Monterey Bay Aquarium Seafood Watch®

Chinook Salmon

Oncorhynchus tshawytscha

Image ©Monterey Bay Aquarium

New Zealand

Marine Net Pens, Freshwater Net Pens

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

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

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

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Guiding Principles

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

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

Seafood Watch will:

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

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

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

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

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

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

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

Final Seafood Recommendation – Marine Farms

Criterion	Score (0-10)	Rank	Critical?
C1 Data	9.20	GREEN	
C2 Effluent	8.00	GREEN	NO
C3 Habitat	7.73	GREEN	NO
C4 Chemicals	10.00	GREEN	NO
C5 Feed	4.96	YELLOW	NO
C6 Escapes	10.00	GREEN	NO
C7 Disease	8.00	GREEN	NO
C8 Source	10.00	GREEN	
C9X Wildlife Mortalities	-6.00	YELLOW	NO
C10X Introduced Species Escape	-0.80	GREEN	
Total	**61.06**		
Final score	**7.63**		

Final Score	7.63
Initial rank	GREEN
Red criteria	0
Interim rank	GREEN
Critical Criteria?	NO
Final Rank	GREEN

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

The final numerical score for marine farming of Chinook salmon in New Zealand is 7.63 of 10. With no red criterion, the final Seafood Watch recommendation is a Green “Best Choice.”

Final Seafood Recommendation – Freshwater Farms

Criterion	Score (0-10)	Rank	Critical?
C1 Data	8.90	GREEN	
C2 Effluent	8.00	GREEN	NO
C3 Habitat	9.07	GREEN	NO
C4 Chemicals	10.00	GREEN	NO
C5 Feed	5.56	YELLOW	NO
C6 Escapes	10.00	GREEN	NO
C7 Disease	8.00	GREEN	NO
C8 Source	10.00	GREEN	
C9X Wildlife Mortalities	0.00	GREEN	NO
C10X Introduced Species Escape	-0.80	GREEN	
Total	**68.72**		
Final score	**8.59**		

Final Score	8.59
Initial rank	GREEN
Red criteria	0
Interim rank	GREEN
Critical Criteria?	NO
Final Rank	GREEN

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

The final numerical score for marine farming of Chinook salmon in New Zealand is 8.59 of 10. With no red criterion, the final Seafood Watch recommendation is a Green “Best Choice.”

Executive Summary

Chinook salmon (also known as King salmon) were initially introduced into New Zealand as a game fish in the mid-1800s, and the species was considered fully established in the early 1900s. In 1976 the first freshwater Chinook salmon farm was established in New Zealand, followed in 1983 by the first marine farm. Although attempts were made to farm other species, Chinook remains the only salmon farmed in New Zealand.

Total production of farmed salmon in New Zealand in 2013 reached 10,843 mt, with approximately 90% coming from marine production and the remaining 10% from freshwater. This makes up approximately 88% of the global production of Chinook salmon, with the remaining production coming from Chile and Canada. The New Zealand King Salmon Company (NZKS) accounts for up to 65% of the total salmon production in New Zealand (around 7,889 mt in 2012 and 6,217 mt in 2013) and approximately 62% of the global Chinook salmon production. Production by Mount Cook Alpine Salmon Ltd (MCAS) using net pens in freshwater hydrocanals accounts for approximately 9% of the total Chinook salmon production in New Zealand, and approximately 40% of freshwater production. A few smaller marine and freshwater salmon farms make up the remainder. Combined, NZKS and MCAS provide the majority of exports into North America (902 mt in 2013).

The industry in New Zealand is, therefore, small compared to other countries. For example, salmon production in Norway (of Atlantic salmon) is currently over 100-times greater than New Zealand's, at 1.2 million mt (1,232,095 mt in 2012). Production in New Zealand recently went through an expansion phase, however, of the 9 additional farm sites that initially applied for expansion by NZKS, only 3 were granted. Therefore, any further expansion of the industry into marine areas is unlikely in the near future. While there is a potential for a 60% production increase due to the addition of 3 new sites, the small scale of the current industry in New Zealand means that the potential for impacts is lower when compared to those of more intensive salmon farming regions.

This Seafood Watch report covers all Chinook salmon farming in New Zealand, but is separated where relevant into two assessments for marine farms and freshwater farms in order to highlight the differences between these production methods. The assessments focus on the two dominant producers in each category (NZKS in the marine environment, and MCAS in freshwater), but are considered relevant to the similar but smaller producers.

Data collection and availability in New Zealand salmon farming is generally robust, with resource consent applications, monitoring reports and historical data available to the public. Marine salmon farming in New Zealand is in the process of an expansion, and publically available expert evidence provided to the Board of Inquiry making the final decisions on applications for new sites has been utilized where applicable. The unique ecology of New Zealand provides a situation where maintenance of some forms of data are currently limited; e.g., with no history of disease outbreaks in salmon farming in New Zealand there have been minimal requirements for data and record keeping of disease, and reporting of outbreaks to any regulatory authority has not been necessary. This type of situation is present in several other areas of the criteria as well (for example, chemical use and monitoring of ecological impacts from escaped Chinook), where a lack of historical events has resulted in minimal record keeping or data collection. The final data score for marine salmon farming is 9.2 of 10, while freshwater salmon farming has a final data score of 8.9 of 10.

Impacts beyond the immediate farm area of effluent discharge from both marine and freshwater salmon farming have proven to be minimal within the water column and the benthos. Monitoring reports for both marine and freshwater salmon farms show little to no impact from effluent in the water column beyond farm site boundaries. In marine environments, the monitoring of nitrate, nitrite, dissolved reactive phosphorous (DRP) and ammonia-N in the water column show levels remaining very similar across the entire gradient from the farm sites out to the furthest sampling site (usually 250m. from the pens). Freshwater sites monitor for suspended solids, ammonia nitrogen, 5-day biochemical oxygen demand (BOD), nitrate nitrogen, nitrite nitrogen, total nitrogen, total phosphorus and total mercury. Monitoring for freshwater farms consistently shows no impact from effluent in the hydrocanals or in the stilling basin where sediment is captured, and the amount of solids that can be generated by the farms is capped at a level, which is believed by the agency granting resource consents, to have no ecological impact on the surrounding environment. Both marine and freshwater farming have been given an effluent score of 8 of 10.

Marine and freshwater salmon farming operations occupy very different habitats, with freshwater net pen farms located in canals previously constructed for hydropower, while the marine net pens are located in the natural inshore marine environment. In marine environments, benthos directly below the pens and within the allowable zone of impact show signs of enrichment, however, these impacts do not reach beyond the permitted area for any of the farm sites. Enriched sites have shown a shift back toward background levels within 1-2 years after production has ended at the site, and can fully return to background levels within 5 or more years. Freshwater farms have consistently shown no impact to environments within the farm sites, including the benthos beneath and around pens. Marine farming has been given a score of 7.73 of 10 and freshwater farming has been given a score of 9.07 of 10.

Unlike other major salmon farming regions (farming Atlantic salmon), disease and parasite outbreaks requiring treatment with antibiotics, pesticides or other chemicals have not been present in the New Zealand Chinook farming industry. This is considered to be due to the relatively small scale of production and also the low susceptibility of Chinook salmon to parasitic sea lice. In addition, local environmental conditions, regional planning efforts, and effective biosecurity measures at the hatchery and farm levels minimize the risk of disease and parasites occurring on the farm sites and being transferred to wild populations. Antifoulants are no longer used to treat the net pens. Therefore, chemical use is currently considered to be negligible, and both marine and freshwater salmon farming in New Zealand have been given a score of 10 of 10 for the Chemicals Criterion.

Due to differences in feed conversion ratio (fish in: fish out ratio (FIFO)) and other aspects of feed formulation, feed scores for marine and freshwater salmon farming have been calculated separately. The FIFO value for marine salmon farming is 2.1 resulting in a score of 4.75 of 10. The FIFO value for freshwater salmon farming is 1.68 due to a lower feed conversion ratio (FCR) leading to a score of 5.8 of 10. Marine salmon farming has a net protein loss of -46.8% while freshwater has a protein loss of -37.1%. The final feed criterion score for marine salmon farming is 4.96 of 10 and the final feed criterion score for freshwater marine salmon farming is 5.56 of 10. While the overall score for this criterion results in a Yellow rating for both marine and freshwater salmon farming in New Zealand, it must be noted that there are still significant conservation concerns, such as protein losses as well as FIFO values that are higher than those commonly attained in the farming of Atlantic salmon.

With respect to escapes, Chinook salmon are non-native in New Zealand, but are now considered to be fully established in the region. There are no wild native stocks of Chinook salmon that could be impacted by an escape of farmed Chinook. Juvenile salmon are deliberately released from the same hatcheries supplying farms through a government program to stock recreational fisheries throughout New Zealand. Because this intentional and routine release of salmon into the wild occurs in numbers far greater than would occur in even a large escape from a salmon farm, the accidental release of farmed salmon from the same hatcheries or the farms is considered (in this assessment) to have little to no additional impact on the ecosystem. While net pens are generally scored as a system with a high risk of escapes by Seafood Watch, this scenario creates a unique circumstance that justifies a high score of 10 of 10 for both marine and freshwater salmon farming in New Zealand.

While multiple pathogens have been recorded in cultured salmon in New Zealand, none of them have been classified as posing a significant risk to wild fish populations and no clinical disease outbreaks have been reported or recorded in either marine or freshwater salmon farming. There are currently no records of sea lice being present on farmed Chinook salmon in New Zealand. Despite no disease outbreaks having been recorded, the potential amplification, and/or discharge of disease from an open system is still a risk. This leads to a score of 8 of 10 for the Disease Criterion for both marine and freshwater salmon farms.

All salmon raised in marine and freshwater farms in New Zealand are sourced from hatchery-raised broodstock. Both marine and freshwater salmon farming get scores of 10 of 10 for the Source of Stock Criterion, as the industry is considered to be independent of wild fisheries for broodstock or juveniles.

The potential for wildlife and predator interactions with marine salmon farms includes several species of birds and marine mammals that are native to the largest salmon farming areas. Three of the species are considered endangered; Hector's dolphins are endemic to New Zealand, and are listed as both endangered by the IUCN and nationally endangered by the New Zealand Department of Conservation; bottlenose dolphins and southern right whales are also endemic to the area and are listed as nationally endangered. Due to their small local population sizes in the salmon farming regions of New Zealand, it is considered that any human-related deaths of these endangered species may impact the populations. Of these endangered species, one Hector’s dolphin was found dead under a net pen at the Ruakaka Bay farm site in 2005 (cause of death unknown), and one bottlenose dolphin died on a salmon farm site due to entanglement in nets in 2010.

Management measures (net changes) were implemented in 2010 to minimize further predator interactions, but occasional mortalities of non-endangered dolphin species have continued (the most recent in 2013). In all, 8 dolphin mortalities have occurred at salmon farming sites in New Zealand since operations began in 1984. Seven of these 8 have been on farm sites currently owned by NZKS, although one mortality of a bottlenose dolphin occurred on the site prior to it being owned by NZKS. While 6 of these deaths have been positively identified, the remainder (some of which have been anecdotally recorded as Hector’s and bottlenose dolphins) have not been positively identified. Overall, while there have been no confirmed deaths of IUCN listed species (Hector’s dolphin) and only one confirmed mortality of a nationally endangered species (bottlenose dolphin) in the 30-year history of the industry, the potential for these species to be included in the remaining unidentified mortalities (or potential future mortalities) is a concern. Other non-endangered or threatened marine mammals are often present at marine farm sites, most commonly the New Zealand fur seal. Approximately 2-3 New Zealand fur seals die each year at salmon farming sites. Populations of New Zealand fur seals are high enough that they are not impacted by these mortalities. With respect to the Seafood Watch criteria scoring, the very low numbers involved over the history of the industry are noted along with improving production practices that reduce the risk of entanglement. However, the potential for isolated mortalities remains a moderate concern due to their conservation status and population sensitivity. The score for the Wildlife and Predator Criterion is therefore -6 out of -10 for marine farms.

Freshwater salmon farming in New Zealand is done entirely in man-made hydrocanals, which are not home to any natural predators of salmon aside from small numbers of diving birds. There have been no reported mortalities of predators at any freshwater salmon farms, and measures have been taken that keep birds from getting into pens and getting tangled. Freshwater salmon farming has been given a score of 0 of -10 for criterion 9X.

Stocking of both marine and freshwater salmon farms in New Zealand is entirely reliant on hatchery-raised juveniles from within New Zealand. Hatcheries are often owned by the farm, with a few privately owned hatcheries supplying smaller farms in freshwater hydrocanals. Therefore, there is no concern regarding the potential introduction of non-native organisms into New Zealand during the international shipment of live salmon (eggs). Juveniles however, are moved from the hatchery to the growout facilities, which are in separate bodies of water and there is a potential for the movement of pathogens from one water body to another. Although the destination of the animal movements is open to the environment (net pens), the source hatcheries are considered to be relatively biosecure and, therefore, there is a low concern for the potential unintentional movement of pathogens or other species. The result is a minor penalty score of -0.80 of -10 for marine and freshwater farms for Criterion 10X.

Overall, the New Zealand salmon farming industry is characterized by its small scale of production and the culture of a historically established species that is currently unaffected by disease or parasite outbreaks. Effluent and habitat impacts have been well-studied and shown to be minor, chemical use is minimal, and with deliberate government stocking of Chinook salmon in New Zealand, escapes from salmon farms also have a low risk of significant impact. Overall, the final recommendation for Chinook salmon farmed in both marine and freshwater net pens is a green “Best Choice.”

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Introduction

Scope of the analysis and ensuing recommendation

Species: Chinook salmon (*Oncorhynchus tshawytscha*) (Walbaum, 1792)

Geographic coverage: New Zealand

Production Methods: Marine and Freshwater Net pens/cages

Species Overview

Chinook salmon are the largest species of the Pacific salmon genus (*Oncorhynchus*). They are an anadromous fish, native to the Pacific Ocean, ranging from the Bering Strait in Alaska to Southern California (NOAA 2013). Wild Chinook salmon spend between 3 months and 2 years in freshwater before spending 2-4 years at sea. They then migrate back to the streams and rivers where they were born, to spawn and die. Wild Chinook salmon mature when they are at a length of about 36" (~30 lbs.) and can often weigh around 18 kg (40 lbs.). They have been reported weighing over 54.43 kg (120 lbs.) (NOAA 2013). In production, Chinook salmon are often in the growout stage for around 18 months and reach an average market size of 3.5–4.0 kg (7.72-8.82 lbs.) at harvest (NZKS 2014). In the wild, Chinook salmon feed on terrestrial and aquatic insects as well as amphipods and other crustaceans. Older Chinook salmon tend to feed on smaller fish (NOAA 2013a). Farmed Chinook salmon are given feeds formulated using various combinations of aquatic and terrestrial crop and animal products.

Common and market names: Chinook salmon, king salmon, quinnat salmon, spring salmon

Product forms: Whole fresh and frozen, filets, steaks, smoked, gravlax

Production statistics:
Total production of Chinook salmon in New Zealand reached 12,397 mt in 2012, and 10,843 mt in 2013, with approximately 90% coming from marine production and the remaining 10% from freshwater (Clarkson 2014; FAO 2014). This makes up approximately 88% of the global production of Chinook salmon, with the remaining production coming from Chile (FAO 2014). FAO figures do not, however, take into account production of farmed Chinook in Canada, which is a significant exporter of Chinook to the United States (NOAA 2014). As a comparison of production levels, salmon production in Canada (mainly Atlantic salmon) reached approximately 108,118 mt in 2012, while salmon production in Norway (mainly Atlantic salmon) reached 1,232,095 mt (FAO 2014).

The majority of commercial production of Chinook salmon in New Zealand is from the company New Zealand King Salmon (NZKS), which accounts for up to 65% of the salmon production in

New Zealand and 62% of the global Chinook salmon production (NZKS 2014b). Production by Mount Cook Alpine Salmon Ltd (MCAS) accounts for approximately 10% of Chinook salmon production in New Zealand and approximately 40% of New Zealand's freshwater Chinook salmon production. Sanford, Akaroa Salmon, Benmore Salmon and High Country Salmon make up the remainder. NZKS, Sanford and Akaroa Salmon all produce Chinook in marine pens, while Benmore Salmon, High Country Salmon and MCAS produce Chinook in freshwater hydrocanals. Salmon farming in New Zealand is located in 3 major farming regions: 1. the Marlborough Sounds, 2. Canterbury (including inland freshwater areas), and 3. Southland in Big Glory Bay off the coast of Stewart Island (NZSFA 2011). NZKS owns 8 farm locations throughout the Marlborough Sounds, 5 of which are in use at one time (NZKS 2014b). Recently, three more farm sites have been granted to NZKS, however, production at these sites has not yet begun. MCAS has taken a different approach to salmon farming, growing Chinook in net pens in freshwater hydrocanals fed by runoff from the Southern Alps (MCAS 2014).

