor for the net pen farm. A 2017 study investigating the waste loads input into Lake Tota specifically from the trout companies operating there provides and corroborates information about current and projected nitrogen loads associated with net pen production. Scoring for the availability of government regulation and implementation data is captured in the data score for Management and Regulations above. The Effluent criterion scores 5 out of 10 for data availability for both raceways and net pens.

Habitat

Information for habitat impacts in Colombian waterways is available from several peer-reviewed sources published between 2011 and 2017, as well as several publications from Colombian federal government agencies and regional government agencies published between 2013 and 2014. The World Wetland Network (WWN; a UK-based NGO) provides an overview of the environmental degradation visible at Lake Tota, attributing it partially to aquaculture; information on regulations within the industry as well as the federal regulations are available from FEDEACUA. A 2017 study investigating the waste loads input into Lake Tota specifically from the trout companies operating there provides and corroborates information regarding the current and projected nitrogen loads associated with net pen production. Habitat impacts for one of the raceway farms is available from communication with the farm, as well as news articles and audit reports, although this type of data is not available for any of the other exporting farms. Peer-reviewed research is available for several studies evaluating the ecological status of Lake Tota, where net pen aquaculture is practiced for export; however, there is a paucity of similar peer-reviewed literature for habitats surrounding raceway farms in Colombia. The data score for Habitat is 5 out of 10 for both raceways and net pens.

Chemical Use

Information is available for one of the raceway farms indicating that chemicals beyond hydrogen peroxide and sodium hypochlorite are not used. Information from another raceway farm confirms the use of only salt and controlled use of an antibiotic classified as "highly important" for human health; however, the volume of use is unknown. Information regarding chemical use for all other farms could not be obtained despite multiple requests, nor is it available online through their websites. The Colombian government does have several laws pertaining to antibiotic and other chemical use in aquaculture facilities, though information on enforcement is low, and currently there is no publicly accessible listing of reported chemical use. A comprehensive FAO report specific to Colombian aquaculture production practices, including chemical use, is available; however, it was published in 2007 and thus may not be fully representative of the current situation. US FDA import refusals were utilized in relation to imports for Colombian trout produced in net pens. Data availability relating to the Chemical Use criterion receives a "moderate" score of 5 out of 10 for raceways and a "moderate" 2.5 out of 10 for net pens.

Feed

Feed composition information used in this report includes specific data from two of the main Colombian feed manufacturers. Reported economic feed conversion ratio (eFCR) values from 2016 were obtained from one farm and from several peer-reviewed articles from 2007 to 2013. In addition, information from the FAO in 2009 and from several Colombian government reports from 2011 and 2014 also contributed to the estimate for average eFCR. For feed ingredient sourcing, the specific feed ingredients and proportions are not available; therefore, information from feed bags used at two of the raceway farms, some information directly from the feed companies, as well as broad studies regarding typical feed ingredients for rainbow trout and for Latin America are used. Typical processing ratios for the Colombian rainbow trout industry are available from a government agency. Feed data relating to both net pens and raceways scores 5 out of 10.

Escapes

The Colombian government does not collect information regarding escapes from farms, even though rainbow trout were until recently officially considered an exotic species. Information about typical safeguards used in raceways to mitigate escapes is available from one of the raceway farms, as well as from an audit report and several peer-reviewed publications. One 2011 publication from MADR, as well as personal communication are used to inform escape mitigation for net pens in Colombia. Data regarding the history of rainbow trout introductions in Colombia and the potential for their competitive and genetic interactions with wild populations are available from the IUCN, several government publications, and peer reviewed literature published between 2008 and 2018. Data relating to the Escapes criterion scores 5 out of 10 for raceways and 2.5 out of 10 for net pens.

Disease

For information surrounding common diseases in Colombian trout aquaculture, communications with industry members, a recent aquaculture improvement plan published by a government agency, and several peer-reviewed articles published between 2009 and 2018 informs the scoring. Official disease occurrence and transmission information is not readily available from the Colombian government. Due to the restrictions on importing eggs and juveniles for rainbow trout farms, there is only one potential external source for disease introduction (Troutlodge in the US) which has publicly available information regarding their biosecurity. Data availability relating to the Disease criterion scores 2.5 out of 10 for both raceways and net pens.

Source of Stock

All commercial trout farms in Colombia are sourcing eggs or juveniles from Troutlodge, which has a multi-decadal breeding program, ensuring independence from wild stocks. The data score for Source of Stock is 10 out of 10 for both raceways and net pens.

Predators and Wildlife

Personal communication with industry members, as well as auditing reports and peer reviewed publications inform the scoring for this criterion. Industry-level good management practices publications are also available; however, the effectiveness of their implementation is not yet clear due to their recent publication. Information about endangered species in the vicinity of farms is available from the IUCN red list. Data availability for the Predators and Wildlife exceptional criterion scores 5 out of 10 for both raceways and net pens.

Introduced Species

Biosecurity protocols are only available from two of the four raceway farms and are not available from the net pen farm. The primary source of the live trout movements into Colombia is known to be one hatchery in the US; their biosecurity protocols are known and verified with several "disease-free" certifications. Environmental license requirements published in a 2015 resolution from the Colombian government also contribute to the scoring for Criterion 10X. The data score for Introduced Species data is 7.5 out of 10 for raceways and 5 out of 10 for net pens.

Conclusions and Final score

The Colombian government, as well as the FAO have both published several helpful reports on the status of Colombian aquaculture, as well as potential environmental impacts and strategies for mitigation. Aquaculture experts and industry members in Colombia were consulted directly for information, as well as some contact with farm representatives and a Colombian Aquaculture industry organization (FEDEACUA) to obtain specific data on farm operations; however, substantial gaps in multiple criteria remain. The availability of data for raceway operations was slightly higher, primarily due to direct communication with two of the farms operating this type of system. For these reasons, the final scores for Criterion 1 – Data are 5.7 out of 10 for raceways and 5 out of 10 for net pens.

Criterion 2: Effluent

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: not allowing effluent discharges to exceed, or contribute to exceeding, the carrying capacity of receiving waters at the local or regional level.

Criterion 2 Summary

Effluent Risk-Based Assessment- Raceways

Effluent parameters		**Value**	**Score**
F2.1a Waste (nitrogen) production per of fish (kg N ton-1)		67.9	
F2.1b Waste discharged from farm (%)		80	
F2 .1 Waste discharge score (0-10)			4
F2.2a Content of regulations (0-5)		2	
F2.2b Enforcement of regulations (0-5)		2	
F2.2 Regulatory or management effectiveness score (0-10)			1.6
C2 Effluent Final Score (0-10)			3.0
	Critical?	NO	**RED**

Effluent Risk-Based Assessment- Net pens

Effluent parameters		**Value**	**Score**
F2.1a Waste (nitrogen) production per of fish (kg N ton-1)		78.2	
F2.1b Waste discharged from farm (%)		80	
F2 .1 Waste discharge score (0-10)			3
F2.2a Content of regulations (0-5)		2	
F2.2b Enforcement of regulations (0-5)		2	
F2.2 Regulatory or management effectiveness score (0-10)			1.6
C2 Effluent Final Score (0-10)			2.0
	Critical?	NO	**RED**

Brief Summary

Data availability for both raceways and net pens regarding effluent monitoring and data collection is low, requiring use of the risk-based assessment. For raceways, the nitrogen waste produced is calculated to be 67.9 kg N per ton of trout, based on an eFCR of 1.35 and 43%

protein in feeds. For net pens, an eFCR of 1.5 and feed protein content of 43% result in a calculated 78.2 kg of waste N per ton of production. The overall Waste Discharge score (Factor 2.1) for raceways is 4 out of 10 and for net pens is 3 out of 10.

Regarding the industry's effluent management and regulation, the content of regulations (Factor 2.2a) for both systems receives a score of 2 out of 5 due to management measures that do not appear to set specific thresholds for aquaculture. The enforcement of those regulations (Factor 2.2b) scores 2 out of 5 for raceways due to little evidence of enforcement, and 2 out of 5 for net pens, due to limited data availability and evidence of potential contribution to eutrophication in Lake Tota. The overall management effectiveness scores (Factor 2.2) for raceways and net pens are both 1.6 out of 10. The final score for Criterion 2 – Effluent (combining Factors 2.1 and 2.2) for raceway operations in Colombia is 3 out of 10 and for net pen operations, is 2 out of 10.

Justification of Ranking – Risk-Based Assessment

Since effluent data quality and availability is moderate/low for both raceways and net pens (i.e., a Criterion 1 score of 5 out of 10 in the effluent category), the Seafood Watch risk-based assessment was used. This method involves assessing the amount of waste produced by the fish and then the amount of that waste that is discharged from the farm. The effectiveness of the regulatory system in managing wastes from multiple farms is used to assess the potential cumulative impacts from the industry as a whole.

Factor 2.1 Waste discharged per ton of fish production

Factor 2.1a: Biological waste production per MT of fish

Raceways

Effluents from an aquaculture operation may contain various sources of nitrogen and phosphorus, known to be typical limiting nutrients in aquatic ecosystems. These are typically due to uneaten feeds or feces and metabolic wastes that may compromise the chemical parameters of a water body (Mugg et al. 2007). In a flow-through system, typically large volumes of very dilute waste are carried downstream unless they are removed prior to entering the water supply (Cho and Bureau 2001) (Tello et al. 2010). Flow-through systems may use settling ponds to collect and store wastes until they can be disposed of properly, and this is confirmed for one of the four trout-exporters utilizing raceways (El Diviso), which employs settling basins for the dual purposes of removing settleable solids and helping to prevent escapes (pers. comm., A. Dueñas November 2016, July 2018). Other techniques like grading fish several times over a production cycle help to maintain optimum feeding efficiency to minimize waste (Fornshell and Hinshaw 2008). Overall, the prevalence of such practices in Colombian trout farms is difficult to ascertain.

The amount of waste produced by trout is estimated through the nitrogen (N) balance between inputs and outputs. In order to calculate this, the economic feed conversion ratio (eFCR) is used in conjunction with the reported protein content of the feed and the protein content of the harvested whole fish.

The range of eFCRs encountered in data pertaining to commercial raceway production in Colombia (and in similar systems globally) was 1.3 to 1.5, with 1.35 being the most commonly reported figure (Lopez-Macias et al. 2007) (Tacon and Metian 2008) (Murillo-Garcia 2009) (FAO 2009) (Bostock et al. 2010) (Tacon et al. 2011) (Merino et al. 2013) (AUNAP 2014B) (pers. comm., D. Avella May 2017). According to El Diviso's records, the farm has calculated an average eFCR of 1.28 between 2013 and 2016, ranging from 1.2 to 1.34 in that timeframe (pers. comm., A. Dueñas October 2016). Therefore, for the purposes of these calculations, an eFCR of 1.35 is used for raceways due to both the precautionary principle and to agreement among multiple data sources, including one of the feed companies.

Based on a dataset comprised of government reports, commercial feed websites, consultations with one of the farms and industry experts, as well as published literature, it is determined that feeds used in commercial trout farming in Colombia average 43% protein through the production cycle (Murillo-Garcia 2009) (Murillo 2012) (Castañeda-Valencia and Ochoa 2013) (Merino et al. 2013) (pers. comm., A. Dueñas June 2018; Solla.com, Contegral.co) (pers. comm., A. R. Quiceno August 2018). This value aligns with commercial trout formulations documented in Chile, the UK and the US, which range from 36 to 50% protein, averaging 45% (Bostock et al., 2010) (pers. comm., M. Garcia April 2015) (McGrath 2015).

Nitrogen inputs are calculated by multiplying the eFCR, the protein level in growout feeds, and the proportion of nitrogen in proteins (16%; Boyd et al. 2007). This results in a nitrogen input of 92.9 kg N per ton of trout products. Nitrogen outputs are represented by the amount in harvested trout tissues, and this value is estimated through the multiplication of the amount of protein in the harvested fish (15.6%; Boyd et al. 2007) and the proportion of nitrogen in protein (16%) resulting in a nitrogen output of 25.0 kg N per MT of harvested fish. The balance between inputs and outputs results in 67.9 kg of waste N produced per ton of trout.