Worldwide, the other countries commercially producing a significant amount of Chinook salmon are Chile and Canada. In 2013, the United States imported 902 mt of farmed Chinook salmon from New Zealand, 1,638 mt from Canada, and 6 mt from Chile (Clarkson 2014; NOAA 2014). The majority of New Zealand farmed Chinook salmon is consumed domestically. For example, 60% of the salmon produced by NZKS is sold within the country. Australia and the United States are the largest importers, each purchasing 13% of the product from NZKS, while Japan follows with 6%, South East Asia with 6% and the rest of the world making up the remaining 2% (NZKS 2014b).

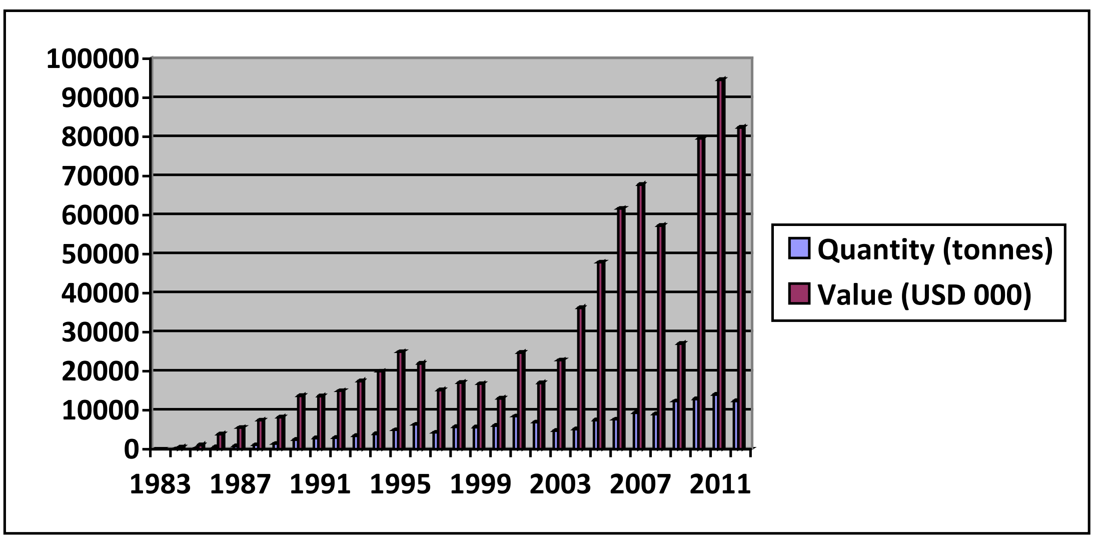

Figure 1. Chinook salmon produced in New Zealand. Source: (FAO 2014) FIGIS Database

Analysis

Scoring guide

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

Criterion 1: Data quality and availability

Impact, unit of sustainability and principle

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

Marine farms

Data Category	Relevance (Y/N)	Data Quality	Score (0-10)
Industry or Production Statistics	Yes	10	10
Effluent	Yes	10	10
Locations/Habitats	Yes	10	10
Predators and Wildlife	Yes	10	10
Chemical Use	Yes	7.5	7.5
Feed	Yes	10	10
Escapes, Animal Movements	Yes	7.5	7.5
Disease	Yes	10	10
Source of Stock	Yes	7.5	7.5
Other – (e.g., GHG Emissions)	No	Not Relevant	n/a
Total			**82.5**

C1 Data Final Score	**9.2**	**GREEN**

Freshwater Farms

Data Category	Relevance (Y/N)	Data Quality	Score (0-10)
Industry or Production Statistics	Yes	10	10
Effluent	Yes	10	10
Locations/Habitats	Yes	10	10
Predators and Wildlife	Yes	7.5	7.5
Chemical Use	Yes	7.5	7.5
Feed	Yes	10	10
Escapes, Animal Movements	Yes	7.5	7.5
Disease	Yes	10	10
Source of Stock	Yes	7.5	7.5
Other – (e.g., GHG Emissions)	No	Not relevant	n/a
Total			**80**

C1 Data Final Score	**8.9**	**GREEN**

Criterion 1 Summary

Data collection and availability in New Zealand salmon farming is generally quite robust, with resource consents, monitoring reports and historical data available to the public. Marine salmon farming in New Zealand is in the process of an expansion. Evidence provided by experts to the Board of Inquiry has been utilized as data sources, helping to make the final decisions on the expansion. Areas where data are not robust are a product of the unique ecology of New Zealand, providing a situation where maintenance of data is relatively unnecessary, (e.g., no history of disease outbreaks in salmon farming results in minimal requirements for data and record keeping, and reporting of outbreaks to any regulatory authority has not been necessary). This situation has led to no use of antibiotics in salmon farming in New Zealand, which, in turn, makes data collection on their use non-existent. This type of situation is present in several other areas of the criterion as well, where a lack of historical events has resulted in minimal record keeping requirements. In these situations, scoring has been based on the capacity of the industry to respond to potential future impacts, and its use of contingency plans, and availability of information that describes potential impacts and management strategies. The final data score for marine salmon farming is 9.2 of 10 and the final score for freshwater salmon farming is 8.9 of 10.

Justification of Ranking

Marine and Freshwater Sites

Industry or production statistics:
Due to the small size of the Chinook salmon farming industry in New Zealand, many of these statistics are provided directly by the farms themselves. Data on the size of the industry are

readily available on the websites of both the largest salmon producer in the country as well as the New Zealand Salmon Farmers Association http://www.salmon.org.nz/, which represents the industry as a whole. Both marine and freshwater salmon farming get scores of 10 of 10 for industry and production statistics.

Effluent:

Resource consents outlining permit conditions for individual sites within a farm are publicly available for both marine and freshwater farms in New Zealand. Annual monitoring reports for the largest marine salmon producing farm in New Zealand are publicly available in a non-aggregated format. These data include information on dissolved oxygen levels (DO), nitrate and nitrite levels, ammonia-N, dissolved reactive phosphorus (DRP) and chlorophyll-a (Chl-a). Monitoring reports for the largest freshwater salmon farm in New Zealand have been provided by the farm for purposes of this assessment, and historical data showing aggregated monitoring data for multiple sites are available publicly, along with drinking water quality test results made available by the regional council. Both marine and freshwater farms have been given data scores of 10 of 10 for effluent data.

Habitats:

Farm locations are all available through direct contact with the farms themselves (due to the small size of the industry in New Zealand), as well as on the websites and through the industry's representative organization, Aquaculture New Zealand. For marine farms, monitoring reports and resource consents address the suitability of sites for salmon and clearly describe the habitat types and farming impacts on the environment on a site-by-site basis annually. These resource consents also include enforcement measures and a direct link for the enforcement agency to take action if necessary. Resource consents, which outline farm locations and habitat types, along with permit requirements are available for freshwater farms . In freshwater farming environments, habitat data are very limited due to the man-made nature of the habitat itself, as well as the minimal impacts due to the high-flow of water. Resource consent requirements for freshwater farms focus on water quality impacts, (assessed in the Effluent Criterion of this report), rather than potential habitat impacts as defined by the Seafood Watch criteria. No benthic impacts have been recorded at farm sites in dive surveys carried out by the hydroelectric companies that own the hydrocanals as well as MCAS. Both marine and freshwater salmon farming have a score of 10 of 10 for habitat data.

Chemical Use:

The use of chemicals in New Zealand salmon farming in both marine and freshwater farms is minimal due to a lack of disease or parasites present in the farming areas. However, there is a paucity of data confirming this, and a challenge to confirm anecdotal reports. A signed letter from a contracted veterinarian (used by the largest marine salmon farm in New Zealand) has been provided, along with a hazardous materials log from the largest freshwater farm with a statement from their contracted veterinarian—both confirming that there is no use of antibiotics. The chemical register for 1 of 8 NZKS farms was provided, which also shows no registration of any antibiotics at the site. While it is understood that this may, in fact, be due to the lack of any need for antibiotics, a conservative chemical data score of 7.5 of 10 is assigned to both marine and freshwater salmon farms.

Feed:
Detailed feed data for both marine and freshwater salmon farms was provided for purposes of this assessment. Ingredients and sources, FCR, inclusion rates of FM and FO and byproducts were provided by the main feed provider for the largest marine farm in New Zealand, and these same details were provided by the largest freshwater farm, which uses a different feed supplier and formulation. Both marine and freshwater farms received a feed data score of 10 of 10.

Escapes:
Data regarding numbers or size of escaped salmon from both marine and freshwater salmon farms have not been provided and are not publicly available. Anecdotal evidence from multiple individuals familiar with the industry as well as evidence formally submitted to the Board of Inquiry for the NZKS hearing state that impacts of escaped Chinook salmon on the ecosystem are minimal, based on the small size of the industry and on the non-native status of salmon stocks in the wild as well as those farmed. Data have been made available that confirm the permitted release of Chinook from hatcheries for recreational fishing purposes. Information available from Fish and Game New Zealand outlines areas where recreational salmon fishing takes place and specifies daily bag limits. This information informs the Recapture and Mortality score in the Escapes Criterion for both marine and freshwater farms.

Animal movements:
This factor assesses the availability of data concerning movement of live animals between countries and between distinct water bodies. A statement of evidence submitted to the Board of Inquiry outlines biosecurity measures that should be taken in the event of the expansion of NZKS; it does not outline biosecurity measures on existing farm sites in New Zealand. The Biosecurity protocols for NZKS have been provided for purposes of this assessment, and apply to both hatchery (source) and farm (destination) sites. A copy of a permit granted to NZKS for transfer of smolt from a hatchery to a growout site was also provided, which shows the origin, destination, date of transfer, authorization, fish health status and other parameters. MCAS provided its biosecurity plan, which outlines measures taken to minimize risk of disease transfer.

Marine and freshwater salmon farming both have a final escapes and animal movements data score of 7.5 of 10

Disease:
This factor assesses the availability of data describing the impacts (or potential impacts) of disease either originating at the farm level or aggregating at the farm level on wild species. Multiple individuals with expertise in farmed salmon diseases have provided publicly available evidence to the Board of Inquiry in relation to the proposed expansion of the largest marine salmon farm in New Zealand. This information describes the risk of an outbreak of specific infectious diseases of concern to marine salmon farming in New Zealand. However, to date,

there have been no infectious disease outbreaks, hence no available data identifying parasite or pathogen outbreaks, numbers of mortalities, or treatments. This same scenario exists for freshwater salmon farming, where disease outbreaks have not been recorded, making collection of data impossible. Publicly available data from OIE and quarterly investigation results corroborate information from individuals stating that no disease outbreaks have ever been recorded in salmon farming in New Zealand. Various veterinarians for the largest marine and freshwater farms in New Zealand provided letters stating that no outbreaks of infectious disease have occurred. A biosecurity plan and disease contingency plan have been made available from the largest freshwater salmon farm, including processes for data collection. These factors have led to a disease data score of 10 of 10 for marine and freshwater farms.

Source of Stock:
This factor assesses the availability of data describing the farm's independence from active capture of wild fish for broodstock and growout operations. Data detailing the source of stock for both marine and freshwater salmon farms in New Zealand are available in the form of anecdotal evidence provided by numerous individuals familiar with the industry, as well as a statement of evidence offered to the Board of Inquiry regarding the proposed expansion of the largest marine salmon farm. One record of transfer between a hatchery and farm growout was made available by NZKS. Anecdotal evidence collected in surveys of multiple individuals familiar with farming of Chinook in New Zealand states that broodstock used to produce growout stock is entirely hatchery raised. Because of this, the data scores for both marine and freshwater salmon farming in New Zealand are 7.5 of 10.

Predators and wildlife:
Data concerning interactions between salmon farms and wildlife/predators are very robust for marine farms. Because of the proposed expansion by the largest marine salmon farm in New Zealand, studies have been conducted by experts (hired by the farms), which outlined the risk of interactions with predators as well as the potential impacts to populations from these interactions . Current data from existing farms are the basis for these conclusions. Data regarding the status of potentially impacted species are available from the IUCN as well as (at the regional level) from the New Zealand Department of Conservation. Instances of mortalities of wildlife either attributed to farming practices or even in the vicinity of a farm (whether it was related to the farm practices or just coincidental) are documented in these independent and contracted studies and are publicly available. Marine salmon farming in New Zealand has a predator and wildlife interaction data score of 10 of 10.

Freshwater salmon farming provides little data on wildlife and predator interactions with salmon farms, however, similar to the situation with habitat impacts, this is a function of very few incidents of interactions and little need for data collection. Data are available in the form of anecdotal evidence from multiple individuals (familiar with the industry) that have stated independently that minimal, if any, predator interactions occur at salmon farms in freshwater hydrocanals, as most of the usual predators are not present in these man-made environments. Freshwater salmon farming in New Zealand has a predator and wildlife interaction data score of 7.5 of 10.

Overall, the final score for the Data Criterion for marine salmon farms in New Zealand is 9.2 of 10 and the final score for the Data Criterion for freshwater salmon farms in New Zealand is 8.9 of 10.

Criterion 2: Effluents

Impact, unit of sustainability and principle

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

Marine farms

C2 Effluent Final Score	**8.00**	**GREEN**

Freshwater farms

C2 Effluent Final Score	**8.00**	**GREEN**

Criterion 2 Summary

Due to the small size of the industry in New Zealand, there is a small amount of effluent discharged to the surrounding environments, which is monitored and reported to the appropriate regional council managing the resource consents for farm sites. Data are in the form of monitoring reports for both marine and freshwater farms that assess site compliance with resource consent conditions, as well as literature covering the subject of water quality associated with salmon farming. Where applicable, scientific evidence submitted to the board of inquiry during the hearings associated with the expansion of New Zealand King Salmon to new sites in the Marlborough Sounds is used as well. Overall, impacts beyond the immediate farm area of effluent discharge from both marine and freshwater salmon farming have been shown to be minimal. Marine farming has been given an effluent score of 8 of 10 and freshwater farming has been given a score of 8 of 10.

Justification of Ranking

For the Effluent Criterion, the evidence-based assessment was used due to the large amount of available data covering potential impacts to the water column from marine and freshwater salmon farms in New Zealand

The Seafood Watch criteria assess the environmental impacts of waste from salmon farms both within and beyond the allowable zone of impact (AZE). The Effluent Criterion (Criterion 2) assesses impacts of both particulate and soluble wastes beyond the immediate vicinity of the farm sites or AZE. The following Habitat Criterion (Criterion 3) assesses the impacts of particulate wastes directly under the farm and within the AZE.

Marine Sites
Impacts to water quality from salmon farming in net pens have been studied extensively around the world, and while academic literature specifically relating to water quality impacts from salmon farming in New Zealand is minimal, monitoring reports for both marine[2] and freshwater[3] farms provide practical evidence of impacts to levels of dissolved oxygen (DO), nitrate and nitrite, ammonia-N, dissolved reactive phosphorus (DRP) and chlorophyll-a (Chl-a). Approximately 80% of nutrient wastes from salmon farms are discharged in the form of soluble ammonia and ammonium excreted across the gills (Gormican 1989).

Nitrogen and phosphorus also enter the water column in a particulate form through waste feed and feces that fall beneath pens and settle on the sea floor (see the Habitat Criterion below for impacts to the area directly under the farm). While the increased nutrient input to the water column from salmon farming has the potential to increase the phytoplankton biomass (using chlorophyll-a as a proxy) monitoring of the eight NZKS sites has never shown Chl-a levels increase to a level that could have an ecological impact. A search of literature relating to harmful algal blooms (HAB) in the Marlborough Sounds turns up reports of a naturally caused HAB in 1989 that caused mortalities of farmed salmon at Stewart Island, but nothing correlating salmon farming with HAB formation in New Zealand. In a report assessing water column effects to the Marlborough Sounds from NZKS salmon farming, the third party conducting the assessment concludes that "to date, there appears to be no spatial correlation between existing salmon farm operations and HAB formation…" (Paul Gillespie 2012). The same report goes on to acknowledge the potential for such an impact to be made in the case of overlapping nutrient enrichment in the water column, and concludes that in the face of expansion of the industry, monitoring of water column effects that address the local marine environment is necessary, but to date there have been no correlations between existing salmon farming operations in the Marlborough Sounds and HAB formation (Paul Gillespie 2012). This is echoed in evidence offered to the Board of Inquiry stating that HABs have not been linked to salmon farming operations in New Zealand thus far, and proposed expansion will likely not produce enough nutrients to trigger the development of any HABs in the future (Mackenzie 2012).

The monitoring reports for NZKS farm sites indicate that DO levels, while often becoming slightly lower directly beneath the pens and increasing in a gradient away from the site, are not impacted by farming practices in a way that causes any significant ecological impacts, and levels were not impacted beyond the consented area.

Additionally, the monitoring reports for NZKS farm sites almost unanimously indicate levels of nitrate, nitrite, DRP and ammonia-N remaining very similar across the entire gradient from the farm sites and out to the farthest sampling site (usually 250 m from the pens). Ammonia-N has

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[2] This refers to multiple monitoring reports available through the Marlborough District Council website using Resource Consent numbers for each of the NZKS farm sites. http://www.marlborough.govt.nz/Services/Property-File-Search.aspx

[3] This refers to historical aggregated monitoring data that is publicly available at http://mtcookalpinesalmon.com/Images/EcoSustainability/Update%20of%20Water%20Testing%20Results%20-%20Nov%202011.pdf as well as multiple monitoring reports that are not publicly available but have been provided for this assessment.

been found (at several of the sites) to be slightly elevated at the pen site, however, in these cases it is reduced to near-background levels by the closest sampling site (usually 50-70 m).

While these values may seem low, it should be taken into account that production of salmon in Norway (the country producing the most intensively farmed salmon) also shows relatively low impacts to the water column from a much larger scale of production in a single fjord (the Hardangerfjord). The Hardangerfjord produces approximately 70,000-80,000 mt of salmon annually (Bridson 2014; V. Husa 2014), whereas the Marlborough Sounds produce approximately 6,000 - 8,000 mt annually (Rosewarne 2014). Similar to Norway, despite the output of nutrients from salmon farming in New Zealand, this increase in nutrients entering the water column is considered insignificant compared to the amount of coastal nutrients already existing in the natural environment. In the case of New Zealand, the input of nutrients to the water column from existing NZKS sites has been found to be “well within experimentally derived ‘critical limits’ for nutrient loading” for the Marlborough Sounds (Paul Gillespie 2012).

The insignificant increase in nutrients entering the water column from salmon farming in the marine environment combined with data showing that these nutrients do not contribute to cumulative local or regional impacts, result in a score of 8 of 10 in the Effluent Criterion for marine salmon farms.

Freshwater sites

Resource consents for freshwater farming of Chinook salmon in New Zealand thus far have all been issued in Canterbury by the regulatory agency Environment Canterbury (ECAN). These consents require monitoring of suspended solids, ammonia-N, 5-day biochemical oxygen demand (BOD), nitrate, nitrite, total nitrogen, total phosphorus and total mercury. Currently, of these 8 parameters, only 4 have stated thresholds for salmon farming: BOD 2 mg/L, ammonia-N 0.1 mg/L, nitrate 11.3 mg/L and total mercury 0.002 mg/L. The others are assessed in relation to the entire drainage area in which the canals are located and do not include limits specific to salmon farming (Bradley 2014). The environmental regulatory body overseeing the resource consents may impose limits on the remaining 4 parameters at any time if it is determined that limits are necessary (Bradley 2014). With the initial lease to MCAS, testing was implemented to monitor water in hydrocanals around salmon farming sites (according to the New Zealand Drinking Water Standards (NZDWS)) to meet standards for potable water upstream and downstream of the farm sites. Due to the maintained consistency with these requirements, this monitoring is no longer a requirement of the lease for MCAS sites, however, farm-level monitoring shows that water in the hydrocanals is identical above and below farm sites, and still consistent with NZDWS. Monitoring of water quality in the stilling basin where sediments collect (glacial, plant material, and salmon farming effluent) show dissolved oxygen, 5-day biochemical oxygen demand, nitrogen and phosphorous levels all the same as levels above the farm (Bradley 2014).

During periods of discharge (while the farm is in operation) monitoring at each site is conducted twice annually at approved sites upstream and downstream of the farm sites (ECAN 2013).

Dishcharge limits are consented for up to 822 kg per day (of effluent waste from feed and feces). This, in turn, reduces the amount of effluent waste entering the hydrocanals from excess feed or feces (Bradley 2014). This limit has never been met due to low production levels on the farm sites and the stringent management of feed inputs, and is capped at a level that is believed to minimize impacts to the environment (ECAN 2013).

The only contaminant inputs permitted in the resource consents are fish feed, fish excreta, and chloramine-T, which is not used at any of the MCAS sites (ECAN 2013; Bradley 2014). Detailed monitoring data have been provided by MCAS for each monitoring site, for one of 2 monitoring events in 2013. as Additionally, independent analysis was completed in 2012 to determine compliance in the site areas with NZDWS. These analyses address BOD, ammonia-N and nitrate N. Historical data have also been provided that show monitoring results for 5-day BOD, ammonia-N, and nitrate N from 1993 to 2011 by MCAS. Other parameters are included in these historical data, however, they are not among the data required by ECAN in resource consents and do not have limits set. They are therefore not included in this report. While some gaps in data exist, language in compliance monitoring reports states that previous years not included in the current monitoring reports are consistent with the fully compliant findings of the current monitoring results (ECAN 2013b; ECAN 2013c). Water quality monitoring tests completed in 2012 by an independent laboratory service at both sites show that water both up and downstream of MCAS sites meets all drinking water quality standards for New Zealand (ELS 2012; ELS 2012a). The monitoring of mercury is included in the 2013 consent monitoring reports provided by MCAS. Monitoring data for mercury does not reach earlier than 2013, however, ECAN has deferred to testing of feeds used by MCAS due to consistent findings that mercury content is much lower than the stated limit (ECAN 2013b; ECAN 2013c). Total suspended solids are monitored as a function of feed inputs. Historical data has been provided by MCAS that shows amounts of TSS upstream, at and downstream of the farm sites.

5-day BOD:
Resource consents set the BOD limit for MCAS sites at 2 mg/L (Bradley 2012). Publicly available data provided by MCAS illustrate the trends in BOD levels between December of 2001 and July 2011 (Bradley 2012). These records show that BOD levels upstream, at the farm sites and downstream of the farm sites were all identical for each year. Monitoring from February 2002 shows a drop from 2 mg/L to 1 mg/L, which is consistent between all monitoring sites, and levels remained at 2 mg/L (Bradley 2012) from December of 2002 through July 2011. There is a gap in the data for 2012, however, the compliance monitoring reports provided by MCAS for 2013 state that the sites are in full compliance for BOD levels consistent with the past years, which has been interpreted to mean that 2012 was compliant as well (ECAN 2013b; ECAN 2013c). Consent monitoring reports[4] for a second farm (Farm A) indicate that between 2005 and 2013 there were no instances of non-compliance for BOD.
Total ammonia nitrogen:

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[4] This refers to Resource Consent monitoring reports that are not publicly available but have been provided for this assessment.

Between 1993 and 2010, levels of ammonia nitrogen upstream, at the farm sites and downstream of the MCAS farm sites have remained either at (one instance in 2000) or below the consented limit of 0.1 ppm (Bradley 2012). One exception occurred in 2007 when the upstream levels of ammonia nitrogen reached 0.15 ppm. However, at and downstream of the farm sites they were 0.018 ppm (ELS 2010), indicating that the elevated ammonia-N levels were not caused by the farm. Data submitted in 2012 for the monitoring site 100 meters upstream from one site and 100 meters downstream show that total ammonia nitrogen levels in 2011 were compliant with resource consent limits as wells as the limits outlined in the New Zealand Drinking Water Standards (Bradley 2012; ELS 2012; ELS 2012a). Data submitted in 2013 show that all sites were compliant with limits for total ammonia nitrogen in 2012 (eurofinsELS 2013). Consent monitoring reports for a second farm (Farm A) indicate that between 2005 and 2013 there were no instances of non-compliance for ammonia-N levels.

Nitrate nitrogen:
Between 1993 and 2010, levels of nitrate nitrogen consistently remained around 0.01 g/m^3; well below the limit of 11.3 g/m^3 (Bradley 2012). Monitoring tests show the peak value during this period was 0.34 g/m^3. Testing at both sites in 2012 resulted in levels ≤0.01 g/m^3, and a 2013 analysis showed levels at each site at ≤0.02 g/m^3 (ELS 2012; ELS 2012a; eurofinsELS 2013). Consent monitoring reports for a second farm (Farm A) indicate that between 2005 and 2013 there were no instances of non-compliance for nitrate nitrogen levels.

Total suspended solids:
Management of TSS by MCAS consists of feed inputs to the growout pens and monitoring of suspended-solids levels downstream of the pens in relation to levels at and upstream from the farm sites (Bradley 2012). Resource consents allow the input of 822 kg/day of solid matter (feed) with the understanding that approximately 1 kg of feed will generate 150-200 g of fecal matter. This, along with small particles from feed, contribute to the total suspended solids, along with natural background levels of particles originating from natural systems (Bradley 2012). On average, the hydrocanals in which the farm sites are located have water flow of 6.48 billion liters per day, allowing minimal buildup of solids within the water column or on the benthos of the hydrocanal (Bradley 2014). There was a period between December 1998 and August 2000 where levels of TSS downstream from the farm were higher than those at and upstream from the farm, however, aside from that time period, TSS levels have been either at or below levels upstream and at the farm sites (Bradley 2012). The highest concentration of TSS that has been recorded in monitoring reports since 1993 was discovered upstream from the farm sites in 2011 at approximately 14 ppm. Monitoring results from this same period, both at and below the farm sites, were slightly lower, showing that inputs at the farm site were not impacting the level of TSS in the water downstream of the farm sites (Bradley 2012). Consent monitoring reports for a second farm (Farm A) indicate that between 2005 and 2013 there were no instances of non-compliance for total suspended solids. Stringent management of feed inputs to the farms leading to a capped limit for effluent waste, results in minor impacts to the hydrocanals and to the stilling basin where sediments from salmon farms, glacial runoff, and plant matter settle prior to entering the hydroelectric plant.
Mercury:

Testing for mercury is required by resource consents held by MCAS; however, statements by the feed company used by the farm, along with results from laboratory testing of feeds, show that mercury levels are well below consented limits in the monitoring reports from 2013. The limit allowed by the resource consent is 0.002 g/m^3 total mercury in water samples. The levels found in the feed (0.03 mg/kg) do not enter the water at a rate higher than the consented limit. Due to this, ECAN, the regulatory body overseeing MCAS' resource consents, has stated that mercury testing on a semi-annual basis by MCAS is no longer required, however, tests of feeds used must still be provided to ECAN (ECAN 2013b; ECAN 2013c). Consent monitoring reports for a second farm (Farm A) indicate that between 2005 and 2013 there was one minor non-compliance for mercury analysis due to a failure of the farm to submit a sample of feed for mercury testing in 2009. This was rectified in 2010.

Overall, based on monitoring data showing that water going into freshwater salmon farming operations is consistently of the same quality as water coming out, there is a low risk that freshwater salmon farming in New Zealand contributes to any localized or cumulative impacts to water quality. Stringent feeding regimes manage the risk of excess feeds entering the hydrocanals and contributing to particulate matter in effluent, and the daily limit of 822 kg of waste from farms has never been met. Monitoring of the stilling basin where sediments settle shows levels of DO, BOD, N and P; all the same as they are above the farms, and resource consents show that if the cap for effluent solids were to ever be met there could be only minor impacts to the environment. Because there is no cumulative impact occurring a score of 8 of 10 is applied to salmon farming in freshwater hydro canals.

Criterion 3: Habitat

Impact, unit of sustainability and principle

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

Marine Farms

Habitat Parameters	Value	Score	
F3.1 Habitat conversion and function		8.00	
F3.2a Content of habitat regulations	4.00		
F3.2b Enforcement of habitat regulations	4.5		
F3.2 Regulatory or management effectiveness score		7.2	
C3 Habitat Final Score		**7.73**	**GREEN**
Critical?	NO		

Freshwater Farms

Habitat Parameters	Value	Score	
F3.1 Habitat conversion and function		10.00	
F3.2a Content of habitat regulations	4.00		
F3.2b Enforcement of habitat regulations	4.5		
F3.2 Regulatory or management effectiveness score		7.2	
C3 Habitat Final Score		**9.07**	**GREEN**
Critical?	NO		

Criterion 3 Summary

Farming of Chinook salmon in New Zealand takes place in both freshwater canals and the inshore marine environment. These two types of operations occupy very different habitats, with many of the freshwater hydrocanals being man-made and used for hydropower, while the marine net pens are located in the natural marine environment. The floating net pens used in salmon farming do not, themselves, have a direct impact on the environment, however the benthic habitats are affected directly below and surrounding the pens. Marine benthic environments directly below pens and within the allowable zone of effect (AZE) show signs of enrichment, however, significant impacts have not been detected beyond the permitted area of any of the farm sites. The impacts are also reversible, with the most significant impacts disappearing within 2 years. Freshwater farms have consistently shown no impact to any surrounding environments, including benthos beneath and around pens. Marine farming has been given a score of 7.73 of 10 and freshwater farming has been given a score of 9.07 of 10.

Justification of Ranking
Factor 3.1. Habitat Conversion and Function

Figure 2, below, shows the regions of New Zealand where marine and freshwater farming of Chinook occurs. All permitted salmon farms are located within these regions, with the majority of production occurring at the 8 sites owned and operated by NZKS in the Marlborough region. Figure 2, from the New Zealand Salmon Farmers Association (NZSFA 2011), shows that at the time, 64% of total production occurred in the Marlborough region while more recent sources show production levels up to 61%, with the remainder split between the Canterbury (12%) and Southland regions (27%) (NZKS 2014b).

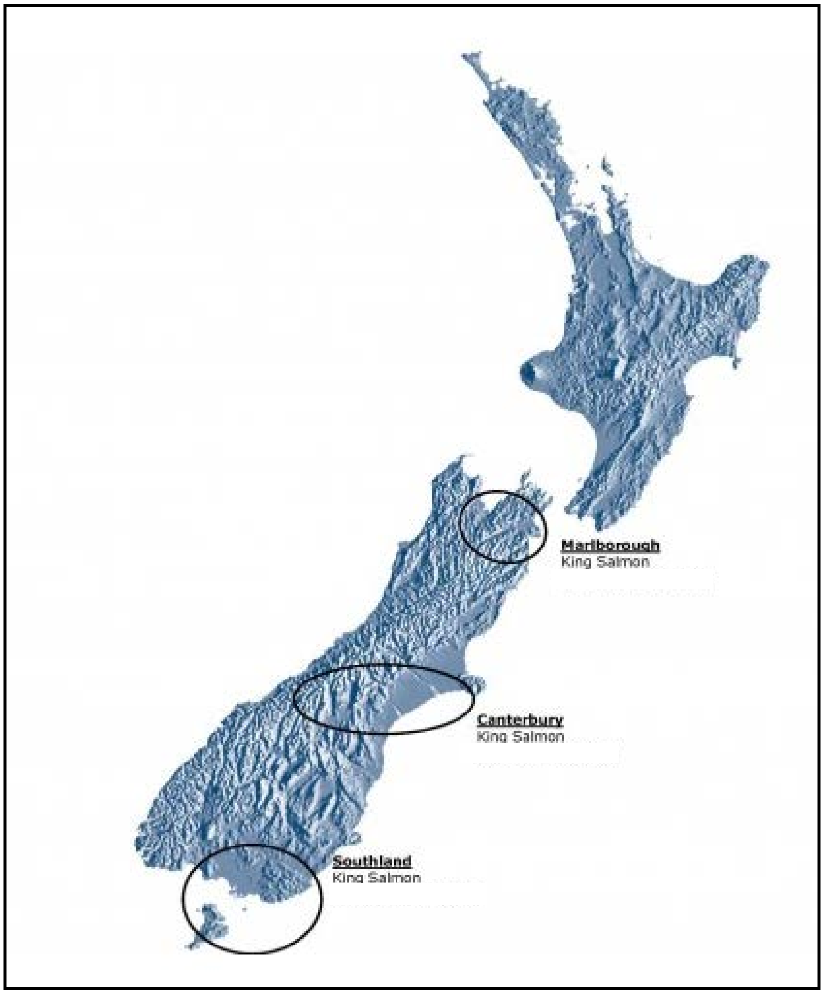

Figure 2: New Zealand salmon farming regions. Source: (NZSFA 2011)

Marine Sites
As is noted above, approximately 90% of Chinook salmon produced in New Zealand comes from marine production, with most produced at New Zealand King Salmon company farm sites in the Marlborough Sounds (NZKS 2014b).