Net pens

For commercial net pen production, Merino et al (2013) report that the average eFCR can range from 1.2 to 1.5. For this report, the high end of the range (1.5) was used, since there is evidence that commercial net pens in Colombia do not use established best management practices for the feed management and efficiency of these systems, such as periodic grading and feeding strategies to reduce waste (Castañeda-Valencia and Ochoa 2013). Utilizing the same feed protein content as raceways (43%), this results in a nitrogen input of 103.2 kg N per MT of trout products. N outputs in harvested fish are calculated as 25.0 kg N per MT, and the balance between inputs and outputs results in 78.2 kg of waste N produced per mt of trout.

Factor 2.1b: Production system discharge

Raceways

In raceway systems with flow rates similar to those used in Colombia (i.e., 1L/min/kg trout), d'Orbcastel et al., (2009) considered stocking densities up to 60kg/m^3 to be optimal for freshwater trout. Both raceway and net pen culture operations in Colombia maintain a lower stocking density of 35 to 40 kg/m^3 (Merino et al. 2013). The raceway systems typically include settling ponds for waste water prior to discharge into local waterways (Lopez-Macías et al. 2007). According to inspection reports and personal communication with El Diviso and Piscicola Occidente (two of the four raceway farms in Colombia), the effluent passes through several holding tanks and drying tanks prior to discharging to the nearby streams (Varadhan, 2016) (pers. comm., A. Dueñas November 2016) (pers. comm., A. R. Quiceno October 2018). This lowered intensity and the use of settling ponds help mitigate effluents from raceway operations in Colombia (CCIC 2005, pers. comm., A. Dueñas November 2016).

For the purposes of the production system discharge calculation, a score of 0.8 is the assumed baseline score for flow-through raceways with solids collection and appropriate disposal of solid wastes, according to the Seafood Watch Standard (that is, 80% of the wastes produced by the fish are considered to be discharged from the farm). There are no further adjustments made to the baseline score. This results in a value of 54.3 kg of nitrogen released per ton of fish and a score of 4 out of 10 for Factor 2.1.

Net pens

There is a lack of scientific study regarding the carrying capacities of Lake Tota, a high-altitude Andean lake that is being used for intensive trout netpen culture. Currently the lake has ten trout net pen farms in operation, with one of them producing for export (Torres-Barrera and Grandas-Rincon 2017). There have been reports of mass mortality events and water quality incidents (pers. comm., M. Mendoza June 2015), though the severity and permanence of losses to habitat function in the lakes are yet to be quantified. One recent study calculates the total amount of waste discharged by netpens in Lake Tota since 2005 and uses this to estimate/project waste loads from 2016 onward to 2020 (Torres-Barrera and Grandas-Rincon 2017). This study implicates the ten trout net pen farms, as a whole, in introducing enough nitrogenous waste over the course of the last >10 years contributing to eutrophication in Lake Tota. It also indicates that the carrying capacity of Lake Tota is unknown and more information is needed. Several studies regarding the planktonic ecosystem of the lake have been performed, but they are outdated or are not extrapolated to anthropogenic inputs (Munoz-Lopez et al 2017) (Rangel and Aguirre 1986) (Pedroz-Ramos et al. 2016) (Vollenweider 1983). Additionally, several other studies indicate that eutrophication is, in fact, visible in Lake Tota and the surrounding watershed; however, these do not separate the direct impact of net pen aquaculture away from other anthropogenic sources, like the green onion industry that is thriving in the surrounding hills (Botero Aguirre 2006) (CONPES 2014) (Munoz-Lopez et al. 2017) (Noriega et al 2010) (Perez-Holguín et al. 2016). This has also been the case with the other lake in Colombia supporting trout cage culture, as well as in other Andean lakes located in Peru, though companies operating in these lakes are not currently exporting to the US (Salas Benavidas et al 2014) (Torres-Barrera and Grandas-Rincon 2017).

Net pens lack safeguards for preventing wastes from entering the environment, since they are open systems with no barrier between farm operations and the outside environment. For the purposes of this calculation, a score of 0.8 is the assumed baseline score for net pens according to the Seafood Watch Standard (that is, 80% of the waste produced by the trout are considered to leave the immediate farm area). There is no indication that the net pen systems employed for trout culture in Colombia utilize modifications to reduce effluent impacts, thus there are no adjustments made to the baseline score. This results in a value of 62.6 kg of nitrogen released per ton of fish and a score of 3 out of 10 for Factor 2.1.

Combining Factors 2.1a and 2.1b gives a score for Factor 2.1 of 4 of 10 for raceways and 3 out of 10 for net pens.

Factor 2.2 Management of farm-level and cumulative impacts

Factor 2.2a: Content of effluent management measures
Many Colombian environmental laws apply to aquaculture facilities, but they do not appear to have been written specifically with aquaculture facilities in mind; thus, the aquaculture regulations are often incorporated into fishery or broader natural resource legislation (FAO NALO). FEDEACUA lists those laws that are applicable to aquaculture on its website; a selection of which can be found in Table 2. The primary legal authority governing the agroindustrial sector, including aquaculture, is the Ministry of Agriculture and Rural Development (MADR), which contains the Subdepartment for Fisheries and Aquaculture. Each region has an environmental authority (Corporación Autónoma Regional, or CAR), which sets the specific requirements for water permits, often including preventive measures to minimize solid and liquid waste discharge, as well as escape prevention (Coze and Flores Nava 2009). The regions currently supporting raceway trout culture are Antioquia, Cauca, and Risaralda. Net pen culture for export is currently operated in Lake Tota, located in the Boyacá department (FEDEACUA 2015).

Under the current governmental management system, environmental licenses are required for any new construction. Regional water controls do not contain set limits; however, the water use taxes depend on the kg of pollutant load measured in the farm's effluent (CRC 2017). The current federal management requirements do not incorporate cumulative impacts specific to aquaculture, nor do they set limits for effluent measurements required. Furthermore, historically there has been a complex system of environmental regulations, leading to confusion and difficulty in implementation (Hernandez-Rodriguez 2001) (OECD 2016).

An example of this lack of specificity is RESOLUCIÓN 631 DE 2015, which indicates detailed limits for physicochemical parameters of effluent water from various industrial and agroindustrial processes. Aquaculture is considered an agroindustrial process for this law, yet there is no specific mention of aquaculture anywhere within it. The only limits listed for several agroindustrial and livestock industries apply to poultry, ovine, swine, bovine, and other land-based livestock production (MADS 2015). Setting of effluent limits are delegated to the regional corporations, but it is unclear where these limits are indicated within the regional laws (Coze and Flores Nava 2009). Furthermore, these limits may vary between regions depending on the determination of the autonomous corporations.

Table 2: Selected laws applicable to aquaculture in Colombia

Name of regulation	General topic
DECRETO 2811 DE 1974	National Code of Renewable Natural Resources and Protection of the Environment
LEY 373 DE 1997	Water use and efficiency
DECRETO 155 DE 2004 DECRETO 3930 DE 2010	Allowable rates for water use, proper disposition of contaminated water
RESOLUCIÓN 631 DE 2015	Public water systems, surface water
RESOLUCIÓN 1207 DE 2014	Regulating the use of treated wastewater

Source: http://www.fedeacua.org/normativa/.

The government is aware of several shortcomings of the current environmental regulations and in 2015 AUNAP, in conjunction with FEDEACUA and several regional departments, published a plan outlining the strengths and challenges for Colombian aquaculture. From that plan, one identified strategy to improve standard practices is to develop a system of good aquaculture practices (GAP) that would apply to the Colombian aquaculture sector. FEDEACUA has been working to develop these; as of December 2016, a draft is now available (FEDEACUA 2016c). Much of the focus is on effluent impacts, including stocking at adequate densities, using biodegradable products, filtering and treating effluent water, and recirculating to reduce water usage (FEDEACUA 2016c). The guidelines do not include specific targets (e.g., suggestions to avoid stocking above a set density level) and their application is currently unclear.

Two of the Colombian farms that are producing trout for export to the US are currently certified at the farm level according to the Global Aquaculture Alliance Best Aquaculture Practices (GAA BAP), which require regular monitoring and reporting for several water quality parameters, including BOD, total phosphorus, total nitrogen, DO and TSS, but do not set limits specific to the farm site. Of the two certified Colombian exporting trout farms (El Diviso and TroutCo), specific reports are only available for El Diviso (raceways) regarding effluent discharge and monitoring for government requirements and BAP compliance. Reports for the farm operation at TroutCo (net pens) are not available publicly.

There is currently a lack of regulation in Colombia to address effluents specific to net pens. In order to begin producing fish in Lake Tota (or any other system), AUNAP and the relevant regional corporation (in this case, Corporación Autónoma Regional de Boyacá [CAR]) mandate a registration process that involves the procurement of an environmental license, which serves as a prerequisite to exercise rights granted by other permits, concessions, contracts or licenses issued by authorities other than the relevant regional corporation (CONPES 2014).

Given the lack of specific effluent limits for aquaculture, the regional variation in allowable effluents, and the lack of clarity in the federal laws applicability to aquaculture, the score for Factor 2.2a is 2 out of 5.

<u>Factor 2.2b: Enforcement of effluent management measures</u>

Raceways

Without official enforcement data available in Colombia, the enforcement of effluent measures is estimated via the only information available, which is from a GAA BAP report from one out of the four raceway farms. Reports available for El Diviso indicate that the farm has remained compliant with both government and GAA BAP requirements for at least the last three years. Based on biosecurity management SOPs from El Diviso, as well, there is evidence of water filtration prior to its release back into the river it was originally drawn from (Rio de las Piedras) (pers. comm., A. Dueñas November 2016) (Varadhan 2016). Pezco has also supplied information indicating the use of a settling pond, though it is unclear whether this is mandated. The records supplied also indicate recent compliance with the relevant regional corporation's effluent discharge limits (pers. comm., A. R. Quiceno October 2018). Enforcement data for the other two raceway trout farms are not available, and though it is likely that settling ponds are used (Lopez-Macias et al. 2007), without further information assumptions on the enforcement of other effluent management measures cannot be made.

The score for Factor 2.2b for raceways is 2 out of 5. When combined with the Factor 2.2a score of 2 out of 5, the final management effectiveness score, Factor 2.2 for raceways is 1.6 out of 10.

Net pens

Neither government nor third-party certification reports are available for the trout net pen culture in Lake Tota; therefore, this report must rely on reports of environmental problems in Lake Tota as an indicator for compliance of implementation. Beyond the lack of thresholds for effluent parameters in the licensing process for net pens, there is sufficient evidence to doubt the capacity of the government to maintain environmental guidelines. For example, there are records of mass die-offs of farmed fish in net pens, particularly during summer months when temperatures rise (pers. comm., M. Mendoza April 2015), likely contributing to a higher biological oxygen demand. It is important to clarify that the cause of these die-offs is uncertain, but Lake Tota received "The Grey Globe" award by the World Wetland Network in 2012, distinguishing it as one of the world's most threatened wetlands in a report that cited trout farming and intensive onion agriculture as the chief pollutants of the water body (Editorial Boyacá 2012) (WWN 2012). In recent years, environmentalists have criticized the practices of trout farmers in Lake Tota, as well as extensive onion agriculture and oil exploration, and point out that an environmental impact study is lacking (Wallace 2012) (Abella and Martinez 2012).

According to Colombia's National Plan for Sustainable Aquaculture Development (AUNAP 2014b), there is evidence that the carrying capacities and baseline water quality parameters of these lakes have not been properly assessed. This continues to be the case, as was found by Torres-Barrera and Grandas-Rincon in their 2017 study detailing the nutrient loads from the trout farms in Lake Tota. In the case of Lake Tota, there are a variety of other anthropogenic inputs contributing to changes in water quality; thus, aquaculture is likely not the primary driving factor but rather a key contributing factor. Additionally, this plan cites a tendency towards eutrophication particularly of water bodies containing cage culture. Historically, there is evidence that net pen farming systems do not employ appropriate measures to minimize the risk of concentrated effluent release and other water quality issues that result from improper farm siting (Cortés 2013) (AUNAP 2014B). Thus, it is clear the current weaknesses in management measures are recognized; however, a plan for more proactive mitigation, though in progress, has not yet been fully implemented.

Because there is evidence to support the claims for eutrophication in Lake Tota, but there is no clear direct evidence to indicate that trout culture is the primary driver, the score for Factor 2.2b is 2 of 5. When combined with the Factor 2.2a score of 2 out of 5, the final Factor 2.2 score for net pens is 1.6 out of 10.

Conclusions and Final Score

Data availability for effluents from both raceways and net pens was low, requiring use of the risk-based assessment. For raceways, a score of 4 out of 10 is calculated for the nitrogen waste discharge in Factor 2.1, and the slightly higher eFCR in net pens results in greater waste discharge and a score of 3 out of 10. For Factor 2.2 (management effectiveness), raceways receive a score of 1.6 out of 10 due to management measures that are not site-specific and little evidence of enforcement. For this same factor, net pens also receive a score of 1.6 out of 10 due to evidence of contributions to eutrophication in Lake Tota. For these reasons, raceway operations in Colombia receive a final score for Criterion 2 – Effluent of 3 out of 10, and net pen operations receive a score of 2 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: being located at sites, scales and intensities that maintain the functionality of ecologically valuable habitats.

Criterion 3 Summary - Raceways

Habitat parameters	Value	Score
F3.1 Habitat conversion and function		8
F3.2a Content of habitat regulations	3	
F3.2b Enforcement of habitat regulations	2	
F3.2 Regulatory or management effectiveness score		2.4
C3 Habitat Final Score (0-10)		**6.1**
Critical?	NO	**YELLOW**

Criterion 3 Summary – Net pens

Habitat parameters	Value	Score
F3.1 Habitat conversion and function		7
F3.2a Content of habitat regulations	3	
F3.2b Enforcement of habitat regulations	2	
F3.2 Regulatory or management effectiveness score		2.4
C3 Habitat Final Score (0-10)		**5.5**
Critical?	NO	**YELLOW**

Brief Summary

Colombia is a hydrologically rich country and contains many watershed areas with high biodiversity. In the case of raceways, there is evidence that many of the farms are sited appropriately outside of protected areas without incurring environmental degradation to the immediate surrounding environment. The net pen company that is exporting to the US is located in a lake that is considered to be high value conservation habitat and has been demonstrably eutrophic, though the role of net pen aquaculture in the continuation of the eutrophic status is not currently clear in comparison to other anthropogenic impacts. These factors result in a habitat conversion (Factor 3.1) score of 8 out of 10 for raceway and 7 out of 10 for net pen production. Government agencies recognize the need for protection of these areas; however, due to excess complexity, frequently changing responsibilities and regulations that are enacted very recently, there is a history of inefficiency in regulation and implementation as it relates to trout aquaculture in raceways and in net pens. This results in a management effectiveness score (Factor 3.2) of 2.4 out of 10 for both raceways and net pens. Combining the scores for both factors in Criterion 3 – Habitat results in a score of 6.1 out of 10 for raceways and 5.5 out of 10 for net pens.

Justification of Ranking

Factor 3.1 Habitat conversion and function

Colombia has over 720,000 basins and micro-watersheds, 26 million m^3 of ground water, and approximately 1800 water bodies classified as ponds, lakes, and reservoirs (Cruz-Casallas et al. 2011). These supply the headwaters to several key rivers in South America, including the Amazon and Orinoco Rivers, making Colombia one of the most hydrologically rich countries on earth (MADR 2010) (Cruz-Casallas et al. 2011) (Merino et al. 2013). Many of these watersheds are areas of high biodiversity, which government agencies work to protect through proper agriculture and aquaculture zoning, best aquaculture management strategies, and mitigating the risk from aquaculture activities interfering with ecosystem services or habitat function (AUNAP 2014b).

Raceways

Raceways in Colombia are typically made of concrete and constructed in hillsides to promote gravitational water flow (FAO NASO). Raceways for farms currently exporting trout to the US were constructed at least 15 years ago. FEDEACUA environmental guidelines include many indicators related to minimizing habitat conversion and wildlife interaction while undergoing construction; however, these guidelines were published many years after construction of the farms so it is not clear if these measures were taken into account previously (FEDEACUA 2016).

In the case of Piscifactoría El Diviso, available land around the farm has been earmarked for the conservation of a forested area, partly to protect Las Piedras River basin, a riparian area that serves as an important source of water for much of the city of Popayan (Periodico la Campana 2014) (El Diviso 2014). Prior to farm construction, much of the land surrounding El Diviso was pastureland and has since been converted back to forested land (El Diviso 2014) (Varadhan 2016).

The raceways for one of the current exporting trout farms were constructed many years ago, are not sited in high value habitat, and the habitats surrounding the farms have not incurred any degradation. However, there is a lack of information regarding the previous habitat for other raceway farms exporting to the US. Therefore, raceways receive a score of 8 out of 10 for Factor 3.1 – Habitat Conversion and Function.

Net pens

Regarding benthic information, there is none available from any one net pen operation in Lake Tota. However, a recent study evaluates the total wastes, and subsequent nitrogen and phosphorus input from all of the current registered trout operations in the lake (Torres-Barrera and Grandas-Rincon 2017). This study does not evaluate the benthic habitat, and thus the results of this study are discussed in Criterion 2 – Effluent.

The Ministry of Agriculture and Rural Development (MADR) reports net pen stocking densities from 7–8 kg/m^3 at first planting to a maximum of 35 kg/m^3 (Merino et al. 2013). These density estimates are an average among commercial trout culture operations within Lake Tota, where it is reported there are approximately 10 licensed trout farms (CONPES 2014) (Torres-Barrera and Grandas-Rincon 2017). Based on the authorized production in all of the licenses, approximately 984 MT of trout can be legally produced per year in Lake Tota (Torres-Barrera and Grandas-Rincon 2017). Based on production in 2014, the volume and space occupied by trout cages in Lake Tota is roughly 0.02% of the area and 0.0019% of the total volume of water in the lake (CONPES 2014).

Lake Tota has been identified as one of the world's most threatened wetlands, due to fertilizer runoff from agriculture and potentially from nitrogen inputs from aquaculture (Editorial Boyacá 2012) (WWN 2012) (Torres-Barrera and Grandas-Rincon 2017). Furthermore, the lake is home to several endangered bird and fish species and has been the last sighting of a now-extinct bird species (WWN 2012), indicating that although it is not designated as any kind of protected area, Lake Tota contains critical habitat for endemic species. It is not currently listed as a Ramsar site of international importance, but there are conservation groups within Colombia that are hoping to have it added to the National Park system (Cuevas 2012). Effluent impacts relating to nitrogen inputs are discussed in Criterion 2 – Effluents and further discussion on interactions with wildlife are discussed in Criterion 9X – Predator and Wildlife Mortalities.

Net pen aquaculture does directly impact habitat, but without more details regarding benthic monitoring or bottom composition/depth, this report uses the precautionary principle and presumes that net pens in Lake Tota have moderate impacts while maintaining functionality. This results in a score of 7 out of 10 for Factor 3.1 – Habitat Conversion and Function.

Habitat: Factor 3.2 Farm siting regulation and management

Factor 3.2a: Content of habitat management measures

Management for aquaculture in Colombia is currently split between two main authorities: the Ministry of Agriculture and Rural Development (MADR) and the Ministry of Environment and Sustainable Development (MADS) (OECD 2016). Beyond working together to create the laws governing fisheries and aquaculture, both entities also work to identify environmental impacts from aquaculture activities on coastal areas and inland watersheds, as well as craft mitigation strategies. Navigating the regulatory framework is complicated by the fact that permits and authorizations for aquaculture operations are granted through shared responsibility of two further entities: the National Aquaculture and Fisheries Authority (AUNAP) and the Autonomous Regional Corporations (CARs). Thus, the framework currently contains redundancies and inefficiencies both in scope and implementation (OECD 2016).

Several federal laws relate to mitigation of environmental impacts from aquaculture, which are organized into an overview by FEDEACUA. For instance, the federal law, Decreto 1076 de 2015, bans siting aquaculture farms in protected areas, but any farms sited prior to their designation as "protected" are exempt (FEDEACUA 2016b). Thus, it is possible for a farm, raceway or net pen, to be sited within an area that is currently considered to be protected. Lake Tota itself is not a protected area. Historically there have been problems with unauthorized aquaculture production with artisanal farms, both in lake and raceway production; this prompted the passing of Resolution 64 in January 2016, which requires all aquaculture farms to be registered with the national agriculture authority, Institucion Colombiano Agropecuario (ICA) (Vargas 2015) (FEDEACUA 2016b). This law applies to any species that is cultured and is not specific only to trout culture.

Finally, FEDEACUA has published a draft guideline for best management practices for aquaculture in Colombia. Many of the guidelines relate to environmental concerns while constructing new facilities, as well as management for production practices (FEDEACUA 2016c). Because these guidelines have only been published recently, the level of implementation throughout the trout industry, especially for exporting trout producers, is unclear.

Raceways

Environmental Impact assessments (EIAs) have been required for newly constructed farms after 1997; however, one of the raceway farms exporting trout to the US from Colombia (El Diviso) was built prior to 1997 and thus was not required to complete an EIA prior to construction (pers. comm., A. Dueñas November 2016). According to the website of another raceway producer, Truchas Belmira SAS, this farm was also established prior to the requirement for EIAs (Belmira Seafood, 2016). No historical information is available for the other two raceway farms, Pescados Frescoes de Colombia and Piscicola de Occidente.

The FEDEACUA draft best management guidelines have several suggestions for strategies to avoid negative environmental impacts from raceway culture, but most focus on effluent impacts. (FEDEACUA 2016c). The guidelines do not include specific targets, and their application is currently unclear.

Net pens

Regarding benthic monitoring or other ecosystem monitoring, there are no requirements from the government. Beyond legislation, the FEDEACUA draft best management guidelines have several suggestions for strategies to avoid negative environmental impacts from net pen culture, including use of sedimentation hoppers to collect excess feed and wastes, rotation of sites, and use of a pump to extract sedimentation (FEDEACUA 2016c). The guidelines do not include specific targets and their application is currently unclear.

For raceway and net pen operations in Colombia, the siting requirements do contain suggestions based on ecological principles (e.g., avoiding protected areas), but they do not include specific targets or limits that would incorporate cumulative impacts. Therefore, raceway and net pen trout operations in Colombia receive a score of 3 out of 5 for Factor 3.2a.

<u>Factor 3.2b: Enforcement of habitat management measures</u>
At the turn of the century, the environmental laws in Colombia were considered to be "complex and unmanageable," which hindered their enforcement (Hernandez-Rodriguez 2001). There have also been reports of management inconsistencies and interruptions to data collection processes due to frequent modification of the agencies responsible for each environmental impact (OECD 2016). Because the responsibility has been passed between agencies and levels of government, this has led to problems with implementation and enforcement.

Raceways

Evidence for enforcement of regulatory measures regarding the habitat impacts of raceway trout culture is limited. Environmental management measures for these farms are restricted mainly to water quality, although there is evidence that at least one farm is sited in a forested area that has been shown to have improved river and stream water quality in comparison to land agricultural areas (pers. comm., A. Dueñas October 2016) (Varadhan 2016) (Giraldo et al. 2014). One of the raceway farms, however, has been implicated in a number of environmental problems over the course of at least 15 years, including extraction of water exceeding permitted amounts and eutrophication of downstream waters from the farm (El Expreso Periodico 2016). This indicates that the enforcement of environmental measures within Colombian raceway farms can vary between provinces.

Net pens

A 2013 report of reactive enforcement in Lake Tota serves as an example of problems with implementation and enforcement. In response to mortality events in Lake Tota, AUNAP and CAR began enforcing more strict regulations in 2013. After allegations of illegal stocking of alevins in Lake Tota, CAR imposed resolution 1505 on 16 August 2013, immediately suspending Truchicol y Cia Ltda. (which is not one of the five companies that currently exports trout to the United States) from stocking any more fish until certain requests for information were met (CAR 2013). An additional resolution (number 1519) in the same month also named several other trout producers; however, none of them export to the US. These requests included: information on daily stock mortality and size of fish, number and dimensions of cages in production, growth and production statistics, physiochemical analysis of the water in the vicinity of net pens, and a contingency plan for controlling mortalities and water quality emergencies (CAR 2013). Although none of the companies involved are among the primary exporters to the US, the reactive management from the regional government showed a gap in implementation of the environmental regulations.

Overall, information regarding enforcement of government policies for raceways and net pens is limited, resulting in a score of 2 out of 5 for Factor 3.2b for both. When combined with the Factor 3.2a score of 3 out of 5, the final Factor 3.2 score for farm siting management and regulations is 2.4 out of 10.