All of the marine farm sites in New Zealand are located in coastal inshore subtidal habitats either in the Marlborough Sounds, the Akaroa region of Canterbury, or in Southland off the coast of Stewart Island. Coastal inshore subtidal habitats are considered "moderate-value" habitat in the Seafood Watch criteria. While it has been found that there are impacts to benthic habitats below sea pens, these impacts have been shown to be at least partially reversible within approximately a year if production is ceased (Black 2013). Characteristics of sites will determine the length of time necessary for recovery; however, it has been noted in the monitoring reports for intensively farmed NZKS sites that even the most heavily impacted sites will return to background levels within 5-10 years (Keeley 2014). Each of the 8 NZKS sites is monitored by Cawthron Institute (Cawthron), a third party scientific research institution, to determine whether they are in compliance with resource consents granted by the Marlborough District Council (MDC) that allow NZKS production to occur (similar to a permit). The monitoring reports from Cawthron are publically available[5]. Cawthron has developed an Enrichment Scale (ES) that assigns a numerical level to each site based on impacts to the surrounding benthic environment and is a determinant of compliance with resource consents. ES1 is a pristine benthic environment while ES7 is characterized by extremely enriched conditions leading to a collapse of benthic infauna (Keeley 2012). NZKS farm sites differ in impact to the benthic environment as a function of water flow at the site. Due to these differences, the ES scale has been applied to "high-flow" sites (average current speed of greater 9.5 cm/s) differently from "low-flow" sites (average current speed less than 9.5 cm/s). Differences are shown in Table 1 below.

Table 1: Environmental characteristics of Low-flow and High-flow sites

ES	General description	Environmental characteristics
1	**Natural/pristine conditions**	LF: Environmental variables comparable to unpolluted/un-enriched pristine reference site.
		HF: As for LF, but infauna richness and abundances naturally higher (~2xLF) and % Organic matter slightly lower.
2	**Minor enrichment**. Low level enrichment. Can occur naturally or from other diffuse anthropogenic sources. 'Enhanced Zone.'	LF: Richness usually greater than for reference conditions. Zone of 'enhancement' – minor increases in abundance possible. Mainly compositional change. Sediment chemistry unaffected, or with only very minor effects.
		HF: As for LF
3	**Moderate enrichment**. Clearly enriched and impacted. Significant community change evident.	LF: Notable abundance increase, richness and diversity usually lower than reference site. Opportunistic species (i.e., capitellid worms) begin to dominate.
		HF: As for LF

[5] Monitoring reports are available on the Marlborough District Council website using Resource Consent numbers for each of the NZKS farm sites. http://www.marlborough.govt.nz/Services/Property-File-Search.aspx

4	**High enrichment**. Transitional stage between moderate effects and peak infauna abundance. Major community change.	LF: Diversity further reduced, abundances usually quite high, but clearly sub-peak. Opportunistic species dominate, but other taxa may still persist. Major sediment chemistry changes (approaching hypoxia).
		HF: As above, but abundance can be very high while richness and diversity are not necessarily reduced.
5	**Very high enrichment**. State of peak infaunal abundance.	LF: Very high numbers of one or two opportunistic species (i.e., capitellid worms, nematodes). Richness very low. Major sediment chemistry changes (hypoxia, moderate oxygen stress). Bacterial mat (Beggiatoa-like) usually evident. Out-gassing on disturbance.
		HF: Abundances of opportunistic species can be extreme (10x LF ES 5 densities). Diversity usually significantly reduced, but moderate diversity can be maintained. Sediment organic content usually slightly elevated. Bacterial mat formation and out-gassing possible.
6	**Excessive enrichment**. Transitional stage between peak abundance and azoic (devoid of any organisms).	LF: Richness and diversity very low. Abundances of opportunistic species severely reduced from peak, but not azoic. Total abundance low but can be comparable to reference site. %OM can be very high (3-6x reference).
		HF: Opportunistic species strongly dominant, taxa richness and diversity substantially reduced. Total infauna abundance less than at sites farther away from farm. Elevated organic matter and sulfide levels. Formation of bacterial mats and out-gassing.
7	**Severe enrichment**. Anoxic and azoic; sediments no longer capable of supporting infauna with organics accumulating.	LF: None, or only trace numbers of infauna remain. Some samples with no taxa. Spontaneous out-gassing. Bacterial mat usually present but it can be suppressed. %OM can be very high (3-6 x reference).
		HF: Not previously observed – but assumed similar to LF sites.

Source: (Keeley 2012)

It is worth noting, that there is a perceived discrepancy in the ES system developed by Cawthron. Dr. Kenny Black, who was hired by the Marlborough District Council in 2012 to provide an assessment and summarization of the NZKS monitoring reports by Cawthron, notes that the difference between ES5 and ES6 is very significant. An ES5 is characterized as having biologically functional benthos capable of the highest level of assimilation and an ES6 having very demonstrable impacts and being characterized by collapsed infaunal communities (Black 2013). Dr. Black states that this gap allows sites to be included in the category ES5 when, in fact, they may be unstable and leaning toward collapse. This discrepancy characterizes the Forsyth Bay site, which is noted as being at "peak assimilative capacity," however, NZKS is voluntarily adopting measures to reduce feed inputs at the site in order to reduce impacts to the benthos (Black 2013). IThis discrepancy also characterizes the Ruakaka Bay site, which is noted as having very high levels of individual organisms in the sampled sediments, but not reaching the ES6 level (Black 2013). It is stated by Keeley that ES5 is generally the highest acceptable ES ranking in the Marlborough Sounds due to the large waste assimilation capacity related to the high level of biomass (Keeley 2012). It is understood that in the succession of the enrichment stages this is the stage before the beginning of collapse of benthic infauna. The perceived discrepancy is based on one view that, while this stage may currently enable waste assimilation at a high level, it is the last stage before collapse and should therefore not be allowable. The other view states that, while this stage is the last before benthic infaunal collapse, it does have high waste assimilative capacity, and is still a productive environment despite being characterized by a few highly opportunistic species rather than the natural infaunal community composition (Keeley 2012).

Monitoring of NZKS sites uses a zonal approach to determining consistency with resource consents. Zones are developed using two different approaches (as shown in Figure 3 below). One approach prescribes boundaries around a site, and another acknowledges the often changing and irregular shape of the impact footprint and assigns zones and limits according to the ecological characteristics of the site. Zone 1 consists of the area directly beneath the pen(s) or footprint of initial impact. Zone 2 includes the area between the edge of the pens and an initial monitoring point (generally between 50 and 70 m from the pens). Zone 3 includes the area from the edge of Zone 2 out to a distance of most commonly 150-250 m. Beyond this limit is Zone 4. Based on the ecological characteristics and estimated impact footprint, zones and allowable limits have been determined for impact to sediments (for each individual NZKS site). Compliance with resource consents is therefore assessed by determining whether each site's zones are in compliance with the applicable ES scale limits. Each zone is monitored for impacts to sediment organic matter and redox potential, sulfur chemistry in the sediments, copper and zinc in sediments and changes to the species composition, total taxa, abundance and total biomass. Sites are also monitored for impacts to the water column. These impacts are discussed in the Criterion 2 Effluents section of this assessment. This current monitoring system will be replaced in 2015 with a more standardized set of best management practices for monitoring benthic impacts from salmon farming. These newly drafted BMPs have not yet been implemented. As such, they have not been included in the scoring of this report.

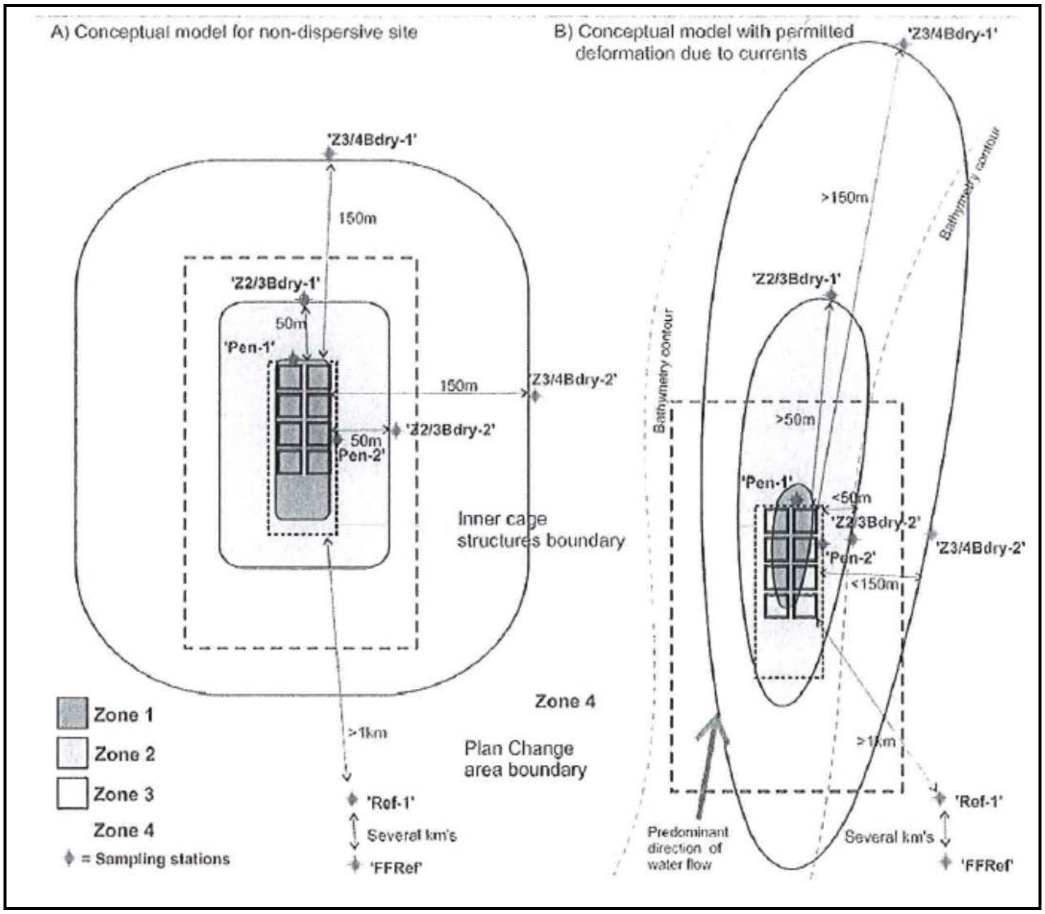

Figure 3: Conceptual model for Zonal approach to monitoring. Source: (Keeley 2012)

Benthic monitoring reports[6] for the 8 NZKS sites show a gradient of organically enriched sediments, with the highest impact on sediments directly below pens (or within the Zone 1 footprint). These sites generally fall into the ES4 and ES5 categories as listed in Table 1 above. Uneaten food as well as feces from salmon collects on the benthic sediments, creating shifts in the sediment chemistry as well as species abundance and richness. Areas of high impact (Zone 1) are generally categorized by high levels of sediment enrichment, in extreme cases leading to cover by bacterial mats (*Beggiatoa* sp.) with outgassing when disturbed. Opportunistic species (*C. capitata*) generally dominate these areas, as is reflected in monitoring reports by Cawthron. While there is not the natural species richness in these habitats, the presence of this opportunistic species implies a functioning benthos and level of productivity remaining. This level of impact falls into the ES5 category of “Very High Enrichment.” This highly impacted state is the highest acceptable limit for compliance with resource consents granted to NZKS (≤ES6). A site that falls into the ES6 category is considered unacceptable and triggers a management response. Note that these highly impacted areas are very localized (in Figure 3). The monitoring reports show organic content of sediment within the consented area ranges and between

[6] Available at http://www.marlborough.govt.nz/Services/Property-File-Search.aspx

zones, with the greatest ash-free dry weight (AFDW) most commonly in Zone 1, but not always limited to that scenario. Monitoring at the boundary between Zones 2 and 3 has shown AFDW levels up to 3 times those at control sites, while AFDW within Zone 1 at the same site is similar to the control site. Redox potential is generally very low and occasionally negative in Zone 1, improving at a gradient away from the pens. Total free sulfide levels are often extremely elevated in areas with high organic content, which is often observed by a distinct smell in samples, along with a black, gritty substrate.

Monitoring reports[7] available to the public show that nearly all NZKS sites have consistently maintained compliance with limits for benthic impacts in all zones. In all but two instances, non-compliance was rectified before the next year's monitoring, based on recommendations for change made by the Cawthron Institute in annual monitoring reports. Voluntary efforts by NZKS to increase compliance have also been made (Black 2013). Monitoring reports available to the public show that of the 18 recorded non-compliance instances (for all 4 zones of all 8 NZKS sites from years ranging from 1993 to 2013), all but 4 were within the consented area of the farm sites.

Despite the localized areas of "very high enrichment" and "excessive enrichment," the very small amount of production and area covered by consented salmon farms in New Zealand (compared to the four major salmon farming countries; Norway, Scotland, Chile and British Columbia) means that impacts to the benthos are considered minor at the ecosystem level. Marine pen farm sites in New Zealand are consented to cover up to 2 hectares of surface structures each, although sites operate at a much smaller scale than this. All structures (including moorings) must be within the consented site, and have a defined area where the surface structures can be located. The 18 ha of marine habitat used for salmon farming in the Marlborough Sounds comprise a minimal fraction of the 725,637.44 ha that make up the Total Marlborough Marine Area (MDC 2014).

Cawthron has noted that zinc and copper levels in sediments beneath pens need to be monitored, despite their lack of inclusion in resource consents granted for salmon farming sites. Both elements are monitored and compared to the Australian and New Zealand Environment and Conservation Council (ANZECC) ISQG-High and Low guideline thresholds (ISQG-High, ISQG-Low) for possible biological effects (ANZECC 2000)[8]. ISQG–Low refers to a 10% probability that a significant toxicity measure will occur in sensitive species, while ISQG-High refers to a 50% probability of this occurring (Sneddon 2012). The monitoring reports show the depositional footprint of both copper and zinc to be within 100-150 m of the nets at all NZKS sites, therefore remaining entirely within the consented area (Sneddon 2012).

Copper antifouling materials on nets have been used in the past by NZKS; however, this practice was ended in 2010 (Rosewarne 2014). The monitoring reports for 2005 to 2013 (with

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[7] Available at http://www.marlborough.govt.nz/Services/Property-File-Search.aspx
[8] Copper : ANZECC ISQG-Low (Trigger value) is 65mg/kg, ISQG-High is 270 mg/kg.
Zinc: ANZECC ISQG-Low (Trigger value) is 200 mg/kg, ISQG-High is 410 mg/kg

continuous monitoring each year at each of the 8 sites) show copper levels in sediments directly below pens to be above the ISQG-Low threshold for possible biological effects on 27 instances (of 65 monitoring events). Copper levels were above the ISQG-High threshold in 4 of 65 monitoring events. The 4 instances of copper levels above the ISQG-High threshold are confined to 2 NZKS sites. Both sites have seen levels decrease since the initial high amounts, with one site decreasing copper levels to just above the ISQG-Low threshold. Two NZKS sites have consistently remained below the ISQG-Low threshold, with a third only exceeding the ISQG-Low threshold on one occasion (where it rose slightly above). The monitoring reports speculate that copper is still coming loose from the nets despite no longer being in use, and that levels will likely decrease as time goes on.

Zinc levels were above the ISQG-Low threshold for possible biological effects for 34 of 65 monitoring events, and above ISQG-High levels 21 of 65 monitoring events. Instances of zinc levels above the ISQG-Low threshold occur almost entirely within 4 of the 8 NZKS sites with one instance occurring at a 5th site. All instances of zinc levels above the ISQG-High threshold occur at the same 4 sites. Similar to copper, the other end of the spectrum shows 3 sites that have consistently remained below the ISQG-Low threshold, with a 4th site showing only 1 instance of breaching the ISQG-Low threshold from 2005 to 2013. Zinc found in sediments below pens is a product of unassimilated zinc from the diet (through feces as well as through a very minor amount of uneaten feed) settling on the benthic habitat. Cawthron recommended that it continue to be monitored, and a study was commissioned to determine the bioavailability of zinc and copper. This study found that the bioavailability of zinc beneath pens is higher than that of copper, and is believed to be the cause of sub-chronic toxicity to copepods in the immediate area of the farm sites. This, however, is expected to change with the adoption by NZKS of a feed with organic zinc (Sneddon 2012).