Conclusions and Final Score

Colombia is a hydrologically rich country and contains many watershed areas with high biodiversity. In the case of raceways, there is evidence that many of the farms are likely sited appropriately outside of protected areas without incurring environmental degradation to the immediate surrounding environment. The net pen company that is exporting to the US, however, is located in a lake that is considered to be high value conservation habitat and has been demonstrably eutrophic, though the role of net pen aquaculture in the continuation of the eutrophic status is not currently clear in comparison to other anthropogenic impacts.

Government agencies do recognize the need for protection of these areas; however, due to excess complexity and frequently changing responsibilities and regulations that were enacted very recently, there has been a history of inefficiency in regulation and implementation as it relates to trout aquaculture in raceways and in net pens. Combining the scores for both factors in Criterion 3 – Habitat results in a score of 6.1 out of 10 for raceways and 5.5 out of 10 for net pens.

Criterion 4: 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: limiting the type, frequency of use, total use, or discharge of chemicals to levels representing a low risk of impact to non-target organisms.

Criterion 4 Summary – Raceways

Chemical Use parameters	Score	
C4 Chemical Use Score (0-10)	**3**	
Critical?	NO	**RED**

Criterion 4 Summary – Net pens

Chemical Use parameters	Score	
C4 Chemical Use Score (0-10)	**2**	
Critical?	NO	**RED**

Brief Summary

Based on information from FEDEACUA and from two of the five exporting farms, the use of chemical treatments and prophylactics in Colombian trout production appears to be generally low; however several antibiotics listed as highly important to human medicine by the World Health Organization (WHO) are allowed by the Colombian government. Although data are only available from two of the four Colombian raceway operations exporting trout to the US, there is evidence of low chemical use in general, as well as reduction for potential effects on non-target organisms due to the use of settling ponds. However, due to a lack of chemical use data from the other farms, as well as the allowance and confirmed use of a highly important antimicrobial, Criterion 4 – Chemical Use scores 3 out of 10 for raceways. For net pen operations, there is also a lack of data for the use of chemicals; nonetheless, given the openness of the system, there is a greater risk of affecting non-target organisms if harmful chemicals are used. This, combined with the allowance for use of a highly important antimicrobial and evidence of US FDA import rejections due to unspecified veterinary drug residues, results in a Criterion 4 – Chemical Use score of 2 out of 10 for net pens.

Justification of Ranking

According to a fish health expert working in the Colombian aquaculture industry, the most commonly used chemicals employed in trout farming are the disinfectants formalin, Timsen (n-alkyl dimethyl benzyl ammonium chloride), sodium hypochlorite and hydrogen peroxide (pers. comm., M. Mendoza 2015). These are used mainly at low concentrations for disinfecting equipment, with sodium hypochlorite and hydrogen peroxide the most commonly used. Other chemicals suggested for use in Colombian trout culture include sodium chloride for treatment of parasites and potassium permanganate for treatment of fungal infections (Murillo 2012). Prohibited substances for use in veterinary applications in Colombia include nitrofurazone, furaltadone, dimetridazole, and gentian violet (FEDEACUA 2015).

Specific information is not available from all farms; however, two of the raceway farms can provide information regarding chemical use and biosecurity protocols. According to personal communication and published SOPs from one of the farms, chemicals are not used on the fish at any point in their life cycle and disinfection of the holding areas and equipment is performed with sodium hypochlorite and hydrogen peroxide (pers. comm., A. Dueñas October 2016). Salt baths are used when transferring fish or if a common bacterial pathogen, *Flavobacterium*, is noticed. The lack of chemical use at this farm can also be corroborated by news reports and third-party audit reports, aside from personal communication, claims on the website, and availability of internal SOP documents (Redacción 2014) (Varadhan 2016). The other farm indicates the use of primarily salt and florfenicol for treating fish (pers. comm., A. R. Quiceno August 2018).

In terms of antibiotics (and in contrast to the references and personal communications above), there is evidence that three antibiotics (oxytetracycline, sulfadimethoxine, and florfenicol) can be legally used in Colombian aquaculture, and at least one (florfenicol) is confirmed to be used in Colombian trout production (pers. comm., A. R. Quiceno August 2018). Tetracyclines are used worldwide in aquaculture, as seen in a study carried out in 2012 covering aquaculture industry members worldwide; it was found that 37% of aquaculture industry members surveyed used tetracyclines frequently, with 3 to 25% also claiming to frequently use antimicrobials in fish production worldwide. However, this study has limited coverage in South America (Tuševljak et al. 2012). Specifically in Colombia florfenicol is the preferred antibiotic used for trout farmers (usually for *Flavobacterium* infections) and can be obtained only with a vet prescription and a confirmed diagnosis (EU 2011) (FEDEACUA 2016b) (pers. comm., A. R. Quiceno August 2018).

All three of these antibiotics are listed as “highly important for human medicine” by the World Health Organization (2017) and are not prohibited for use in a veterinary capacity by the Colombian government. Additionally, several sources confirm that florfenicol, in particular, is available for use with a vet prescription on some trout farms, though the frequency of use, or quantities of florfenicol used in Colombian trout farms cannot be confirmed (EU 2011) (FEDEACUA 2016b) (pers. comm., A. R. Quiceno August 2018).

According to a 2007 FAO report, there is evidence that a typical aquaculture operation in Colombia may be more likely to self-administer chemicals such as malachite green or furazone rather than send samples to a lab for diagnosis (Villaneda 2007). Because this report is outdated and does not specify the species or farming systems, however, it cannot be assumed that it applies to all trout farms exporting to the US from Colombia.

Raceways

Although data are only available for two of the four Colombian raceway operations exporting trout to the US, there is evidence of low chemical use at one farm and biosecurity protocols from another farm indicate controlled use of disinfectants, though the specific disinfectants used are not indicated (pers. comm., A. Dueñas October 2016) (pers. comm., A. R. Quiceno Aug 2018). The highest concern relates to the unknown use of antibiotics listed as highly important to human medicine in other farms. Typical farm effluents from raceways in Colombia are passed through several series of settling ponds, as noted in Criterion 2, which can reduce the risk of effect on non-target organisms (Lopez-Macías et al. 2007). The reported lack of antibiotic use at one farm is commendable, but the lack of data from the other farms in addition to the allowance and apparent use of highly important antimicrobials results in a Criterion 4 – Chemical Use score of 3 out of 10 for raceways.

Net pens

As open systems, there is a stronger possibility of effects on non-target organisms for net pen culture. Furthermore, there is evidence that net pen-raised trout in Colombia may be using veterinary drugs later in the production cycle. This evidence is indicated by USFDA import refusals outlined in Table 3.

Table 3. US FDA Import refusals for trout products imported from Colombia[4]

<table>
<tr><th>Company</th><th>Import refusal date</th><th>Reason</th><th>Section</th><th>Charge statement</th></tr>
<tr><td>Trout Co. S.A.S.</td><td>5 April 2017</td><td rowspan="2">VETDRUGRES</td><td rowspan="2">402(a)(2)(C)(ii); 801(a)(3); ADULTERATION</td><td rowspan="2">The article is subject to refusal of admission pursuant to Section 801(a)(3) in that it appears to contain a new animal drug (or conversion product thereof) that is unsafe within the meaning of Section 512.</td></tr>
<tr><td>Trout Co. S.A.S.</td><td>2 June 2017</td></tr>
</table>

These import refusals are the only refusals for drugs or pesticides for Colombia trout products and though they do not indicate which drug residue was detected, they indicate that veterinary drugs have likely been used shortly prior to harvest.

Due to a lack of data from the only net pen trout farm exporting to the US despite multiple attempts to make contact, the allowance for use of highly important antimicrobials, as well as several recent import rejections due to veterinary drug residues for net-pen raised trout in Colombia, Criterion 4 – Chemical Use scores 2 out of 10 for net pens.

[4] https://www.accessdata.fda.gov/scripts/importrefusals/

Conclusions and Final Score

Although data are only available from two of the four Colombian raceway operations exporting trout to the US, there is evidence of low chemical use in general, as well as reduction for potential effects on non-target organisms due to the use of settling ponds. However, due to a lack of chemical use data from the other farms, as well as the allowance and confirmed use of a highly important antimicrobial, Criterion 4 – Chemical Use scores 3 out of 10 for raceways. For net pen operations, there is also a lack of data for the use of chemicals; however, given the openness of the system, there is a greater risk of affecting non-target organisms if harmful chemicals are used. This, combined with the allowance for use of a highly important antimicrobial and evidence of US FDA import rejections due to unspecified veterinary drug residues, results in a Criterion 4 – Chemical Use score of 2 out of 10 for net pens.

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: sourcing sustainable feed ingredients and converting them efficiently with net edible nutrition gains.

Criterion 5 Summary – Raceways

Feed parameters	Value	Score
F5.1a Fish In: Fish Out ratio (FIFO)	0.60	8.5
F5.1b Source fishery sustainability score	–8.00	
F5.1: Wild fish use score		7.54
F5.2a Protein IN (kg/100kg fish harvested)	28.64	
F5.2b Protein OUT (kg/100kg fish harvested)	16.27	
F5.2: Net Protein Gain or Loss (%)	–43.19	5
F5.3: Feed Footprint (hectares)	9.85	6
C5 Feed Final Score (0-10)		**6.5**
Critical?	NO	**YELLOW**

Criterion 5 Summary – Net pens

Feed parameters	Value	Score
F5.1a Fish In: Fish Out ratio (FIFO)	0.67	8.33
F5.1b Source fishery sustainability score	–8.00	
F5.1: Wild fish use score		7.27
F5.2a Protein IN (kg/100kg fish harvested)	31.82	
F5.2b Protein OUT (kg/100kg fish harvested)	16.65	
F5.2: Net Protein Gain or Loss (%)	–47.68	5
F5.3: Feed Footprint (hectares)	10.95	6
C5 Feed Final Score (0-10)		**6.4**
Critical?	NO	**YELLOW**

Brief Summary

The majority of feeds for rainbow trout farms in Colombia are produced by four feed companies, but specific data on the ingredients used and their sources are only available from two of them. Data on the efficiency of feed use on farms are also limited, but typical feed conversion ratios (FCR) of 1.35 for trout in raceways and 1.50 for net pens are used. Average fishmeal and fish oil inclusion levels in trout feeds are estimated to be 20.0% and 6.3% respectively. Information from two feed companies indicates 100% byproducts sourcing for fish oil, and an estimated 50% byproducts use for fish meal. This leads to a Forage Fish Efficiency Ratio (FFER) of 0.60 for raceways and 0.67 for net pens. From first principles, this means 0.60 or 0.67 MT of wild fish would need to be caught to supply the fishmeal used to grow one MT of farmed trout in Colombia. Information regarding the sustainability of the fishery sources of marine ingredients is very limited. The net protein loss for raceway and net pen production is calculated to be approximately 43% and 48% respectively, and the global area required to produce the ingredients needed for one MT of trout is 9.9 ha and 11.0 ha for raceways and net pens respectively. The numerical scores for Factors 5.1, 5.2, and 5.3 combine to give a final score for Criterion 5 – Feed of 6.5 out of 10 for raceways, and 6.4 out of 10 for net pens.

Justification of Ranking

According to Esquivel et al. (2014) and Flores-Nava (2007), the formulated aquafeed industry in Colombia is characterized by a high level of inter-dependence with feed manufacturers across Latin America, leading to sophistication and competitive pressure on par with the global aquafeed industry, and driving producers to incorporate current industry standards and developments in nutrition research into their feed formulations.

A handful of companies currently produce the majority of compound feeds for commercial trout farming operations in Colombia: Solla (45%), Finca-Contegral (24%), Italcol (23%), and CIPA (2%). Feed information is available directly from two of these producers: Solla and Italcol, and this forms the basis for the calculations throughout this criterion (pers. comm., D. Avella May 2017) (pers. comm., A. Amorocho May 2017).

The Seafood Watch Aquaculture Standard assesses three feed-related factors: wild fish use (including the sustainability of the source), net protein gain or loss, and the feed "footprint" or global area required to supply the ingredients. For full detail of the calculations, see the Seafood Watch Aquaculture Standard document.

5.1 Wild fish use

<u>Factor 5.1a: Feed Fish Efficiency Ratio (FFER)</u>

According to feed info supplied by the El Diviso farm and the Solla feed company, the fish meal (FM) and fish oil (FO) inclusion rates for Solla growout trout feed produced in Colombia are 20% and 4.5%, respectively (pers. comm., A. Dueñas October 2016) (pers. comm., A. Amorocho May 2017). More broadly, a now-dated reference paper on aquaculture feeds (Tacon and Metion 2008) reports FM and FO inclusion levels for trout feeds in Colombia range from 15 to 30% for FM and 8 to 10% for FO, and Tacon et al. (2011) predict global average inclusions of FM and FO for trout feeds in 2015 to be 16% and 10% respectively. Average FM and FO inclusion levels in compound trout feeds are considered to have steadily declined over the last two decades (Troell et al. 2014).

It is unclear whether FM or FO in the Solla feed are sourced from fishery byproducts; however, based on the source fisheries listed, many of them are typically reserved for human consumption. The source for fish oil is listed as a cultured species (coho salmon; see Table 4) and this is presumed to be a byproduct. Further information from Italcol, another Colombian feed supplier, indicates 100% byproduct use, with inclusion rates of 20% FM and 8% FO for their growout feed. Thus, it is assumed that some of the FM and FO is sourced from byproducts for other feed producers, but the exact amount used across the four feed producers is uncertain.

Based on the varying inclusion rates and varying reports for byproduct use, an average inclusion rate for FM and FO is estimated to be 20%[5] and 6.3%[6] respectively, with 50% byproduct use for FM and 100% byproducts use for FO. The eFCR used in these calculations is 1.35 for raceways and 1.5 for net pens (for further justification, see Criterion 2 – Effluent).

Table 4. Summary of Feed Factor 5.1 Wild Fish Use scores

Parameter	Raceways	Net pens
Fishmeal inclusion level	20%	20%
Percentage of fishmeal from byproducts	50%	50%
Fishmeal yield (from wild fish)	22.5%	22.5%
Fish oil inclusion level	6.3%	6.3%
Percentage of fish oil from byproducts	50%	50%
Fish oil yield	5%	5%
Economic Feed Conversion Ratio (eFCR)	1.35 (raceways)	1.50 (net pens)
Calculated Values		
Feed Fish Efficiency Ratio (FFER) (fishmeal)	0.6 (raceways)	0.67 (net pens)
Feed Fish Efficiency Ratio (FFER) (fish oil)	0	0
Seafood Watch FFER Score (0-10)	**8.50 (raceways)**	**8.33 (net pens)**

Utilizing these values, the calculated FFER for raceways is 0.60 and the calculated FFER for net pens is 0.67, both based on fishmeal (the FFER for fish oil is considered to be zero based on the available data on the use of byproduct fish oil sources). This results in scores of 8.50 out of 10 for raceway operations and 8.33 for net pens for Factor 5.1.a – Fish Feed Equivalency Ratio.

Factor 5.1b: Sustainability of the source of wild fish

[5] FM inclusion rates for both Solla and Italcol feeds are 20%

[6] Based on an average of Solla (4.5%) and Italcol (8%) FO inclusion

Data for this factor are provided in written statements from the technical managers at the Solla and Italcol feed companies. The precise sourcing for the FM and FO is unknown for the other two Colombian feed producers (Finca-Contegral, CIPA). Based on the stated sources for FM and FO reported by these two companies (Table 4), there is little robust information with which to assess their sustainability. Only two fisheries (chub mackerel, southeast Pacific; yellowfin tuna, Eastern Central Pacific) have FishSource scores.

Table 5. Sustainability information reported for two of the four Colombian feed companies (pers. comm., Solla, Italcol May 2017)

<table>
<tr><th>Source</th><th>Use in FM or FO</th><th>Sustainability information</th><th>Byproduct use</th></tr>
<tr><th colspan="4">Solla</th></tr>
<tr><td>Chub mackerel (Scomber japonicus), Chile (Southeast Pacific)</td><td>FM</td><td>IUCN: least concern
CITES: not listed
FishSource: <6 for management quality, no score for other parameters</td><td rowspan="4">None specified; presumed to be 50%</td></tr>
<tr><td>Frigate tuna (Axis thazard), Southeast Pacific</td><td>FM</td><td>IUCN: least concern
CITES: not listed
FishSource: not listed for Southeast Pacific stock</td></tr>
<tr><td>Picudillo/Shortfin Scad (Decapterus macrosoma), no geographic origin listed</td><td>FM</td><td>IUCN: not listed
CITES: not listed
FishSource: not listed</td></tr>
<tr><td>Yellowfin tuna (Thunnus albacares), Eastern Central Pacific (FAO 77), Southeast Pacific (FAO 87)</td><td>FM</td><td>IUCN: near threatened
CITES: not listed
FishSource: ≥8 for management strategy, ≥6 for managers compliance, ≥6 for fisher compliance, 10 for current stock health, 8.6 for future stock health</td></tr>
<tr><td>Coho salmon (Oncorhynchus kisutch), farmed, Chile</td><td>FO</td><td>None listed</td><td>Not specified, presumed to be 100%</td></tr>
<tr><th colspan="4">Italcol</th></tr>
<tr><td>Yellowfin tuna (Thunnus albacares), no geographic origin listed</td><td>FM, FO</td><td>None listed</td><td>Yes, 100%</td></tr>
<tr><td>Skipjack tuna (Katsuwonus pelamis), no geographic origin listed</td><td>FM, FO</td><td>None listed</td><td>Yes, 100%</td></tr>
</table>

As the wild fish sources for Italcol are known to be 100% byproduct, these sources are not incorporated into the score for Factor 5.1b. Overall, given that fisheries information from Solla is limited, and is not available at all from two other companies, the sustainability of the marine ingredients in Colombian trout feeds is considered to be largely unknown, and the score for

Factor 5.1b – Sustainability of the Source of Wild Fish is –8 out of –10 for both raceways and net pens. When combined, the Factor 5.1a and Factor 5.1b scores result in a final Factor 5.1 score of 7.54 out of 10 for raceways and 7.27 out of 10 for net pens.

Factor 5.2 Net protein gain or loss

The net protein gain or loss of an aquaculture operation depends on characteristics of the various feed *inputs,* and details of the system *outputs,* or (utilized) animal product produced. Factors included in the analysis of inputs are protein content of feed, the eFCR (which implicitly includes mortality and feed waste) and the percentage of feed that is sourced from edible, in comparison with non-edible, plant or animal sources. Outputs are considered in terms of edible or utilized protein leaving the system (i.e., protein content of the harvested farmed fish, edible yield of that fish based on processing and morphology, and the percentage of non-edible animal products from the harvested fish that are used for subsequent food production).

Based on a dataset comprised of government reports, commercial feed websites, consultations with one of the farms and industry experts, as well as the literature, it was determined that feeds used in commercial trout farming in Colombia average 43% protein through the production cycle (Murillo-Garcia 2009) (Murillo 2012) (Castañeda-Valencia and Ochoa 2013) (Merino et al. 2013) (pers. comm., D. Dueñas June 2018; Solla.com, Contegral.co) (pers. comm., A. R. Quiceno August 2018). This value is in line with commercial trout formulations documented in Chile, the UK, and the US, which range from 36 to 50% protein, averaging 45% (Bostock et al., 2010) (pers. comm., M. Garcia April 2015) (McGrath 2015).

The major terrestrial plant protein sources used in commercial aquafeeds in Latin America are soybean meal, wheat bran, and wheat meal, in varying inclusion rates depending on commodity prices and exchange rates (Merino et al. 2013). Specifically from Italcol, one of the four main feed producers in Colombia, terrestrial plant protein sources also include corn gluten meal, yellow corn, rice grain and byproducts, and cassava flour for trout growout feeds (pers. comm., D. Avella May 2017). According to the Seafood Watch Standard for Aquaculture, all of these are considered potentially suitable for human consumption.

Blood and bone meal from the cattle industry, poultry by-product meal, and hydrolyzed feather meal, which are all considered inedible, are also known to be protein ingredients in Colombian aquafeeds; however, specific data on inclusion levels were not attainable (Flores-Nava 2007) (Tacon et al. 2011) (pers. comm., D. Avella May 2017). An ingredients list is not available directly from any of the other trout feed producers. Without specific inclusion level availability, the calculations here are based on a "typical" trout feed (Hardy 2013) which is considered to be comprised of roughly 49% edible plant components, 25% land animal byproduct components.

Based on these ingredient inclusion levels and default protein contents in the Seafood Watch Standard, 49.3% of the total protein in the feed is calculated to be supplied by edible marine and crop sources and 50.6% from non-edible byproduct ingredients. Utilizing the same eFCR values as were used previously (1.35 for raceways, 1.5 for net pens), this results in a total edible protein input of 28.6 kg per 100 kg of trout harvested from raceways and 31.8 kg per 100 kg of trout harvested from net pens in Colombia.

Regarding the protein outputs in harvested rainbow trout, the majority of trout exported from Colombia to the United States are sold as whole, head-on or butterflied, with a smaller percentage also sold head off and as gourmet fillets (MADR 2011). Based on NOAA trade data from 2017, approximately 50% of Colombian trout imports were whole fish, with the other 50% being non-specified fillets (NOAA 2018). The "edible losses" of trout products differ depending on processing, and the subsequent yields for each of the named preparations are as follows: whole (85%), butterflied (77%), whole head-off (65%), and filleted (52%) (Murillo-Garcia 2009) (MADR 2011). For this report, a value of 65% edible yield was used.

El Diviso confirms that 100% of the trimmings are used for fish oil in pet feeds, fiber byproducts are milled for local cattle feeds, and all other trimmings are packed and donated to local communities (pers. comm., A. Dueñas October 2016). Because this is only one of the five exporting trout farms, the level of by-product reutilization from harvested rainbow trout in Colombia could not be confirmed for all farms and an assumed value of 50% is used.

The protein content of a whole rainbow trout carcass is estimated to be 15.6%, per the Seafood Watch Standard for Aquaculture. The final net protein loss calculated for raceway-produced rainbow trout is 43.19%, and for net pen production is calculated at 47.68%, resulting in a score of 5 out of 10 for Factor 5.2 – Net Protein Gain or Loss both for raceways and net pens.

Factor 5.3 Feed footprint

As discussed above, accurate data on the inclusion rates of terrestrial ingredients could not be obtained for trout feeds from government, commercial, or expert sources in Colombia.

As outlined in Factors 5.1 and 5.2, without specific inclusion level availability from feed companies, the feeds used are assumed to be comprised of roughly 26% marine ingredients, 49% plant, and 25% land animal ingredients. The data used and resultant calculated values are available in Table 7 below.

Table 6. Summary of Feed Factor 5.3 – Feed Footprint Scores

Parameter	Data (raceways)	Data (net pens)
Marine ingredients inclusion	26%	26%
Crop ingredients inclusion	49%	49%
Land animal ingredients inclusion	25%	25%
Ocean area (hectares) used per ton of farmed tilapia	9.23	10.26
Land area (hectares) used per ton of farmed tilapia	0.62	0.69
Total area (hectares)	9.85	10.95
Seafood Watch Score (0-10)	**6**	**6**

The ocean area necessary to produce the marine ingredients required for one ton of farmed trout is estimated to be 9.23 ha for raceways and 10.26 ha for net pens; the land area is estimated to be 0.62 ha and 0.69 ha for respectively. The combination of these two values results in an overall feed footprint of 9.85 ha/ton of farmed fish in raceways, and 10.95 for net pens. This results in a final Factor 5.3 score of 6 out of 10 for both raceway- and net-pen raised trout.

Conclusions and Final Score

Overall, the final score is a combination of the three factors with a double-weighting for the Wild Fish Use factor. For raceways, Factors 5.1 (7.54 out of 10), 5.2 (5 out of 10), and 5.3 (6 out of 10) combine to result in a final score of 6.52 out of 10 for Criterion 5 – Feed. For net pens, Factors 5.1 (7.27 out of 10), 5.2 (5 out of 10), and 5.3 (6 out of 10) combine to result in a final score of 6.38 out of 10 for Criterion 5 – Feed (see the Seafood Watch Aquaculture Standard for further details on all scoring tables and calculations).

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: preventing population-level impacts to wild species or other ecosystem-level impacts from farm escapes.