While it may appear that ecosystem services are lost in the areas directly below and immediately adjacent to marine salmon farms, major impacts have been shown to be rapidly reversible over the course of 1 year (C.K. Macleod 2008; Black 2013), with conditions showing substantial ongoing improvements over the course of 2-3 years (K. Black 2008). Habitats are capable of returning to background conditions within 5 to 10 years, as mentioned in monitoring reports by Cawthron and by Keeley et al. (2014). Due to this relatively rapid reversibility of even the most severe benthic impacts from salmon farming, the habitat impact is considered to be only minor at the ecosystem level. This minor impact combined with the extremely small total area associated with production of salmon in New Zealand results in a score of 8 of 10 for habitat function (Factor 3.1).

Freshwater sites

Approximately 10% of the Chinook salmon produced in New Zealand comes from farms located in man-made freshwater hydrocanals located in the mountains of Canterbury (NZKS 2014b). Around 75% of freshwater production comes from Mt. Cook Alpine Salmon (MCAS). The freshwater hydrocanals were developed under a government program between 1970 and 1983 to provide the surrounding area with electricity (Martin 1999). The canals are constructed in grasslands, which are considered a “low value” habitat in the Seafood Watch Aquaculture

Criteria. Salmon farms located within the canals have had no further impact on the surrounding grasslands, allowing the surrounding area to maintain full functionality. The functionality of the hydrocanal environments themselves is also not impacted by the salmon farms.

The 2013 monitoring reports prepared for MCAS by the local environmental authority, ECAN, show full compliance with all parameters included in the resource consents granted for all MCAS sites (ECAN 2013b; ECAN 2013c). These parameters include water quality metrics, which are discussed in the Effluent Criterion (Criterion 2) of this document. Resource consents do not require monitoring of benthic impacts from salmon farms in the hydrocanals. Personal communication with multiple farm representatives from salmon farms located in freshwater hydrocanals in New Zealand indicates that, due to the high rate of water flow at farm sites (50-125 m^3/second or approximately 750,000-1,900,000 gallons/minute), benthic habitats within the farm boundaries are either very minimally impacted or show no signs of impact at all (Anonymous 2014; Bradley 2014; Swart 2014). The above factors lead to a score of 10 of 10 for F3.1 for salmon farming in freshwater hydrocanals.

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

Marine and Freshwater sites

With the passage of aquaculture legislative reforms under the Resource Management Act (RMA) in 2004 and 2011, primary authority of aquaculture regulation is now the responsibility of New Zealand's 12 regional councils and 4 unitary authorities. These councils are charged with coastal management, identification of areas that are appropriate for new aquaculture development, and processing of consent applications (MFE 2014). Each of the 12 councils is responsible for coastal planning and management of the variety of uses of their coastal areas, including aquaculture. Applications for resource consent (RC) are required for any action that may have an impact on the environment, including aquaculture operations (MFE 2014a), and are processed by the appropriate regional council. This results in a variety of management strategies reflecting the values of that region. Farms that were established prior to 1991 must be reviewed under the RMA if they apply for any changes to their existing RC, including renewals, extensions, or changes to the conditions of the RC (Coates 2014).

<u>Key relevant information:</u>

The RMA Section 5 guides the decision-making process for management of all resources in New Zealand, and its application provides a judgment of whether a proposed action will be managed in a way that is environmentally sustainable. Decision makers for RMA actions use the New Zealand Coastal Policy Statement (NZCPS) as a guideline for balancing uses of the coastal environment in a way that promotes long-term protection of the natural environment, along with sustainable social, economic and cultural interests (BOI 2013). The NZCPS specifically addresses aquaculture, stating that New Zealand will:

"Recognize the significant existing and potential contribution of aquaculture to the social, economic and cultural well-being of people and communities by:

> *(a) including in regional policy statements and regional coastal plans provision for aquaculture activities in appropriate places in the coastal environment, recognizing that relevant considerations may include:*
>
> > *(i) the need for high water quality for aquaculture activities; and*
> >
> > *(ii) the need for land-based facilities associated with marine farming;*
>
> *(b) taking account of the social and economic benefits of aquaculture, including any available assessments of national and regional economic benefits; and*
>
> *(c) ensuring that development in the coastal environment does not make water quality unfit for aquaculture activities in areas approved for that purpose* (DOC 2010)."

Under the RMA each district is required to develop a Regional Policy Statement. Regional councils can then identify areas that are, or are not, appropriate for aquaculture within their marine zones in accordance with the directives of the RMA and the NZCPS. In the Marlborough district aquaculture development is considered potentially appropriate within Coastal Marine Zone 2 (CMZ2). The Marlborough District Council has developed a Regional Policy Statement (MRPS) in order to "provide a community-based vision and direction for the management of the natural and physical resources of Marlborough." This statement directs that "allocation of space for aquaculture will be based on marine habitat sustainability, habitat protection, landscape protection, navigation and safety, and compatibility with other adjoining activities." It is under these guidelines that NZKS operates its sites in the Marlborough Sounds. While this wording is specific to the Marlborough district and NZKS sites, other NZ salmon farming sites in the Canterbury and Southland districts also operate under policies that similarly reflect the purpose of the RMA and the NZCPS. The Marlborough district has been the focus of this Seafood Watch assessment due to the large majority of salmon farming occurring there.

F3.2a Regulatory or management effectiveness

Marine and freshwater sites

Each application for a resource consent (marine and freshwater) must include an Assessment of Environmental Effects (AEE) based on ecological principles. This process must be completed for any new sites, including expansion of existing sites. In the case of some NZKS sites and other salmon farms in New Zealand, sites were established prior to the Resource Management Act in 1991 and therefore did not need to obtain a resource consent. However, all pre-RMA sites have been deemed by law to hold a resource consent; hence, regional councils can place conditions on the consents in the same manner as more recent sites. It is worth noting that many, if not all, of these sites and farms have implemented conditions and monitoring measures consistent with their other sites.

Aquaculture in marine environments in New Zealand is limited either to specific aquaculture management zones within each council's jurisdiction or to tightly consented areas. These areas are zoned specifically with aquaculture in mind, however other areas outside of these zones may also be attractive to aquaculture companies. NZKS has expanded to 3 new sites beyond the established aquaculture management zones in the Marlborough Sounds District (BOI 2013). Each of the proposed new sites has avoided being sited directly in or immediately adjacent to any areas of high ecological significance (BOI 2013) and includes consent conditions specific to each. The sites were approved by the EPA Board of Inquiry and confirmed subsequently by the High Court and Supreme Court.

The RMA includes cumulative impacts in its scope of "sustainable management" and requires regional councils and authorities to use planning tools to address impacts over time or in combination with other impacts. "State of the environment monitoring" is carried out at the regional level, and examines cumulative impacts of existing aquaculture operations. Currently, efforts to collect comprehensive monitoring data are ongoing, and frameworks for implementing the monitoring of cumulative impacts are being developed (MPI 2013a). Recent applications for marine aquaculture sites have included extensive predictive modelling of wider ecosystem effects and assessments of potential cumulative effects and these inform the ultimate decision (Keeley 2014a).

Siting of freshwater farms in hydrocanals is based on ecological factors using the same framework as siting of marine farms; however, the variables for siting of salmon farms in freshwater are distinctly different from siting in marine environments. Annual monitoring of Trophic Level Index in freshwater hydrocanals looks to identify cumulative impacts to the environment. While these tests do not focus on cumulative impacts directly from salmon farming, they do monitor the overall health of the hydrocanals, and can, in turn, lead to decisions made on resource consents and monitoring requirements for salmon farms. These water quality tests are carried out by Environment Canterbury (ECAN) and results are available to the public.[9]

For freshwater sites it is noted in information collected from members of the industry in the Canterbury region that the regional environmental agency, Environment Canterbury (ECAN), conducts monitoring for cumulative impacts from freshwater salmon farms in the Mackenzie Basin (Anonymous 2014). These factors lead to a score of 4 out of 5 for F3.2a for both marine and freshwater sites.

F3.2b Siting regulatory or management enforcement
Marine and freshwater sites
The agencies charged with enforcing compliance of aquaculture operations to the conditions of the resource consent are the regional councils or unitary authorities. The councils are readily accessible and contactable, and the monitoring reports are publicly available describing the sizes and locations of sites. The RC process invites public comment at various stages, and there are opportunities provided for appeal of the decision, often leading to the avoidance of high-value habitats for conversion to other uses, or conditions mandating restoration of habitats of similarly high value. Siting and permitting (consent) of farms operates according to the process

[9] Available on the Mount Cook Alpine Salmon website at http://www.mtcookalpinesalmon.com/our-water.aspx

outlined in the RMA and are based on zoning and management in that district. As is evidenced by the above analysis of monitoring reports for both marine and freshwater farms, it can be seen that, for the most part, impacts are constrained to the consented areas, with management actions taken upon the event of a finding of non-compliance. These factors lead to a score of 4.5 of 5 for F3.2b and a final score of 7.2 of 10 for F3.2 for both marine and freshwater sites.

Final scores for Criterion 3 Habitat:
The combination of scores for F3.1 and F3.2 result in a Final Score of 7.73 of 10 and a "Green" rating for the Habitat Criterion for marine salmon farms.

The final combination of scores for F3.1 and F3.2 result in a Final Score of 9.07 of 10 and a "Green" rating for the Habitat Criterion for freshwater salmon farms.

Criterion 4: Evidence or Risk of Chemical Use

Impact, unit of sustainability and principle

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

Marine farms

Chemical Use parameters	Score	
C4 Chemical Use Score	**10.00**	
C4 Chemical Use Final Score	**10.00**	**GREEN**
Critical?	NO	

Freshwater farms

Chemical Use parameters	Score	
C4 Chemical Use Score	**10.00**	
C4 Chemical Use Final Score	**10.00**	**GREEN**
Critical?	NO	

Criterion 4 Summary

To date, salmon farming in New Zealand, in both marine and freshwater environments, has not suffered the same disease and parasite outbreaks that have affected much of the global salmon farming industry. Because of this, there has been no recorded use of veterinarian approved use of antibiotics and very little use of any other chemical in the salmon farming industry in New Zealand. Both marine and freshwater salmon farming in New Zealand have been given a score of 10 of 10 for the chemicals criterion.

Justification of Ranking

Marine and freshwater sites

Salmon farming in New Zealand, in both marine and freshwater environments, has the luxury of not being subjected to disease or parasite outbreaks that characterize much of the global salmon farming industry. While some species of sea lice have been found in the wild in the waters of New Zealand, none have been discovered on farmed Chinook, despite the relative close proximity of one species to a Chinook farming site (Diggles 2012). While the use of a variety of sea lice treatments to control populations of sea lice in farmed Atlantic salmon is common in Norway and Chile (and to a lesser degree in Scotland and British Columbia) (Bridson 2014), these measures have not been necessary for production in New Zealand (BOI 2013; Johnston 2014). This is due to the lack of any specimens present on farmed Chinook (Auditor 2013). It has also been stated that Chinook salmon are less susceptible to sea lice than are the more commonly farmed Atlantic salmon, which are not farmed in New Zealand (S. Bravo 2011).

As is stated above, the farming conditions and the scale of the industry, in addition to hatchery and farm-level biosecurity plans, has helped prevent diseases and parasites commonly associated with salmon farming. Therefore, there is no need for the use of antibiotics to treat primary or secondary infections in farmed salmon. Letters have been provided by veterinarians contracted by both of the largest freshwater and marine Chinook producers in New Zealand, along with a list of registered chemicals on the premises of MCAS and a list of chemicals registered at 1 of 8 NZKS sites. According to these sources, no antibiotics are used in salmon farming in New Zealand (Knowles 2013; Johnston 2014; MCAS 2014; NZKS 2014).

As part of biosecurity protocols, both freshwater and marine Chinook farms use chemicals and foot baths to sanitize equipment. There are no chemicals listed for cleaning of nets in freshwater farms, and it is stated by the veterinarian contracted by NZKS that cleaning of nets is done in situ either in the water or using power washers. Neither identifies the use of chemicals that may enter the surrounding environments (Knowles 2013; Johnston 2014; MCAS 2014)..

Anecdotal evidence from multiple parties, independent veterinary assurance, evidence provided at a Board of Inquiry Hearing, and audit data provided by a farm all consistently point to a lack of antibiotic or pesticide use in both marine and freshwater Chinook production. In the case of an infectious disease outbreak, the use of veterinary medicines (including antibiotics and other therapeutants) is controlled by the Agricultural Compounds and Veterinary Medicines Act, which requires registration of all veterinary medicines used in aquaculture. Although there are no limits in place to restrict total antibiotic use in New Zealand if a disease outbreak were to occur, this will not currently affect the score for this criterion while no antibiotics are being used. The final score for the Chemical Use Criterion is 10 out of 10.

Criterion 5: Feed

Impact, unit of sustainability and principle

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

Criterion 5 Summary

Marine farms

Feed parameters	Value	Score	
F5.1a Fish in: Fish Out Ratio (FIFO)	2.10	4.75	
F5.1b Source Fishery Sustainability Score		-4.00	
F5.1: Wild Fish Use		3.91	
F5.2a Protein IN	33.24		
F5.2b Protein OUT	17.70		
F5.2: Net Protein Gain or Loss (%)	-46.76	5	
F5.3: Feed Footprint (hectares)	8.97	7	
C5 Feed Final Score		**4.96**	**YELLOW**
Critical?	NO		

Freshwater Farms

Feed Parameters	Value	Score	
F5.1a Fish in: Fish Out Ratio (FIFO)	1.68	5.80	
F5.1b Source Fishery Sustainability Score		-4.00	
F5.1: Wild Fish Use		5.13	
F5.2a Protein IN	33.41		
F5.2b Protein OUT	21.00		
F5.2: Net Protein Gain or Loss (%)	-37.1	6	
F5.3: Feed Footprint (hectares)	10.01	6	
C5 Feed Final Score		**5.56**	**YELLOW**
Critical?	NO		

Criterion 5 Summary

Feeds used by NZKS and MCAS are sourced from different companies, and use different formulations due to the differences in production method between the two companies. The company supplying feed to NZKS has provided information on the contents of its feed for this assessment and has chosen to remain anonymous. It is referred to in the text as "Feed Company A." The feed company supplying MCAS was not able to provide data, therefore, information on the feed contents have come directly from the technical director of MCAS, Dr. Terry Bradley. This information is verified annually by third party audits. Other minor feeds may vary in content, but this assessment was based on the major suppliers who wish to remain anonymous in this report. The FIFO score for marine salmon farming is 4.75 of 10, while the FIFO score for freshwater farming is 5.8 of 10 due to a lower inclusion rate of FM and high usage of byproducts. Marine salmon farming has an overall protein loss of -46.8% while freshwater has a protein loss of -37.1. The final feed criterion score for marine salmon farming is 4.96 out of 10 and the final feed criterion score for freshwater marine salmon farming is 5.56 out of 10.

Justification of Ranking

Due to differences between the marine and freshwater feed formulations and feeding efficiencies, the two types of feed have been calculated separately generating separate scores.

Marine Sites

The feed company supplying NZKS opted to remain anonymous and is referred to below as "Feed Company A." Due to NZKS producing up to 70% of Chinook in New Zealand (and the vast majority of marine farmed Chinook), only data from Feed Company A was assessed.

Factor 5.1. Wild Fish Use

This factor combines the amounts of wild fish used to produce fishmeal and fish oil used in feeds with the sustainability of these wild stocks.

Factor 5.1a Fish In: Fish Out (FIFO)

Information provided by Feed Company A is shown in Table 2. Both the feed company and NZKS specified an FCR of 1.75 for Chinook farmed in marine net pens.

Table 2: Marine- Feed data points and calculations for wild fish use

Parameter	Feed Company A
Fishmeal inclusion level	**11.4%**
Percentage of fishmeal from byproducts	**44%**
Fishmeal yield (from wild fish)	**22%**
Fish oil inclusion level	**6%**
Percentage of fish oil from byproducts	**0**
Fish oil yield (from wild fish)	**5%**
Economic Feed Conversion Ratio (FCR)	**1.75**

Calculated values	
Fish In : Fish Out ratio for fishmeal	**0.51**
Fish In : Fish Out ratio for fish oil	**2.10**
Seafood Watch FIFO score (0-10)	**4.75**

Source: (Feed Company A 2014)

The FIFO value of 2.1 means that approximately 2.1 mt of wild-caught fish are necessary to produce one ton of farmed Chinook in New Zealand. This is driven by the FO inclusion level of 6%, which does not include any byproducts. This results in a moderate FIFO score of 4.75 of 10 for F5.1a.