Criterion 6 Summary - Raceways

Escape parameters	Value	Score
F6.1 System escape risk	6	
F6.1 Recapture adjustment	1	
F6.1 Final escape risk score		7
F6.2 Competitive and genetic interactions		8
C6 Escape Final Score (0-10)		**7**
Critical?	NO	**GREEN**

Criterion 6 Summary - Net pens

Escape parameters	Value	Score
F6.1 System escape risk	2	
F6.1 Recapture adjustment	0	
F6.1 Final escape risk score		2
F6.2 Competitive and genetic interactions		8
C6 Escape Final Score (0-10)		**5**
Critical?	NO	**YELLOW**

Brief Summary

Due to the use of multiple settling ponds and redundancy in containment screens, the risk of escapes from raceway systems in Colombia is considered low. In net pen farming systems, the single net barrier and the exposure to the open environment increases the risk of escape and makes recapture difficult. In Colombia, 70 years of rainbow trout introductions for sport fishing mean it is already present in many of the freshwater streams, rivers, and lakes in which aquaculture activities take place. The species was been classified in Colombia as "introduced and invasive" in 2008, but in 2015 it was reclassified as "domesticated." Studies in other regions indicate the species exerts competitive and predatory pressure on native species, yet several studies within Colombia indicate that the previously stocked rainbow trout stocks dwindled after the stocking ceased in 2008. This indicates that rainbow trout may not be as strong a concern for competitive and genetic interactions in Colombian waterways. Nevertheless, given the established nature of trout prior to aquaculture in Colombia, the impact of further escapes from farms is uncertain. Overall, the risk of escape and the risk of impact combine to give Criterion 6 – Escapes final scores of 7 out of 10 and 5 out of 10 for raceways and net pens respectively.

Justification of Ranking

Factor 6.1 Escape risk

Raceway and net pen farming systems in Colombia are characterized by considerable differences in the risk of escapes into the wild, both because of inherent attributes of the production systems and due to differences in the management practices that they employ.

Raceways

The raceway systems typically include settling ponds for waste water that represent secondary barriers in the event of an escape from the raceways (Lopez-Macías et al. 2007). According to inspection reports and personal communication with El Diviso, there is redundancy in effluent screens and effluent passes through various holding tanks and drying tanks prior to discharging to the nearby streams (Varadhan, 2016). At any point throughout this effluent maze, any escapes can be removed; this design is typical for the companies producing in raceways in Colombia (A. Dueñas, pers. comm. October 2016). At El Diviso, escapes that are recaptured from the farm canals are sent directly to processing for biosecurity reasons (pers. comm., A. Dueñas October 2016). Although a moderate initial degree of escape risk exists, raceways in Colombia typically employ multiple avenues for preventing and capturing any escapes. As a result, the Escape Risk score (Factor 6.1) for raceways in Colombia is 7 out of 10.

Net pens

The net pen farming industry in Colombia is relatively unregulated, and it lacks adequate technology to minimize the risk of escapes into the freshwater Andean lakes in which farming occurs (pers. comm., M. Mendoza March 2015; MADR 2011). Net pens in general are considered a high-risk farming system (regarding escapes) because of their direct exposure to the environment and the challenge of recapturing escaped animals (Jensen et al. 2010). Although there is anecdotal evidence of local fisheries in the lakes that may capture escapes, there is not enough evidence to justify a recapture adjustment for net pens. As a result, net pens receive a score of 2 out of 10 for Factor 6.1 – Escapes.

Factor 6.2 Competitive and genetic interactions

Rainbow trout is the most widely-introduced of the salmonid species, having established self-sustaining populations outside of its native range all over the world (Crawford and Muir 2008). As mentioned in previous justification texts, rainbow trout are not native to South America, and have been classified as an introduced, invasive species by the Colombian government; see AUNAP Resolucion 2287, 29 Diciembre 2015 (Merino et al. 2013). Rainbow trout were first introduced to the country's Andean streams, rivers, and lakes in 1939, primarily to populate the region's watersheds with a species of higher economic value than native species (Esquivel et al. 2014) (Cruz-Casallas 2011) (CONPES 2014). A long history of intentional introductions in the Andean region, mostly for sportfishing purposes, has resulted in established trout populations throughout nearly all the country's high-elevation lakes, rivers, and tributaries, which was the basis for the original "invasive" designation (Alvis 2006) (Cruz-Casallas 2011) (Mora et al. 1992) (Pascual et al. 2007). The restocking programs in Colombia were terminated after 2008 due to Resolution 0848, which declared the following as exotic, invasive species: trout (*O. mykiss; S. trutta*), tilapia *(O. niloticus; O mossambicus),* common carp (*C. carpio*), largemouth bass (*M. salmoides*) and snakeskin gourami (*T. pectoralis*) (Merino et al. 2013). As a result of this termination, many of the previously stocked populations have vastly diminished (CONPES 2014). In December 2015, another resolution (2287) was passed declaring tilapia and trout as domesticated species, which allows the producers to import live fish, although previously only eggs were allowed to be imported. Intentional release of all species listed in both resolutions is prohibited and special regulations govern their continued, controlled use for aquaculture activities only (IABIN 2007-2008; AUNAP Resolucion 2287, 29 Diciembre 2015).

Currently, trout farmed in Colombia are the progeny of highly domesticated (i.e., >4 generations captive-spawned) broodstock and sourced (as eggs) from a US-based hatchery (Troutlodge 2017). Domestication of fish is demonstrated to have benefits for growth, FCR, age at sexual maturity and resistance to bacterial and viral diseases; however, it is also proposed to be a greater ecological danger when these fish escape into the environment due to potential habitat destruction, introduction of pathogens, and competition with native species (Teletchea and Fontaine 2014). In a comparative study of total predation behavior by introduced trout and an endemic catfish utilizing the same food resource in Northwestern Patagonia, Argentina, Geray et al. (2015) demonstrated that predation by populations of introduced rainbow trout was 2–3 times higher than by native catfish. This implies that trout are stronger competitors for food resources in the Southern Andes, since they exert a stronger influence on the abundance and species composition of native macroinvertebrates than native catfish. Additionally, in a similar study carried out in 21 fishless streams in the Sierra Nevada mountains, California, Herbst et al. (2009) found that the ecological structure of invaded vs. fishless streams differed significantly, indicating that the presence of trout even in the absence of other native piscine species can select for overgrowth of certain algae and macroinvertebrate species**.**

In Lake Tota, the intentional stocking of several species (*Eremophilus mutisii, Grundulus bogotensis, Carassius auratus, Oncorhynchus mykiss*) from 1944 has been implicated in the likely extinction of the native pez graso (grease fish; *Rhizosomichthys totae*). Although rainbow trout are among the introduced species, a particular catfish with morphology and ecological niche similar to the pez graso (*Eremophilus mutisii*) has been identified as the most likely direct competitor that drove the extinction, with the last confirmed pez graso specimen caught in 1958 (IUCN 2018). This introduction and interaction was far prior to the development of an aquaculture industry in the country. Though it indicates the potential for trout to compete with native species, in this case the trout are not likely the main competitors.

The possible ecological damage of trout introductions in Colombia, past and present, has yet to be studied, though damaging ecological effects in other parts of the world, including Chile, Bolivia, and Argentina have been examined (Consuegra et al. 2011) (Perez et al. 2003) (Geray et al. 2015). However, after intentional stocking was halted, the populations of trout in Colombian waterways exhibited a stark decline, indicating that the species may not be as competitive in the region as it has been in others. Because the species was established by the Colombian government in the 1930s, prior to the advent of farming the species in Colombia, and the Colombian government now tightly controls the further introduction to waterways containing native fish, the score for Factor 6.2 – Competitive and Genetic interactions both for net pens and raceways is 8 out of 10.

Conclusions and Final Score

Although the raceways employed in Colombia are considered flow-through systems, multiple settling ponds and redundancy in screens reduces the chances of a large escape. Escape risk for net pens in Colombia is assumed to be much higher, given that the industry is newer and there are less regulations in place to ensure the risk of escape is low

Rainbow trout was initially introduced by the Colombian government prior to the development of a farming industry, but has more recently been classified as an invasive, introduced species. For aquaculture, it is now reclassified as a domesticated species, but the government restricts any efforts to release rainbow trout into native waterways. Introduced rainbow trout in other regions have been successful competitors and have been shown to exert competitive and direct predatory pressure on native species; however, after intentional stocking in Colombian waterways ceased, the trout populations have significantly declined. Though government efforts to curb introductions are proving to help reduce previously established populations, there remains a risk that escaped fish could be competitive with native species.

Overall, for raceways, factors 6.1 and 6.2 combine to give a final numerical score of 7 out of 10 for Criterion 6 – Escapes. For net pens, the factors combine to give a final numerical score of 5 out of 10 for Criterion 6 – Escapes.

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: preventing population-level impacts to wild species through the amplification and retransmission, or increased virulence of pathogens or parasites.

Criterion 7 Summary – Raceways and Net Pens

Disease Risk-based assessment

Pathogen and parasite parameters	Score	
C7 Disease Score (0-10)	4	
Critical?	NO	**YELLOW**

Brief Summary:
Currently there is minimal disease reporting in Colombia, but though many common trout diseases are not generally considered to be present (likely due to import restrictions on ova suppliers), *Flavobacterium* is a common bacterial disease that does appear at hatcheries in Colombia and is a concern for wild fish. Two farms exporting trout to the US shared their biosecurity plans for the purposes of this assessment, but raceways and net pens are open systems that have an inherent risk of disease transmission and amplification. With limited data availability, the risk-based assessment was used for both raceways and net pens, and the final numerical score for Criterion 7 – Disease is 4 out of 10 for both systems.

Justification of Ranking:
As disease data quality and availability is moderate/low (i.e., Criterion 1 score of 2.5 for the disease category), the Seafood Watch Risk-Based Assessment is used.

Trout ova imported into Colombia come only from hatcheries in the US, and have been, and continue to be certified biosecure/disease-free, thanks to biannual inspections and adherence to a stringent Fish Health Management plan at the hatchery facility (Merino et al. 2013) (Troutlodge 2017). Further information regarding the specific diseases that Troutlodge is inspected for can be found under Criterion 10X – Escape of secondary species in this report. Although disease introduction to farms can occur from the source of the eggs or juveniles, and from wild fish via the water supply, this criterion primarily evaluates the potential transmission from farmed fish to wild fish.

The most common on-farm pathogen has been identified as *Flavobacterium psychrophilum*, a bacteria that commonly affects trout fry in Colombia (pers. comm., A. Dueñas October 2016) (Iregui Castro et al. 2004). Flavobacterial infections are a worldwide concern for various fish species, of which rainbow trout are particularly susceptible. The bacterium grows best at temperatures below 15°C and cause both bacterial cold-water disease and rainbow trout fry syndrome (Loch and Faisal 2015). *F. psychrophilum* is considered one of the "big three" fish-pathogenic species of *Flavobacterium*, along with *F. columnare* and *F. branchiophilum*, and has been identified as a threat to major fish stocks worldwide (Loch and Faisal 2015) (Wahli and Madsen 2018). Though there are no ecological studies focused on the effects of *Flavobacterium* presence/prevalence in wild fish populations in Colombia, there is a risk that this disease could spread from farmed fish to wild fish.

This has been the only disease concern for the trout industry so far in Colombia, since tight restrictions on ova imports have prevented introduction of common trout diseases, such as infectious pancreatic necrosis (IPN) (pers. comm., A. Dueñas October 2016; AUNAP 2015). The development of a vaccine is an active area of research that is promising, though nothing is currently available on the market in Colombia (Hoare et al 2017a) (Hoare et al 2017b) (Zamora et al. 2013) (Zhang et al 2017).

According to a government publication in 2010, the tools and specialized centers for the diagnosis of pathogens were lacking at that time in Colombia (MADR 2010). Additionally, record keeping of pathogen monitoring, detections, disease outbreaks and treatments applied were lacking or unavailable to external investigators, because the government does not currently mandate disease reporting (pers. comm., M. Mendoza March 2015; MADR 2011). Although it is possible this may have improved in the interim, there is currently still no baseline dataset of disease outbreaks or monitoring.

Farms that are certified to the GAA BAP standards are required to have biosecurity plans and fish health management plans; however, an example of such a biosecurity plan could only be obtained from one of the certified farms (El Diviso 2014). Another biosecurity plan was made available from one other raceway farm that is not currently certified to GAA BAP standards. Both plans include detailed measures for prevention of farm-related disease introduction or intrusion into the surrounding environment, such as quarantine for each shipment of eggs, disinfection after each harvest, and restricted access for both humans and animals (El Diviso 2014) (Piscicola de Occidente 2018). Presumably, the biosecurity plans for all other exporting trout farms are equivalent to these two; however, without having access to them it is not possible to determine. The recent publication of FEDEACUA environmental guidelines touches briefly on biosecurity, but does not offer details regarding specific elements required in biosecurity plans for the region (FEDACUA 2016c). The same can be said of the GAA BAP requirements for biosecurity plans (GAA 2016).