Factor 5.1b – Sustainability of the Source of Wild Fish

This factor applies a deduction to the F5.1a score to account for the sustainability of the sources of wild fish used for fish meal and fish oil in the development of feeds. The use of demonstrably sustainable fisheries (MSC certified without conditions, FishSource scores all >8 or Seafood Watch Green) is the baseline and garners a deduction of 0 points. An increasing deduction is applied for the use of increasingly unsustainable fisheries.

Information from Feed Company A indicates that the dominant source fishery for fishmeal and fish oil used in feeds is the Peruvian anchovy. This fishery is IFFO certified "responsible" and has a FishSource score of ≥6, leading to a Seafood Watch Factor 5.1b score of -4 of -10. The overall Factor 5.1 score for marine farming of Chinook salmon is 3.91 of 10 and a moderate conservation concern.

Factor 5.2-Net Protein Gain or Loss

Information provided by Feed Company A is included in the table below. As is stated above in Section 5.1a for marine farms, Feed Company A is the main producer of feed for marine Chinook farming in New Zealand. The data provided by them is, therefore, the most accurate and up-to-date and is used as the sole data set for this section of the assessment with input on post-harvest practices provided by NZKS.

Table 3: Marine feeds - Protein composition data

Parameter	Feed Company A
Protein content of feed	**39%**
Percentage of total protein from non-edible sources (byproducts etc.)	**47%**
Percentage of protein from edible crop sources	**15%**
Feed Conversion Ratio	**1.75**
Protein INPUT per ton of farmed salmon	**33.24 kg**
Protein content of whole harvested salmon[10]	**17.7 %**
Edible yield of harvested salmon	**67%**
Percentage of farmed salmon byproducts utilized	**100%**

[10] Nofima (2011), quoting unpublished marine harvest data

Utilized **protein OUTPUT** per ton of farmed salmon	**17.7 kg**
Net protein loss	**-46.8%**
Seafood Watch score (0-10)	**5**

Source: (Feed Company A 2014; Rosewarne 2014)

The protein content of feeds used by NZKS has decreased over the past decade from an average 45.2% (NZKS 2002) to 39% today; however, despite this decrease, feeding farmed salmon still represents a 46.8% net loss of edible protein. This leads to a final Factor 5.2 score of 5 of 10.

Factor 5.3-Feed Footprint

The feed footprint score combines the inclusion levels of marine and terrestrial ingredients (animal and crop) to estimate the area needed for production of feed for farmed species. Data provided by Feed Company A show that the inclusion level of marine feed ingredients (fishmeal and fish oil) is 17.4%, crop ingredients comprise 35.2% and land animal products comprise 42.8%.

Table 4: Marine Farms—Feed Footprint Data

Parameter	Feed Company A
Marine ingredients inclusion	**17.4%**
Crop ingredients inclusion	**35.2%**
Land animal ingredients inclusion	**42.8%**
Ocean area (hectares) used per ton of farmed salmon	**7.92 ha**
Land area (hectares) used per ton of farmed salmon	**1.05 ha**
Total area (hectares)	**8.97**
Footprint score (0-10)	**7**

Source: (Feed Company A 2014)

The ingredients required to feed one ton of farmed Chinook in marine net pens utilize a "footprint" of 7.92 ha for ocean-based ingredients and 1.05 ha for land-based ingredients. These areas result in a score of 7 of 10 for F5.3.

The feeds used by NZKS are high in byproduct ingredients, particularly those of land animals, and this improves the FIFO values and the net loss of edible protein. The final feed score for Chinook salmon farmed in marine net pens in New Zealand is 4.96 of 10, and results in a Yellow rating.

Freshwater Sites

Factor 5.1a Fish In: Fish Out (FIFO)

Information provided on feeds used in freshwater farming of Chinook salmon was provided by Dr. Terry Bradley, Technical Director of Mt. Cook Alpine Salmon.

Table 5: Freshwater- Feed data points and calculations for wild fish use

Parameter	**MCAS**
Fishmeal inclusion level	**20%**
Percentage of fishmeal from byproducts	**50%**
Fishmeal yield (from wild fish)	**22.5%**
Fish oil inclusion level	**6%**
Percentage of fish oil from byproducts	**0%**
Fish oil yield (from wild fish)	**5%**
Economic Feed Conversion Ratio (FCR)	**1.4**
Calculated values	
Fish In : Fish Out ratio for fishmeal	**0.62**
Fish In : Fish Out ratio for fish oil	**1.68**
Seafood Watch FIFO score (0-10)	**5.80**

Source: (Bradley 2014; Swart 2014)

The FIFO value of 1.68 means that approximately 1.68 tons of wild-caught fish are necessary to produce one ton of farmed freshwater Chinook in New Zealand. This score is driven by the FO content of the feeds. It is unknown what, if any, percentage of fish oil is derived from byproducts, so it is assumed zero in Seafood Watch calculations out of an abundance of precaution. This results in a FIFO score of 5.80 of 10 for F5.1a.

Factor 5.1b – Sustainability of the Source of Wild Fish

Similar to F5.1b for marine farms above, the F5.1b score is applied to the FIFO score as a deduction based on the degree of unsustainability of the source fisheries. Information provided by High Country Salmon identified "South American fish meal and fish oil" as the sources of protein from wild-caught fisheries, and information provided by Dr. Bradley of MCAS identifies Peruvian anchovy and byproducts from tuna caught in American Samoa (Bradley 2014; Swart 2014). As is noted above, the Peruvian anchovy fishery is both IFFO certified as "responsible" and has a FishSource score of ≥6; therefore, this section applies a deduction score of -4 to the FIFO value of 1.68 due to some significant concerns in fishery management, but acceptable certification. Because tuna trimmings (byproducts) are used, the sustainability of the American Samoa tuna fishery is not included in this assessment. The final F5.1 score is 5.13 of 10 for freshwater salmon farming.

Factor 5.2-Net Protein Gain or Loss

Information provided by MCAS is included in the table below. The total protein content of feeds used for Chinook salmon in freshwater farms in New Zealand is 42%. It is calculated that approximately 26.8% of this protein comes from non-edible sources (byproducts from marine, crop and/or terrestrial sources) while 57.3% of the protein in feeds comes from crop sources fit for human consumption (e.g., soy meal). Using these percentages, along with values listed in Table 6 (below) it is calculated that there is a net protein loss of 37.1%. This results in a score of 6 of 10 for F5.2.

Table 6: Freshwater Feeds—Protein Composition Data

Parameter	MCAS
Protein content of feed	**42%**
Percentage of total protein from non-edible sources (byproducts etc.)	**26.8%**
Percentage of protein from edible crop sources	**57.3%**
Feed Conversion Ratio	**1.4**
Protein INPUT per ton of farmed salmon	**33.4 kg**
Protein content of whole harvested salmon	**21%**
Edible yield of harvested salmon	**62%**
Percentage of farmed salmon byproducts utilized	**100%**
Utilized **protein OUTPUT** per ton of farmed salmon	**21 kg**
Net protein loss	**-37.1%**
Seafood Watch score (0-10)	**6**

Source: (Anonymous 2014; Bradley 2014; Swart 2014)

Factor 5.3-Feed Footprint

The ingredients required to feed one ton of farmed Chinook in freshwater pens characterize a “footprint” of 9.47 ha for ocean-based ingredients and 0.54 ha for land-based ingredients (crops and animal). These areas result in a score of 6 of 10 for F5.3.

Table 7: Freshwater farms- Feed footprint data

Parameter	MCAS
Marine ingredients inclusion	**26%**
Crop ingredients inclusion	**59%**
Land animal ingredients inclusion	**15%**
Ocean area (hectares) used per ton of farmed salmon	**9.47 ha**
Land area (hectares) used per ton of farmed salmon	**0.54 ha**
Total area (hectares)	**10.01 ha**
Footprint score (0-10)	**6**

Source: (Bradley 2014)

The final feed score for Chinook salmon farmed in freshwater pens in New Zealand is 5.56 of 10, and results in a Yellow rating.

Criterion 6: Escapes

Impact, unit of sustainability and principle

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

Marine and freshwater farms

C6 Escape Final Score		10.00	GREEN
Critical?	NO		

Criterion 6 Summary

Chinook salmon are non-native in New Zealand, but were introduced in the mid- to late 1800s, more than a century before salmon farming began in the region. Juvenile salmon continue to be released deliberately in large numbers (from the same hatcheries supplying farms) through a government program to stock recreational fisheries throughout New Zealand. Therefore, the accidental release of farmed salmon from the same hatcheries, or from net pen farms is considered to have no significant additional impact on wild stocks of fish or the environment. In freshwater farming sites, net pens are in a closed hydrocanal system, where escaped fish are commonly caught by recreational fishermen. Escaped fish that are not caught are not able to reach a natural water body because of the system of dams built to supply hydroelectric power. Overall, both marine and freshwater Chinook farming get a score of 10 of 10 for Criterion 6.

Justification of Ranking

Factor 6.1a Escape Risk
Marine and Freshwater Sites

Chinook salmon has been present in the New Zealand environment since the early 1900s when it was first successfully introduced to stock a recreational fishery. This fishery is ongoing, and is restocked with Chinook on a regular basis. Juvenile Chinook used to stock the recreational fishery originate from some of the same hatcheries that supply juveniles to farms for commercial growout operations. Others originate from Fish and Game New Zealand hatcheries and Department of Conservation hatcheries (Johnston 2014). Numbers released annually vary widely (and will include differing numbers of Chinook salmon and trout) as do stocking rates in sea pens as size of fish changes, but the numbers represent the intentional release of 5-20 times more fish than could be released in a large-scale escape event (Johnston 2014). MCAS has provided numbers of fish released from their hatcheries which can be seen in Table 8 below.

Table 8 Smolt released from MCAS hatchery

Year	Smolt released
2011	17,000
2012	100,000
2013	40,000
2014 (ongoing)	50,000 (possibility of more)

Source: (Bradley 2014; Graybill 2014)

In the event of an escape from a salmon farm, the fish become the jurisdiction of Fish and Game New Zealand (Anonymous 2014). There is an established year-round recreational fishery for Chinook salmon in rivers and tributaries, including those near marine net pen sites and in the hydrocanals where salmon farms are located. In the event of an escape, the number of anglers in the area increases, leading to a conclusion that a percentage of farmed, escaped fish are recaptured (Stuff.co.nz 2010; Bruce 2012; MCAS 2012). The large population of pinnipeds in the marine areas leads to the assumption that escaped salmon from farms may be consumed by these species.

While Seafood Watch normally scores net pens as a 'high-risk' system in F6.1a and reduces this risk based on recaptures or mortality of escapees, the inherent risk of net pen farming of Chinook in New Zealand is not an appropriate measure for scoring due to the unusual circumstances of the intentional release of Chinook for the recreational fishery and the lack of any native stocks of Chinook salmon in New Zealand.

Factor 6.1b Invasiveness

Marine and Freshwater Sites

Since the early 1900s, Chinook have been fully established in marine and freshwater areas of New Zealand due to their introduction for development of a sport fishery (MCAS 2012). There has been no evidence provided showing that escaped salmon from farms in New Zealand have negative impacts on populations of fish in the wild. Often the lack of research or evidence of an impact is not a robust reason to base scoring on, however, the plethora of evidence that has been submitted to the board of inquiry, both promoting and against the proposed expansion of NZKS, has not cited any impacts of escaped salmon on the ecosystem. The Cawthron report states that it is unlikely that escaped salmon in marine environments will have an impact on the ecosystem due to the very small size of the industry and the non-native status of the salmon in the wild (Forrest 2007). This document states that the small size of the industry means that there are no potential impacts from escapes competing with wild species for food and habitat, and no modification to wild habitat. Any potential interbreeding between escaped farmed salmon and species in the wild is of minimal consequence due to the non-native status of the salmon in the wild.

Freshwater systems in New Zealand are unique compared with the marine systems or other freshwater systems outside of the country, given that the hydrocanals in which Chinook are farmed are man-made. A variety of salmonid species (trouts), aside from Chinook, inhabit the canals and were also introduced to develop a sport fishery (MCAS 2012). Because all of these salmonid species are released to the hydrocanals purposefully in order to supplement the recreational fishery and all are non-native in New Zealand, there is no significant competition between introduced species and wild stocks in freshwater hydrocanals, and species are all replenished for recreational fishing.

Overall, a final Criterion 6 score of 10 of 10 has been given for both marine and freshwater farming of Chinook salmon in New Zealand.

Criterion 7: Disease; pathogen and parasite interactions

Impact, unit of sustainability and principle

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

Marine and freshwater farms

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

Criterion 7 Summary

While various pathogens, including vibriosis, fin rot and gill rot have been recorded in cultured salmon in New Zealand, clinical disease outbreaks have not been reported in either marine or freshwater farms. New Zealand is a member country of the World Organization for Animal Health (OIE) and must provide immediate notifications of any epidemiological events along with quarterly reports stating the health status of OIE-listed diseases. Reports submitted from 2005 to 2013 are publicly available on the OIE website on a country-by-country basis and show that during this time there have been no reports of any epidemiological events to the OIE.[11] None of the pathogens recorded in New Zealand salmon farms have been classified as posing a significant risk to wild fish populations. However, although no disease outbreaks have been recorded to date, the industry is expanding and the introduction and discharge of disease from an open system is still a risk (Krkosek 2012). This leads to a score of 8 of 10 for the Disease Criterion. The largest freshwater farm in New Zealand has provided a biosecurity plan and has a score of 8 of 10 for the Disease Criterion.

Justification of Ranking

Under the Biosecurity Act of 1993 in New Zealand any occurrence or suspicion of occurrence of any notifiable organism considered new to New Zealand must be reported to the Ministry for Primary Industries (Lees 2014). Results and outcomes of investigations are published quarterly and have shown no instances of epidemiological events or any significant risks to the environment from diseases in farmed salmon.[12] The majority of salmon farms in New Zealand take part in the Salmon Export Surveillance Program, which carries out targeted testing for all

[11] World Animal Health Information Database, http://www.oie.int/wahis_2/public/wahid.php/Wahidhome/Home

[12] Quarterly reports are published in Surveillance Magazine, http://www.biosecurity.govt.nz/publications/surveillance/index.htm

cytopathic viruses, *Mxyobolus cerebralis*, *Aeromonas salmonicida*, *Yersinia ruckeri* and *Renibacterium salmoninarum*. Testing has revealed no significant pathogens (Clarkson 2014).

New Zealand is also a member country of the World Organization for Animal Health (OIE) and is therefore obligated to provide the OIE with immediate notifications and follow-up reports of any exceptional epidemiological events. New Zealand must also submit quarterly regional and bi-annual national reports stating the health status of OIE-listed diseases as well as bi-annual reports on the prophylactic and control measures in use for each disease. To date, no epidemiological events have required notification from New Zealand (Clarkson 2014).

Marine Sites:
Based on the findings of a qualitative risk analysis for the transfer of aquatic disease agents, the following 4 diseases were identified as potential diseases of concern for marine salmon farming in New Zealand: aquatic birnavirus, amoebic/nodular gill disease, sea lice and whirling disease (Diggles 2011; Diggles 2012). These 4 are discussed further in this document. While other diseases have been detected, they have not been identified as significant risks to salmon farming or to wild fish populations. A species of *Aeromonas* has been identified in a separate statement of evidence as having been found in species of trout and eel in New Zealand, but has not been found in any salmon farmed or in the wild (Diggles 2012; Krkosek 2012). It is believed by some that this species is *Aeromonas salmonicida* (Krkosek 2012)*,* which is the causative agent of Furunculosis, while other evidence states that no records of *Aeromonas salmonicida* in New Zealand exist despite targeted surveillance (Johnston 2014). A statement of evidence submitted to the board of inquiry on the expansion of NZKS farm sites in the Marlborough Sounds identifies this expansion as a possible catalyst for increased instances of disease in New Zealand salmon farming (Krkosek 2012). However, of the 9 sites applied for in the expansion by NZKS, only 3 have been granted, reducing the potential risk of increased disease and parasite interaction with farmed fish. It is not within the scope of this assessment to address potential future impacts of expanded farming that has not been implemented.

NZKS has implemented biosecurity protocols at each of their farm sites as well as their hatchery sites. These biosecurity measures reduce the risk of disease and pathogens entering and leaving the farms and hatcheries. However, due to the open nature of net pen systems used by NZKS, there is still an inherent risk of introduction of pathogens or parasitesto the ecosystem.