Raceways

In the case of raceways, there is very low potential contact with wild trout populations in the influent water, since the historically stocked trout populations have decreased once the government stocking programs were discontinued (pers. comm., A. Dueñas October 2016; CONPES 2014). Also, effluent waters coming from raceways go through sedimentation ponds prior to being discharged to the waterway, sometimes with multiple ponds. However, it is unclear how prevalent the use of multiple sedimentation ponds is, nor the number of times per cycle the sedimentation ponds release water beyond the farm. Therefore, while biosecurity protocols are in place, the production system is still considered to be open and the final score for raceways is 4 out of 10 for Criterion 7 – Disease.

Net pens

Net pens are a production system that allows open exchange with the environment; thus, there is an inherent risk of disease transmission and amplification. Without access to the biosecurity protocols for TroutCo, the only net pen farm producing trout for the US market, this report can only rely on the recently published industry environmental guidelines (FEDEACUA 2016c) and the portions of the raceway biosecurity protocols that are relevant to hatchery protocols (El Diviso 2014) (Piscicola de Occidente, 2018). Therefore (similar to raceways), while biosecurity protocols are in place, the production system is still considered to be open and the final score for raceways is 4 out of 10 for Criterion 7 – Disease.

Conclusions and Final Score

Currently there is minimal disease reporting in Colombia, but though many common trout diseases are not generally considered to be present (perhaps due to import restrictions on ova suppliers), *Flavobacterium* is a common bacterial disease that does appear at hatcheries in Colombia and is a concern for wild fish. Two farms exporting trout to the US shared their biosecurity plans for the purposes of this assessment, but raceways and net pens are open systems that have an inherent risk of disease transmission and amplification. With limited data availability, the risk-based assessment was used for both raceways and net pens, and the final numerical score for Criterion 7 – Disease is 4 out of 10 for both systems.

Criterion 8X: 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: using eggs, larvae, or juvenile fish produced from farm-raised broodstocks thereby avoiding the need for wild capture.

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 8X Summary - Raceways and Net pens

Source of stock parameters	Score	
C8X Independence from unsustainable wild fisheries (0-10)	–0	
Critical?	NO	GREEN

Brief Summary:
The large Colombian farms exporting trout to the US use imported juveniles and ova from domesticated broodstock in US trout hatcheries. Therefore, both net pens and raceways in Colombia are independent from wild broodstock or seed. The final score for Criterion 8X – Source of Stock is a deduction of 0 out of –10.

Justification of Ranking:
As mentioned previously in the justification for Criterion 6 – Escapes, eyed ova and now juveniles imported for commercial export trout farming in Colombia originate from broodstock that are fully independent from wild stock (Alvis 2006) (Esquivel et al. 2014). Seed comes exclusively from Troutlodge, a US hatchery which (similar to most commercial rainbow trout hatcheries in the US) has established a multi-decadal breeding program and is entirely independent from wild trout populations (Troutlodge 2017) **(**Isaac 2017**).**

Conclusions and Final Score

Commercial trout farming in Colombia utilizes juveniles and ova from domesticated broodstock in US trout hatcheries. Therefore, both net pens and raceways in Colombia are independent from wild broodstock or seed, and the final numerical score for Criterion 8X – Source of Stock is a deduction of 0 out of –10.

Criterion 9X: Predator and wildlife mortalities

Impact, unit of sustainability and principle

- Impact: mortality of predators or other wildlife caused or contributed to by farming operations
- Sustainability unit: wildlife or predator populations
- Principle: preventing population-level impacts to predators or other species of wildlife attracted to farm sites.

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 – Raceways

Wildlife and predator mortality parameters	Score	
C9X Wildlife and predator mortality Final Score (0-10)	**–2**	
Critical?	NO	**GREEN**

Criterion 9X Summary – Net pens

Wildlife and predator mortality parameters	Score	
C9X Wildlife and predator mortality Final Score (0-10)	**–6**	
Critical?	NO	**YELLOW**

Brief Summary

Trout raceways in Colombia utilize full enclosures to exclude wildlife and reduce interactions, and wildlife mortality is considered to be limited to exceptional circumstances. Net pens are sited in Lake Tota, which is home to two populations of endangered bird species; however, the extent of measures taken to prevent wildlife interactions is uncertain (for example, top nets do not appear to be used), as is the extent to which these and other birds interact with the farm. Regulations in Colombia regarding interactions with wildlife at aquaculture facilities are minimal, and there is no clear enforcement. Overall, the final score for Criterion 9X – Predator and Wildlife Mortalities is a deduction of –2 out of –10 for raceways and –6 out of 10 for net pens in Lake Tota.

Justification of Ranking:

Raceways

Producers using raceways in Colombia cover the enclosures with large wire cages, often covered in shadecloth, ensuring birds are not able to access the raceways (pers. comm., A. Dueñas October 2016) (pers. comm., A. R. Quiceno August 2018) (Alvis 2006).

A now outdated 2003 study on bird depredation at aquaculture facilities throughout Colombia found that trout raceway facilities do not experience bird depredation problems, nor do they require any sort of lethal interactions with them for this reason (Bechard and Marquez-Reyes 2003). These findings are supported by a recent BAP audit report for El Diviso farm that indicates there have been zero wildlife and predator mortalities on the farm (Varadhan 2016).

There are no direct wildlife mortalities, endangered or otherwise, related to raceway culture of trout in Colombia; however, this is based only on information from two of the four raceway farms currently exporting to the US as well as a study from 2003. Although it is highly likely that the other raceway farms in Colombia operate in the same way, without information from them it is not possible to be sure.

Net pens

Very little is known about the interactions between net pen farms and predators in Colombia, since information is not publicly available from the primary exporting company or elsewhere. There is a national law (Resolution no. 461 (1995) outlining the requirements for top-nets to exclude avian predators; however, personal communication with individuals working in net pen aquaculture in Colombia suggests that these measures are not in place. This indicates that enforcement may be minimal (pers. comm., M. Mendoza March 2015; FEDEACUA 2016b,).

Interactions with wildlife are addressed in the recent drafts of the FEDEACUA guide for Environmental Management, but they are only in relation to constructing new projects (FEDEACUA 2016c). Furthermore, in Lake Tota there are two known populations of endangered bird species: the Bogota Rail (*Rallus semiplumbeus*) and the Apolinar's wren (*Cistothorus apolinari*) (IUCN 2018). Although neither of these are likely to interact directly with the farm, there is currently no information indicating that farms make any efforts to exclude intrusion of wildlife into the net pens. Additionally, Lake Tota is a known breeding ground for several bird species classified as "Least Concern" on the IUCN red list, such as the least bittern (*Ixobrychus exilis bogotensis*) and the Colombian ruddy duck (*Oxyura jamaicensis andina*). Lake Tota is also the location of the last confirmed sighting (in 1977) of the Colombian grebe (*Podiceps andinus*) (IUCN 2018). Again, although there is no evidence of direct interactions with these species, the lack of data to confirm this, and the apparent lack of effective top nets, means that mortalities are unknown.

Conclusions and Final Score

Raceways in Colombia utilize enclosures to minimize interactions with potential predators and other wildlife. This can be confirmed in peer-reviewed literature, as well as in communication with one of the farms. The final raceway score for Criterion 9X – Predator and Wildlife

Mortalities is a deduction of –2 out of –10 on the basis that mortalities are limited to exceptional circumstances.

Net pens raising trout in Colombia are sited in a lake that is home to two populations of endangered avian species. The extent to which these (and other) birds interact with the farm is unknown, as is the extent of any mitigation measures taken to prevent any wildlife interactions on the farm. The final net pen score for Criterion 9X – Predator and Wildlife Mortalities is a deduction of –6 out of –10 on the basis that mortalities are unknown.

Criterion 10X: Escape of secondary species

Impact, unit of sustainability and principle

- Impact: movement of live animals resulting in introduction of unintended species
- Sustainability unit: wild native populations
- Principle: avoiding the potential for the accidental introduction of secondary species or pathogens resulting from the shipment of animals.

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.

Criterion 10X Summary - Raceways and Net pens

Escape of secondary species parameters		Score	
F10Xa International or trans-waterbody live animal shipments (%)		0	
F10Xb Biosecurity of source/destination		9	
C10X Escape of secondary species Final Score		**–1.0**	**GREEN**

Brief Summary:

The Colombian farms exporting rainbow trout to the US are entirely dependent on the import of live trout in the form of eggs and juveniles from the US. The shipments originate from a highly biosecure hatchery, with little chance of unintentionally transferring live animals or pathogens due to multiple disease-free certifications and licensing requirements for import into Colombia. The destinations of the shipments (i.e., raceways and net pen farms in Colombia) are more open; therefore, the biosecurity score is based on the more secure source. Overall, despite the dependence on shipments, the high biosecurity means there is only a minor deduction of –1 out of –10 for Criterion 10X – Escape of secondary species for both raceways and net pens.

Justification of Ranking:

Factor 10Xa: International or trans-waterbody live animal shipments

The Colombian trout industry relies on eyed ova and juveniles from the United States to stock commercial raceway and net pen farms (Alvis 2006) (Esquivel et al. 2014). The hatchery supplying the companies that ultimately export trout products to the US is Troutlodge, located in the US Pacific Northwest. Eggs and juveniles from Troutlodge are imported through a Colombian company called Aquagranja (Cortés 2013) (Troutlodge 2017) (Aquagranja 2016). According to Esquivel et al. (2014), Colombia imported 82 M eyed-ova from the US, valued at USD 4.2 M in 2013 (Esquivel et al. 2014). More recent data are not currently available.

Due to 100% reliance on international transport of eggs and possibly juveniles, Factor 10Xa scores 0 out of 10 for both raceways and net pens.

Factor 10Xb: Biosecurity of source/destination

Troutlodge employs various techniques to prevent disease outbreak and transmission, such as UV filtration of water and approved chemical treatments to sterilize eggs from fungus or potential pathogens (pers. comm., J. Taylor October 2013) (USGS 2013) (Troutlodge 2017). Also, the facility undergoes biannual inspection to be certified disease-free for a number of pathogens (Table 6) and follows a stringent Fish Health Management plan.

Table 7. Diseases for which Troutlodge is certified "disease-free"

Viral Pathogens	**Bacterial Pathogens**
Infectious Hematopoietic Necrosis (IHN)	*Renibacterium salmoninarum* (Bacterial Kidney Disease)
Viral Hemorrhagic Septicemia (VHS)	*Yersinia ruckeri* (Enteric redmouth)
Infectious Pancreatic Necrosis (IPN)	*Aeromonas salmonicida* (Furunculosis)
Oncorhynchus masou virus (OMV)	*Piscirickettsia salmonis*
Epizootic Hematopoietic Necrosis (EHN)	**Parasitic Pathogens**
Infectious Salmon Anemia (ISA)	*Myxobolus cerebralis* ("Whirling Disease")
Spring Viremia of Carp (SVC)	*Ceratomyxa shasta*

Source: www.troutlodge.com

Environmental licenses are required for importing animals into Colombia (Ministerio de Ambiente y Desarrollo Sostenible 2014), and this is also outlined specifically for rainbow trout in the AUNAP resolution declaring rainbow trout a domesticated species (2015). AUNAP also requires that the facilities importing trout provide a detailed biosecurity plan that includes procedures to address quarantine for animals entering the facilities, overall prevention of disease presence by management of handling stress, eradication of any identified disease presence, and control of animal human and/or supporting equipment movements between sites. These measures are also inspected by AUNAP as a function of license validity (AUNAP 2015).

Due to certified disease-free facilities (for the pathogens specified above) and requirements on producers and importers for importing rainbow trout into Colombia, the source of transported animals scores 9 out of 10 for both raceways and net pens. As the biosecurity of this source is higher than both the raceway and net pen destinations of the shipments, the score for Factor 10Xb is for the source, and is therefore 9 out of 10.

Conclusions and Final Score

Although the exporting rainbow trout producers in Colombia are entirely dependent on imported eggs and juveniles, the source is a highly biosecure hatchery in the US with little chance of unintentionally transferring live animals or pathogens. Overall, the final score combines Factors 10Xa and 10Xb, and both raceways and net pens receive a minor deduction score of –1.00 out of –10 for Criterion 10X – Escape of secondary species.