A die-off of young (~1 kg) salmon from a farm site in the Marlborough Sounds (in 2012) was thought initially to be caused by disease and was reported to MPI for investigation. It was found that infectious disease was not the cause of the die-off, and while there is still work to do on the investigation, there is clear evidence that the event was caused by a combination of environmental factors (Rissa Williams 2013; Johnston 2014). This is unusual compared to other major (global) salmon farming regions where disease and, particularly, parasites are a common production problem.

Aquatic birnavirus: This type of virus is present in the wild in sea run Chinook salmon stocks around the South Island of New Zealand (Diggles 2012). It has been determined that the likelihood of introducing birnavirus to a salmon farming operation in New Zealand through stocking of infected fish into open net pens is extremely low because broodstock salmon used by NZKS are held in freshwater their whole lives where birnavirus cannot survive (Diggles 2012). While the potential for this type of introduction is extremely low, the possibility for cultured salmon to become infected and create a reservoir of the virus does exist, however, Diggles has determined that due to its presence in the wild it would have minimal ecological impacts and would be controllable (Diggles 2012). It is stated, however, that it is extremely difficult to track and attribute deaths of wild fish to common pathogens and, without research and data illustrating that the risk of significant ecological impacts is low, this type of conclusion should be taken with caution (Krkosek 2012).

Amoebic/nodular gill disease: Chinook salmon have proven to be highly resistant to amoebic gill disease (AGD) caused by *Neoparamoeba perurans*, often carrying the infection but never experiencing mortality (Diggles 2012). Because these amoeba exist in the natural environment and sea runs of Chinook salmon are already exposed to them, it is not likely that they would experience any additional exposure to AGD from farmed salmon. Australian studies of wild fish near sea pens with salmon infected with AGD have shown that salmon do not act as a reservoir for infection (Diggles 2012). Instances of bacterial nodular gill disease have been recorded at freshwater hatcheries in New Zealand, however, none of these events has reached the scale of an epidemic or spread to wild fish stocks (Varney 2008; Tubbs 2010). Other instances of mortalities due to gill damage have been reported in New Zealand, however, it was found that this damage was due to increased turbidity and algae irritating the gills, and not due to a viral or bacterial disease (Bingham 2008).

Sea Lice: Several species of sea lice have proven to be of significant issue in salmon farming around the world, however, a 2009 study of the economic costs of sea lice management in salmon producing countries specifically excludes New Zealand because it notes sea lice are not found to be a significant issue (Costello 2009).

Several species of sea lice exist in New Zealand, however, none has proved to be of any significant issue whatsoever to Chinook salmon produced in New Zealand or elsewhere in the world (Diggles 2012). For examples, *Caligus elongatus* has been recorded in the wild in Christchurch on a species of flounder, but has not been problematic in farming of Chinook salmon in New Zealand. *Caligus epidemicus* has also been recorded in New Zealand on the same species of flounder, but has not been found on Chinook salmon in the wild or farmed. One species of sea lice, *Caligus longicaudatus*, has been found on sockeye salmon in New Zealand, however, Chinook salmon farmed nearby were not affected (Diggles 2012). In the evidence document prepared for the board of inquiry, Diggles states that in the event of an infection of sea lice in farmed Chinook salmon, sea lice could be transferred between farmed stocks and recreational stocks in the wild. However, due to the lack of evidence of any issue with sea lice in New Zealand farmed Chinook salmon as well as the often subclinical effects of sea lice on wild salmon, even the worst case scenario was deemed a low risk of impact to wild species (Diggles 2012).

Whirling disease: The parasite *Myxobolus cerebralis* that causes whirling disease has been found in multiple salmonid species on the South Island of New Zealand, including Chinook salmon (Diggles 2012). *M. cerebralis* is often found in freshwater environments where Chinook salmon are reared prior to being placed into sea pens. However, Diggles finds that despite this potential exposure pathway, Chinook salmon in New Zealand have not been diagnosed with clinical whirling disease (Diggles 2012). *M. cerebralis* does not survive in marine environments, and is therefore a very low risk to farming of Chinook salmon in marine net pens. It is a higher concern to farming of Chinook salmon in freshwater environments, however, as stated above, has never been clinically diagnosed in Chinook salmon in New Zealand (Diggles 2012).

As there have been no infectious disease outbreaks to date in New Zealand's marine salmon farms, there is no evidence of increased infection rates in wild fish, and parasites and pathogens are not amplified on farms. The farm sites, however, are exposed to the introduction and discharge of local pathogens and parasites due to the open nature of the system itself and therefore, a small but inherent element of risk remains.

Overall, a score of 8 of 10 is applied to the Disease Criterion for marine farms.

Freshwater Sites:

Similar to the marine sites, freshwater salmon farming is host to a variety of pathogens and parasites. Despite this, disease outbreaks in farmed Chinook salmon have not been recorded by any of the freshwater salmon farming companies, and an independent veterinarian (involved with MCAS since 2003) states that during that time, there have been no incidents of parasitic infections of *M. cerebralis* in Chinook salmon and therefore, no need for antibiotic use (Knowles 2013; Anonymous 2014; Swart 2014). As there have been no disease outbreaks to date in freshwater salmon farms in New Zealand, parasites and pathogens are not considered to be amplified on farms, nor is there expected to be any increased infection rates in wild fish. Biosecurity measures and contingency plans are in place should a disease outbreak occur on a farm, however, the sites are open to introduction and discharge of local pathogens and parasites due to the open nature of the system itself and, therefore, a small but inherent element of risk remains.

Because of the factors listed above, a score of 8 of 10 is applied to Criterion 7 for the Disease Criterion for freshwater farms.

Criterion 8: Source of Stock – independence from wild fisheries

Impact, unit of sustainability and principle

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

Marine and Freshwater Farms

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

Criterion 8 Summary

All salmon raised in New Zealand are sourced from hatchery-raised broodstock. Both marine and freshwater salmon farming get scores of 10 of 10 for the Source of Stock criterion as the industry is considered to be independent of wild fisheries for either broodstock or juveniles.

Justification of Ranking

Marine and Freshwater

There are no native wild Chinook salmon fisheries in New Zealand, and all salmon produced in both marine and freshwater net pens are from broodstock that have been raised in freshwater hatcheries in New Zealand. Larger companies in New Zealand are vertically integrated, producing their own smolt from broodstock while smaller companies source smolt from local hatcheries (BOI 2013; Anonymous 2014; Bradley 2014; Swart 2014).

Because 100% of Chinook salmon produced in New Zealand (marine and freshwater pens) comes from hatchery-raised broodstock, Criterion 8 is given a score of 10 of 10.

Criterion 9X: Wildlife and predator mortalities

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

This is an "exceptional" factor 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.

Marine Farms

Wildlife and predator mortality parameters	Score	
C9X Wildlife and predator mortality Final Score	**-6.00**	**YELLOW**
Critical?	NO	

Freshwater Farms

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

Criterion 9X Summary

The main species of concern in marine salmon farming in New Zealand include several species of birds, and marine mammals that are native to the largest salmon farming areas. One of these species is listed as endangered by the IUCN (Hector's dolphin), and 6 are listed as Nationally Endangered by the New Zealand Department of Conservation (New Zealand king shag, black-billed gull, black-fronted tern, bottlenose dolphin, southern right whale and Hector's dolphin). Of these endangered species, one Hector's dolphin (not officially confirmed) was found dead under a net pen at the Ruakaka Bay farm site in 2005 (cause of death unknown), and one bottlenose dolphin that died on a salmon farm site due to entanglement in nets in 2010.

The local population (20-30 individuals) of Hector's dolphins is a sub-population of a larger one of approximately 900 individuals in the surrounding bays, and part of a total population of around 9000 along the east coast of the South Island (MacKenzie 2014). Cawthorn states that deaths of individual dolphins at salmon farming sites will not impact the population (Cawthorn 2014), however, this assessment recognizes that unidentified dolphin mortalities may, in fact, be IUCN or nationally endangered species and a precautionary score has been applied for this criterion.

New Zealand fur seals are listed as a species of least concern by the IUCN and as Not Threatened by the New Zealand Department of Conservation (DOC), however, interactions with marine salmon farms result in approximately 2-3 mortalities each year for all NZKS sites combined.

Because of the potential ongoing interaction with endangered species, marine salmon farming has been given a score of -6 of -10 for Criterion 9X.

Freshwater salmon farming in New Zealand is done entirely in man-made hydrocanals, which are not home to any natural predators of salmon aside from small numbers of diving birds. There have been no mortalities of predators at any freshwater salmon farm, and measures have been taken to keep birds from getting into pens and becoming tangled. Freshwater salmon farming has been given a score of 0 of -10 for Criterion 9X.

Justification of Ranking

Marine Sites
C9X Wildlife and Predator Score:
Due to the siting of NZKS in the Marlborough Sounds, which is home to marine mammals and birds, measures must be taken in order to minimize interactions between wildlife and farmed salmon and avoid any mortality. Other marine farms are located in different areas of the marine environment of New Zealand, however NZKS' size and potential impact make it the focus of this analysis.

Seabirds
There are 3 species of seabirds listed as nationally endangered by the New Zealand Department of Conservation (NZDOC). that inhabit the Marlborough Sounds: the New Zealand king shag, black-billed gull and black-fronted tern (Sagar 2012). Each is endemic to New Zealand, with the entire population of New Zealand king shags (650 individuals) confined to the Marlborough Sounds (Sagar 2012). Only a small number of the black-billed gull and black-fronted tern populations can be found in the Marlborough Sounds, making the king shag the species of most concern with regard to salmon farming. To date, there are no records of mortalities of New Zealand king shags associated with salmon farming or aquaculture. There is one record of a seabird becoming caught in a net at a NZKS farm in 2009, however, it was an Australasian gannet not a king shag (Sagar 2012). Since then, NZKS has been progressively installing a smaller mesh size, which has successfully kept more seabirds from becoming tangled in nets (Gillard 2014).

Marine Mammals
Marine mammals present in the Marlborough Sounds and Cook Strait area include the New Zealand fur seal, 6 baleen whale species and 7 toothed whale species. Of these 13 whale species, 7 have been recorded in the Marlborough Sounds, the rest are found only in Cook Strait (Cawthorn 2011). The 7 whale species found in the Marlborough Sounds include humpback whale, southern wright whale, orca, Hector's dolphin, dusky dolphin, bottlenose dolphin and common dolphin (Cawthorn 2011). The species statuses of each of these 7 whale species along with the New Zealand fur seal are included in Table 9 below.

Table 9: Marine Mammal Species status. Source: (CS Baker 2010; IUCN 2014)

Species	**IUCN listing**	**New Zealand DOC listing**
Orca Whale	Data Deficient	
Type A		Nationally Critical
Type B		Vagrant
Type C		Vagrant
Type D		Vagrant
Dusky Dolphin	Data Deficient	Not Threatened
Common Dolphin	Least Concern	Not Threatened
New Zealand Fur Seal	Least Concern	Not Threatened
Bottlenose Dolphin	Least Concern	Nationally Endangered
Southern Right Whale	Least Concern	Nationally Endangered
Humpback Whale	Least Concern	Migrant
Hector's Dolphin	Endangered	Nationally Endangered

New Zealand Fur Seals

New Zealand fur seals are listed as a species of "least concern" by the IUCN (IUCN 2014) and as "not threatened" by the New Zealand Department of Conservation (DOC 2009). At the global level, seals seem to have become indifferent to the noise, light, floating structures and human presence associated with aquaculture facilities, and commonly haul-out to rest on floating pontoons and attempt to create holes in pens or bite fish through the netting. They have also been known to climb over pens with open tops and gain access to fish from within the net. New Zealand fur seals have occupied 4 of the 5 currently operating NZKS sites and have established haul outs within very close vicinity to 2 of the sites with predation causing significant damage to salmon pens and growout stocks (Cawthorn 2011). NZKS has installed predator nets to avoid further interactions between fur seals and salmon, and have taken other measures such as increasing tension of nets and implementing staff training and reporting measures. A close relationship with the New Zealand Department of Conservation and a 15-year permit under the Marine Mammal Protection Act for NZKS to "take" fur seals has resulted in minimizing interactions between fur seals and salmon as well as minimizing mortalities of fur seals and net entanglements.. Under this permit, "take" is defined as "catch and release seals which have entered salmon pens; harass while attempting to deter them from entering salmon pens; and injure, attract, herd, disturb and possess seals [….]. Killing of any seal (or other marine mammal) is not authorized (Baxter 2012; DOC 2014)." Since the installation of predator nets, fur seal mortalities are limited to a total of approximately 2-3 per year at NZKS (Baxter 2012; Cawthorn 2012; Rosewarne 2014). One fur seal became trapped in loose netting (during net maintenance, input or harvest) while 4 juveniles attempted to squeeze through mesh, getting their heads caught (Baxter 2012; Cawthorn 2012). Other incidents of interactions between fur seals and NZKS sites include 17 seals becoming caught in anti-predator netting and being freed by NZKS staff, and 9 seals making their way into salmon pens and being "escorted out" by NZKS staff (Cawthorn 2012). Because of these interactions, NZKS has opted to move to a smaller mesh size (from 240 mm to 200 mm), which is expected to lessen the number of mortalities (Baxter

2012). Since switching to nets with a smaller mesh size in 2012, a total of 3 seal mortalities have occurred at NZKS sites; 2 in 2013 and 1 in 2014 (Gillard 2014).

Baleen Whales

Humpback whales and southern right whales have been recorded in the Marlborough Sounds. Both are listed as “Least Concern” by the IUCN (IUCN 2014), however, the New Zealand Department of Conservation (NZDOC) lists humpback whales as “Migrant” and southern right whales as “Nationally Endangered.” Humpback whales migrate southward between the Ross Sea and the waters around Tonga, Niue and Fiji to breed, and migrate North again for feeding. During the Southward migrations, the whales pass along the eastern coast of New Zealand, while passing along the western coast upon their return to the Ross Sea (Cawthorn 2011). During their Northern migration, some humpbacks travel through the Cook Strait and into the Marlborough Sounds. The Department of Conservation does a daylight count of humpback whales during the migration period, resulting in sightings of an average of 33 individuals annually in the years between 2004 and 2010, while the 2011 count recorded 60 (Cawthorn 2011). There are no records of humpback whales interacting with salmon farms in New Zealand. However, there is a report of a humpback becoming tangled in craypot fishing lines in the Marlborough Sounds and later becoming snarled in mussel rope buoy lines at a mussel farm as it became tired and swam into shallower waters. This is the only report of a humpback whale becoming tangled in lines associated with marine farming in New Zealand (Cawthorn 2011) and it is highly unlikely, with the predator nets and pen design featuring taut ropes and nets, that large whales would become tangled in salmon farms (Cawthorn 2011; Baxter 2012; Cawthorn 2012).

Southern right whale populations are increasing, with breeding areas located in the Southern hemisphere and around New Zealand (Cawthorn 2011). The southern right whale population collapsed in the 1920s, but was given full protection in 1936, and has subsequently been able to reestablish (Cawthorn 2011). They are considered a species of “Low Concern” by the IUCN, however despite their reestablishment, southern right whales are still relatively scarce around the mainland of New Zealand. There have been only 11 sightings around mainland New Zealand between 1986-2011, with 3 per year since 2000 (Cawthorn 2011; Cawthorn 2012) leading to their ranking by the Department of Conservation as “Nationally Endangered” in New Zealand (CS Baker 2010). Similar to humpback whales, southern right whales have been known to become tangled in craypot buoy lines. They also have a tendency to rub against anchor chains and warps, however, there are no known instances of this leading to any adverse effect from aquaculture facilities in New Zealand (Cawthorn 2011).

Toothed Whales

Several species of toothed whale inhabit the Marlborough Sounds, including orca whales, bottlenose dolphins, Hector’s dolphins, dusky dolphins and common dolphins (Cawthorn 2011; Baxter 2012; Cawthorn 2012). Of these species, Hector’s dolphin is the only one that is listed as “Endangered” by the IUCN, while the others are either “Data Deficient” (dusky dolphin and orca whale) or species of "Least Concern." The DOC, however, has listed some of these species differently based on local observations. IUCN and DOC listings are shown in Table 7 above.