Acknowledgements

Scientific review does not constitute an endorsement of the Seafood Watch® program, or its seafood recommendations, on the part of the reviewing scientists. Seafood Watch® is solely responsible for the conclusions reached in this report.

Seafood Watch would like to thank Marcelo Hidalgo (Aquaculture Stewardship Council) and several anonymous reviewers for graciously reviewing this report for accuracy and providing an understanding of many of the laws and enforcement, as well as an avenue to industry data for trout production in Colombia.

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Data Points – Raceway Trout Production

Criterion 1: Data quality and availability

Data Category	Data Quality (0-10)
Industry or production statistics	7.5
Management	5
Effluent	5
Habitats	5
Chemical use	5
Feed	5
Escapes	5
Disease	2.5
Source of stock	10
Predators and wildlife	5
Secondary species	7.5
Other – (e.g., GHG emissions)	n/a
Total	**62.5**

C1 Data Final Score (0-10)	**5.681818182**	**YELLOW**

Criterion 2: Effluents

Factor 2.1 - Biological waste production and discharge

Factor 2.1a - Biological waste production

Protein content of feed (%)	43
eFCR	1.35
Fertilizer N input (kg N/ton fish)	0
Protein content of harvested fish (%)	15.6
N content factor (fixed)	0.16
N input per ton of fish produced (kg)	92.88
N in each ton of fish harvested (kg)	24.96
Waste N produced per ton of fish (kg)	**67.92**

Factor 2.1b - Production System discharge

Basic production system score	0.8
Adjustment 1 (if applicable)	0
Adjustment 2 (if applicable)	0
Adjustment 3 (if applicable)	0
Discharge (Factor 2.1b) score (0-1)	**0.8**

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

Factor 2.1 Score - Waste discharge score

Waste discharged per ton of production (kg N ton-1)	54.34
Waste discharge score (0-10)	**4**

Factor 2.2 – Management of farm-level and cumulative effluent impacts

2.2a Content of effluent management measure	2
2.2b Enforcement of effluent management measures	2
2.2 Effluent management effectiveness	**1.6**

C2 Effluent Final Score (0-10)	**3.00**	**RED**
Critical?	NO	

Criterion 3: Habitat

Factor 3.1. Habitat conversion and function

F3.1 Score (0-10)	8

Factor 3.2 – Management of farm-level and cumulative habitat impacts

3.2a Content of habitat management measure	3
3.2b Enforcement of habitat management measures	2
3.2 Habitat management effectiveness	**2.4**

C3 Habitat Final Score (0-10)	**6**	**YELLOW**
Critical?	NO	

Criterion 4: Evidence or Risk of Chemical Use

Chemical Use parameters	**Score**	
C4 Chemical Use Score (0-10)	**3**	
C4 Chemical Use Final Score (0-10)	**3**	**RED**
Critical?	NO	

Criterion 5: Feed

5.1. Wild Fish Use

Feed parameters	**Score**
5.1a Fish In : Fish Out (FIFO)	
Fishmeal inclusion level (%)	20
Fishmeal from by-products (%)	50

% FM	10
Fish oil inclusion level (%)	6.3
Fish oil from by-products (%)	100
% FO	0
Fishmeal yield (%)	22.5
Fish oil yield (%)	5
eFCR	1.35
FIFO fishmeal	0.60
FIFO fish oil	0.00
FIFO Score (0-10)	**8.50**
Critical?	NO
5.1b Sustainability of Source fisheries	
Sustainability score	–8
Calculated sustainability adjustment	–0.96
Critical?	NO
F5.1 Wild Fish Use Score (0-10)	**7.54**
Critical?	NO

5.2 Net protein Gain or Loss

Protein INPUTS	
Protein content of feed (%)	43
eFCR	1.35
Feed protein from fishmeal (%)	
Feed protein from EDIBLE sources (%)	49.33
Feed protein from NON-EDIBLE sources (%)	50.67
Protein OUTPUTS	
Protein content of whole harvested fish (%)	15.6
Edible yield of harvested fish (%)	65
Use of non-edible by-products from harvested fish (%)	50
Total protein input kg/100kg fish	58.05
Edible protein IN kg/100kg fish	28.64
Utilized protein OUT kg/100kg fish	16.27
Net protein gain or loss (%)	–43.19
Critical?	NO
F5.2 Net protein Score (0-10)	**5**

5.3. Feed Footprint

5.3a Ocean Area appropriated per ton of seafood	
Inclusion level of aquatic feed ingredients (%)	26.3
eFCR	1.35
Carbon required for aquatic feed ingredients (ton C/ton fish)	69.7

Ocean productivity (C) for continental shelf areas (ton C/ha)	2.68
Ocean area appropriated (ha/ton fish)	9.23
5.3b Land area appropriated per ton of seafood	
Inclusion level of crop feed ingredients (%)	49
Inclusion level of land animal products (%)	25
Conversion ratio of crop ingredients to land animal products	2.88
eFCR	1.35
Average yield of major feed ingredient crops (t/ha)	2.64
Land area appropriated (ha per ton of fish)	0.62
Total area (Ocean + Land Area) (ha)	9.85
F5.3 Feed Footprint Score (0-10)	6

Feed Final Score

C5 Feed Final Score (0-10)	**6.52**	**YELLOW**
Critical?	**NO**	

Criterion 6: Escapes

6.1a System escape Risk (0-10)	6	
6.1a Adjustment for recaptures (0-10)	1	
6.1a Escape Risk Score (0-10)	**7**	
6.2. Competitive and genetic interactions score (0-10)	**8**	
C6 Escapes Final Score (0-10)	**7**	**GREEN**
Critical?	**NO**	

Criterion 7: Diseases

Disease Evidence-based assessment (0-10)		
Disease Risk-based assessment (0-10)	4	
C7 Disease Final Score (0-10)	**4**	**YELLOW**
Critical?	NO	

Criterion 8X: Source of Stock

C8X Source of stock score (0-10)	0	
C8 Source of stock Final Score (0-10)	**0**	**GREEN**
Critical?	NO	

Criterion 9X: Wildlife and predator mortalities

C9X Wildlife and Predator Score (0-10)	**–2**

C9X Wildlife and Predator Final Score (0-10)	**-2**	**GREEN**
Critical?	NO	

Criterion 10X: Escape of secondary species

F10Xa live animal shipments score (0-10)	0.00	
F10Xb Biosecurity of source/destination score (0-10)	9.00	
C10X Escape of secondary species Final Score (0-10)	**-1.00**	**GREEN**
Critical?	n/a	

Data Points – Net pen trout Production

Criterion 1: Data quality and availability

Data Category	Data Quality (0-10)
Industry or production statistics	7.5
Management	5
Effluent	5
Habitats	5
Chemical use	2.5
Feed	5
Escapes	2.5
Disease	2.5
Source of stock	10
Predators and wildlife	5
Secondary species	5
Other – (e.g. GHG emissions)	n/a
Total	**55**

C1 Data Final Score (0-10)	**5**	**YELLOW**

Criterion 2: Effluents

Factor 2.1 - Biological waste production and discharge

Factor 2.1a - Biological waste production

Protein content of feed (%)	43
eFCR	1.5
Fertilizer N input (kg N/ton fish)	0
Protein content of harvested fish (%)	15.6
N content factor (fixed)	0.16
N input per ton of fish produced (kg)	103.2
N in each ton of fish harvested (kg)	24.96
Waste N produced per ton of fish (kg)	**78.24**

Factor 2.1b - Production System discharge

Basic production system score	0.8
Adjustment 1 (if applicable)	0
Adjustment 2 (if applicable)	0
Adjustment 3 (if applicable)	0
Discharge (Factor 2.1b) score (0-1)	**0.8**

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

Factor 2.1 Score - Waste discharge score

Waste discharged per ton of production (kg N ton-1)	62.59
Waste discharge score (0-10)	**3**

Factor 2.2 – Management of farm-level and cumulative effluent impacts

2.2a Content of effluent management measure	2
2.2b Enforcement of effluent management measures	2
2.2 Effluent management effectiveness	**1.6**

C2 Effluent Final Score (0-10)	**2.00**	**RED**
Critical?	NO	

Criterion 3: Habitat

Factor 3.1. Habitat conversion and function

F3.1 Score (0-10)	7

Factor 3.2 – Management of farm-level and cumulative habitat impacts

3.2a Content of habitat management measure	3
3.2b Enforcement of habitat management measures	2
3.2 Habitat management effectiveness	**2.4**

C3 Habitat Final Score (0-10)	**5**	**YELLOW**
Critical?	NO	

Criterion 4: Evidence or Risk of Chemical Use

Chemical Use parameters	**Score**	
C4 Chemical Use Score (0-10)	**2**	
C4 Chemical Use Final Score (0-10)	**2**	**RED**
Critical?	NO	

Criterion 5: Feed

5.1. Wild Fish Use

Feed parameters	**Score**
5.1a Fish In : Fish Out (FIFO)	
Fishmeal inclusion level (%)	20
Fishmeal from by-products (%)	50
% FM	10

Fish oil inclusion level (%)	6.3
Fish oil from by-products (%)	100
% FO	0
Fishmeal yield (%)	22.5
Fish oil yield (%)	5
eFCR	1.5
FIFO fishmeal	0.67
FIFO fish oil	0.00
FIFO Score (0-10)	**8.33**
Critical?	NO
5.1b Sustainability of Source fisheries	
Sustainability score	–8
Calculated sustainability adjustment	–1.07
Critical?	NO
F5.1 Wild Fish Use Score (0-10)	**7.27**
Critical?	NO

5.2 Net protein Gain or Loss

Protein INPUTS	
Protein content of feed (%)	43
eFCR	1.5
Feed protein from fishmeal (%)	
Feed protein from EDIBLE sources (%)	49.33
Feed protein from NON-EDIBLE sources (%)	50.67
Protein OUTPUTS	
Protein content of whole harvested fish (%)	15.6
Edible yield of harvested fish (%)	65
Use of non-edible by-products from harvested fish (%)	50
Total protein input kg/100kg fish	64.5
Edible protein IN kg/100kg fish	31.82
Utilized protein OUT kg/100kg fish	16.65
Net protein gain or loss (%)	–47.68
Critical?	NO
F5.2 Net protein Score (0-10)	**5**

5.3. Feed Footprint

5.3a Ocean Area appropriated per ton of seafood		
Inclusion level of aquatic feed ingredients (%)		26.3
eFCR		1.5
Carbon required for aquatic feed ingredients (ton C/ton fish)		69.7
Ocean productivity (C) for continental shelf areas (ton C/ha)		*2.68*

Ocean area appropriated (ha/ton fish)	10.26
5.3b Land area appropriated per ton of seafood	
Inclusion level of crop feed ingredients (%)	49
Inclusion level of land animal products (%)	25
Conversion ratio of crop ingredients to land animal products	2.88
eFCR	1.5
Average yield of major feed ingredient crops (t/ha)	2.64
Land area appropriated (ha per ton of fish)	0.69
Total area (Ocean + Land Area) (ha)	10.95
F5.3 Feed Footprint Score (0-10)	6

Feed Final Score

C5 Feed Final Score (0-10)	**6.38**	**YELLOW**
Critical?	**NO**	

Criterion 6: Escapes

6.1a System escape Risk (0-10)	2	
6.1a Adjustment for recaptures (0-10)	0	
6.1a Escape Risk Score (0-10)	**2**	
6.2. Competitive and genetic interactions score (0-10)	**8**	
C6 Escapes Final Score (0-10)	**5**	**YELLOW**
Critical?	**NO**	

Criterion 7: Diseases

Disease Evidence-based assessment (0-10)		
Disease Risk-based assessment (0-10)	4	
C7 Disease Final Score (0-10)	**4**	**YELLOW**
Critical?	NO	

Criterion 8X: Source of Stock

C8X Source of stock score (0-10)	0	
C8 Source of stock Final Score (0-10)	**0**	**GREEN**
Critical?	NO	

Criterion 9X: Wildlife and predator mortalities

C9X Wildlife and Predator Score (0-10)	**–6**	
C9X Wildlife and Predator Final Score (0-10)	**–6**	**YELLOW**
Critical?	NO	

Criterion 10X: Escape of secondary species

F10Xa live animal shipments score (0-10)	0.00	
F10Xb Biosecurity of source/destination score (0-10)	9.00	
C10X Escape of secondary species Final Score (0-10)	**-1.00**	**GREEN**
Critical?	n/a	