Orca whales are listed as "Nationally Critical" by DOC due to the small size of the population that inhabits the inshore areas of New Zealand. This population consists of approximately 117 individuals (Baxter 2012). This species is characterized as "stable with no known threat or evidence of decline," however, a newly documented threat is entanglement in untensioned fishing lines, specifically lobster pot lines. This is due to the discovery and rescue of 2 entangled orcas in 2011 and 2012 (Baxter 2012). Orca whales have been sighted in the Marlborough Sounds consistently and there are no known incidences of them becoming caught in lines or pens from salmon farms (Baxter 2012). The large size and rounded head of orcas make entanglement in tensioned lines from salmon farms a very slim possibility (Baxter 2012). It is assumed that the orcas may be attracted to salmon pens because of the abundance of sting rays (orca prey) feeding on the increased benthic organisms beneath the pens, making entanglement in salmon pens less likely (Cawthorn 2011; Cawthorn 2012).

Hector's dolphins are listed by the IUCN as "Endangered" and by DOC as "Nationally Endangered." These dolphins are endemic to New Zealand and have a limited distribution within this range (Cawthorn 2011). The local population (20-30 individuals) of Hector's dolphins is a sub-population of a larger one (approximately 900 individuals) in the surrounding bays. A study conducted in 2014 by MPI states that the total population consists of approximately 9,130 individuals along the east coast of the South Island during the summer, and 7,456 in the winter (D.L. MacKenzie 2014). However, current IUCN figures identify a population of 7,381 individuals and estimate a 74% rate of decline over the next 3 generations (IUCN 2014). There has been only one instance of mortality of a Hector's dolphin associated with salmon farming in New Zealand where, in 2005, one was found dead on the sea floor under a predator net at NZKS Ruakaka Bay site. Due to depth and poor visibility, attempts to recover the body of the dolphin were unsuccessful and it is not known whether the dolphin was trapped under the net and drowned or died of natural causes and was washed there (Cawthorn 2012). Due to the inability of staff to collect the carcass, statements that it was a Hector's dolphin are strictly anecdotal.

Bottlenose dolphins are listed as a species of "Least Concern" by the IUCN (IUCN 2014), however DOC has listed them as "Nationally Endangered" (DOC 2009). In New Zealand bottlenose dolphins inhabit a variety of areas, with some remaining in a narrow area while others have a large home range (Cawthorn 2011). Of the population of around 400 individuals in the Cook Strait, it is estimated that between 195 and 232 individuals visit and/or inhabit the Marlborough Sounds annually (Cawthorn 2011; Cawthorn 2014). It is because of this small number of individuals in three distinct populations and the reported decline in individuals that DOC has categorized bottlenose dolphins as "Nationally Endangered" (Baxter 2012). As shown in Table 8, a bottlenose dolphin became tangled in the net from a salmon farm in 2010. The farm site where these entanglements occurred has since changed the type of net being used in order to address the issue. While marine mammal experts have stated that given the management practices in place on salmon farms in New Zealand the likelihood of entanglement of dolphins is relatively low, any mortalities of this “Nationally Endangered” species from human activities is of high concern (Baxter 2012; Cawthorn 2012).

Both the common dolphin and the dusky dolphin are listed by DOC as “Not Threatened” in New Zealand (DOC 2009). Dusky dolphins are listed by the IUCN as “Data Deficient” while the common dolphin is a species of “Least Concern” (IUCN 2014). Both are found throughout the Southern hemisphere in pods ranging from a few individuals to hundreds (dusky dolphin) or over 1000 (common dolphin) (Cawthorn 2011). As seen in Table 8, mortalities of dusky dolphins in nets from salmon farms have been recorded in New Zealand, however, due to the large number of individuals, these losses are not a threat to the population (Cawthorn 2012). There are no official records of mortalities of common dolphins on salmon farms in New Zealand.

Management measures (net changes) were implemented in 2010 to minimize further predator interactions (Cawthorn 2014), but occasional mortalities of non-endangered dolphin species have continued (the most recent in 2013) (Gillard 2014). In all, 8 dolphin mortalities have occurred at salmon farming sites in New Zealand since operations began in 1984. Seven of these 8 were on farm sites currently owned by NZKS, although one mortality of a bottlenose dolphin occurred on the site prior to it being owned by NZKS (NZDOC 2011). While 6 of these dolphins were positively identified, the remainder (some of which have been anecdotally recorded as Hector’s and bottlenose dolphins) were not (Gillard 2014).

Table 10: New Zealand Chinook farming dolphin mortalities. Source: (Cawthorn 2011; Baxter 2012; Cawthorn 2012; Gillard 2014)

Species	**Number**	**Site**	**Year**	**Cause**	**Response**
Dusky Dolphin	2	Ruakaka	1999	Entrapment or entanglement	Significant changes in predator net design and operational procedures
Hector’s Dolphin (No formal identification)	1	NZKS Ruakaka	2005	Unknown • Either lost under pen and drowned or; • Natural causes and washed under the net	Reporting Multiple unsuccessful attempts to recover dolphin
Bottlenose Dolphin	1	Crail Bay (pre-NZKS)	2010	Entanglement in net during removal	Reporting Site sold to NZKS
Dusky Dolphin	1	NZKS Crail Bay	2011	Snout tangled in slack tensioned netting	NZKS in process of adapting farm to comply with policies and procedures at

					time of entanglements
Dusky Dolphin (possibly a common dolphin. No formal identification)	1	NZKS Crail Bay	2011	Snout tangled in slack tensioned netting	NZKS in process of adapting farm to comply with policies and procedures at time of entanglements
Dusky dolphin	1	NZKS Waihinau Bay	2012	Entrapment during net decommissioning. Found under predator net	Changing to smaller net mesh size (200 mm.) (Cawthorn 2014)
Dusky dolphin	1	Forsyth Bay	2013	Found under predator net	

Overall, while there have been no confirmed deaths of IUCN listed species (Hector's dolphin) and only one confirmed mortality of a nationally endangered species (bottlenose dolphin) in the 30-year history of the industry, the potential for these species to be included in the remaining unidentified mortalities (or potential future mortalities) is a concern. Criterion 9X is given a deduction of -6 of -10.

Freshwater Sites

C9X Wildlife and Predator Score:
Information obtained through personal contact with industry representatives in freshwater salmon farming in New Zealand indicates that minimal predator control is necessary for salmon farming in freshwater hydrocanals. There are no pinnipeds or fish predators present in hydrocanals. Members of the industry noted that, in some cases, cover nets are used to deter birds (specifically black shags, which are considered "naturally uncommon" by the New Zealand Department of Conservation) from eating smolt, however, these methods have never resulted in any entanglements or mortalities (Bradley 2014; Swart 2014) while another states that no predator controls are necessary at their farm (Anonymous 2014). On the New Zealand DOC scale ranging from "Not threatened" to "Extinct," the category "naturally uncommon" is less dire than "Not threatened" (Andrew J. Townsend 2008).

Because there are no reports of any predator entanglements or mortalities associated with freshwater salmon farming in New Zealand, and the only predator that interacts with freshwater salmon farms is not threatened, 9X is given a deduction of 0 of -10.

Criterion 10X: Escape of unintentionally introduced species

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

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

Marine farms

Escape of unintentionally introduced species parameters	Score	
10Xa International or trans-waterbody live animal shipments (%)	8.00	
10Xb Biosecurity of source/destination	6.00	
C10X Escape of unintentionally introduced species Final Score	**-0.80**	**GREEN**

Freshwater farms

Escape of unintentionally introduced species parameters	Score	
10Xa International or trans-waterbody live animal shipments (%)	8.00	
10Xb Biosecurity of source/destination	6.00	
C10X Escape of unintentionally introduced species Final Score	**-0.80**	**GREEN**

Criterion 10X Synthesis

The stocking of both marine and freshwater salmon farms in New Zealand is entirely reliant on hatchery-raised juveniles that are raised in the country. At the national level, importation of live animals is banned unless certain conditions are met that would allow an import permit to be issued, and any movement of live fish from one site to another requires approval by the Ministry for Primary Industries and/or Department of Conservation (Skonhoft 2006). Hatcheries are often owned by the farm, with a few exceptions supplying smaller farms in freshwater hydrocanals. Juveniles are moved from the hatchery to the growout facilities, which are in separate bodies of water. Hatcheries must be certified disease free and have a permit issued by the Ministry for Primary Industries in order to supply smolt or ova to farms (MPI 2013; Swart 2014).

Biosecurity measures are in place at the national, regional and farm levels in order to monitor for the emergence of any infectious disease, and to minimize the risk of introduction of pathogens and parasites. At the national level, the Biosecurity Act of 1993 is implemented by the Ministry for Primary Industries (MPI) and includes surveillance, risk management, and incursion investigation programs (MPI 2013a). A list of "notifiable organisms" is provided under the Biosecurity Act of 1993, and specifically lists "Organisms primarily affecting fish" that must be reported to MPI by anyone who identifies them (MPI 2010). Regional councils are required to address biosecurity issues in decision making and activities planning under the Resource Management Act and in their New Zealand Coastal Policy Statements. This is often done in the form of farm spacing, zoning, and staged development (MPI 2013a). At the farm level, biosecurity plans for both NZKS and MCAS have been shared for this assessment and include measures to prevent introduction of disease and parasites to the farm sites, as well as measures to avoid the spread of any disease or parasite that may occur at the farm (Knowles 2012; NZKS 2012).

Biosecurity protocol for NZKS describes measures taken at both the hatchery and growout sites to minimize the risk of introduction and spread of pathogens and parasites, resulting in a score of -0.8 of 10. The biosecurity plan for the largest freshwater farm has been shared, and raises the score to a -0.8 of 10.

Justification of Ranking

Marine Sites

Criterion 10Xa International or trans-waterbody live animal shipments

Marine salmon farming in New Zealand is entirely reliant on juveniles sourced from freshwater hatcheries which are, in most cases, owned by the farms. While this strategy involves trans-waterbody movements from the freshwater source to the marine growout site, this change in salinity makes it highly unlikely that any external parasites would survive from the hatchery to the growout site (Johnston 2014). Freshwater hatcheries are also subject to health monitoring requirements and MPI must be notified in the event of any mortalities or suspicion of notifiable disease (MPI 1983; Bradley 2014; Johnston 2014). Criterion 10Xa has been given a score of 8 of 10.

Criterion 10Xb Biosecurity of Source/Destination

NZKS biosecurity protocols outline measures to be taken at both the hatchery and growout facilities in order to manage and reduce the risk of disease and parasite introduction and transfer. The NZKS biosecurity protocols describe factors that predispose fish to disease, potential modes of transmission of disease and parasites, principles for control and eradication, current notifiable (to MPI) diseases, critical control points for biosecurity management actions to be taken, and specific measures and protocol to follow (NZKS 2012). Reports provided by independently contracted researchers to describe potential biosecurity impacts from marine salmon farms have focused on the potential impacts from introduction or enhancement of invasive and/or non-native species, however, specific biosecurity measures are not outlined for disease transfer prevention or management of impacts of unintended “pest” species (Forrest 2012). Based on biosecurity measures taken at the national, regional and farm level, a high score of 6 of 10 has been assigned to Criterion 10Xb for both the source and the destination of farmed Chinook salmon in marine farms in New Zealand.

The final combination of 10Xa and b for marine salmon farming is a score of -0.8 of -10.

Freshwater Sites

Factor 10Xa International or trans-waterbody live animal shipments

All freshwater salmon farming in New Zealand is supplied by hatcheries within the country; many operated by the farms themselves (Bradley 2014; Swart 2014). While farms are vertically integrated and include hatchery operations within their production, many of the hatchery sites are not in the same body of water as the growout sites, and production requires movement of live juveniles from one body of water to another. Although these practices have an inherent risk for transmission of diseases and/or non-target organisms, both the hatcheries and the farm sites have stringent biosecurity measures in place that minimize the risk (Knowles 2012). Criterion 10Xa has been given a score of 8 of 10.

Criterion 10Xb Biosecurity of Source/Destination
Hatcheries in New Zealand use biosecurity measures to reduce the risk of disease transfer between hatcheries and farms. MCAS outlines biosecurity protocols taken to avoid the unintentional introduction of non-targeted species in its Fish Health Management Plan developed by veterinarian Dr. Garry Knowles (Knowles 2012). These biosecurity guidelines apply to both the hatchery and the farm and are shown in Table 9 below.

Movement of fish is regulated by the Ministry for Primary Industries and requires permits certifying that all individuals are healthy and that "no site will have its disease status compromised" (Knowles 2012). In the event that a disease outbreak does occur, a contingency plan is provided that outlines procedures for isolating infected fish in order to minimize biosecurity risks (Knowles 2012). Based on biosecurity measures taken at the national, regional and farm levels, a score of 6 of 10 was applied for both the source and destination of farmed Chinook.

Table 11: Biosecurity Protocol at MCAS

There is no movement of equipment between sites without the express permission of the respective managers.
Any equipment that is transferred between sites must be thoroughly disinfected.
No equipment shall be loaned or transferred to or from other farms without the express permission of the technical manager.
All personal equipment, including boots, gloves, overalls and wet weather gear should be restricted to use on one site only. Gear must be left at the respective sites and not transferred between the two. None of this equipment is to be used for fishing.
Personnel will not work at different sites in the same day unless specifically directed to do so by the manager.
All staff and approved visitors shall disinfect their footwear by stepping into the disinfectant footbaths provided.
Disinfectant shall be replaced on a routine basis (twice weekly) and more often if required due to sediment, dirt or dilution.
If staff have been fishing, none of the clothing from that outing should be worn on the farm prior to thorough washing. Staff must

notify the respective managers before entering the farms if they have been fishing or tramping in direct proximity to streams, rivers or other bodies of water.
No unauthorized personnel will be permitted on the rafts.
All fish, ova and milt will be obtained from approved sources only.

The final combination of 10Xa and b for freshwater salmon farming is a deduction of -0.8 of -10.

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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.

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Data points and all scoring calculations

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

Marine Farms

Criterion 1: Data quality and availability

Data Category	Relevance (Y/N)	Data Quality	Score (0-10)
Industry or production statistics	*Yes*	10	10
Effluent	Yes	10	10
Locations/habitats	Yes	10	10
Predators and wildlife	Yes	10	10
Chemical use	Yes	7.5	7.5
Feed	Yes	10	10
Escapes, animal movements	Yes	7.5	7.5
Disease	Yes	10	10
Source of stock	Yes	7.5	7.5
Other – (e.g. GHG emissions)	No	Not relevant	n/a
Total			**82.5**

C1 Data Final Score	9.17	GREEN

Criterion 2: Effluents

C2 Effluent Final Score	**8.00**	**GREEN**
	Critical?	NO

Criterion 3: Habitat

3.1. Habitat conversion and function

F3.1 Score	**8**

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

Factor 3.2a - Regulatory or management effectiveness

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

Factor 3.2b - Siting regulatory or management enforcement

Question	Scoring	Score
1 - Are enforcement organizations or individuals identifiable and contactable, and are they appropriate to the scale of the industry?	Yes	1
2 - Does the farm siting or permitting process function according to the zoning or other ecosystem-based management plans articulated in the control measures?	Yes	1
3 - Does the farm siting or permitting process take account of other farms and their cumulative impacts?	Mostly	0.75
4 - Is the enforcement process transparent - e.g. public availability of farm locations and sizes, EIA reports, zoning plans, etc?	Yes	1
5 - Is there evidence that the restrictions or limits defined in the control measures are being achieved?	Mostly	0.75
		4.5

F3.2 Score (2.2a*2.2b/2.5)	**7.20**

C3 Habitat Final Score	**7.73**	**GREEN**
	Critical?	NO

Criterion 4: Evidence or Risk of Chemical Use

Chemical Use parameters	Score	
C4 Chemical Use Score	**10.00**	
C4 Chemical Use Final Score	**10.00**	**GREEN**
Critical?	NO	

Criterion 5: Feed

5.1. Wild Fish Use

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

Fishmeal inclusion level (%)	11.4
Fishmeal from byproducts (%)	44
% FM	6.38
Fish oil inclusion level (%)	6
Fish oil from byproducts (%)	0
% FO	6
Fishmeal yield (%)	22
Fish oil yield (%)	5
eFCR	1.75
FIFO fishmeal	0.51
FIFO fish oil	2.10
Greater of the 2 FIFO scores	2.10
FIFO Score	**4.75**

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

SSWF	-4
SSWF Factor	-0.84

F5.1 Wild Fish Use Score	**3.91**

5.2. Net protein Gain or Loss

Protein INPUTS	
Protein content of feed	39
eFCR	1.75
Feed protein from NON-EDIBLE sources (%)	47
Feed protein from EDIBLE CROP sources (%)	15
Protein OUTPUTS	
Protein content of whole harvested fish (%)	17.7
Edible yield of harvested fish (%)	67
Non-edible byproducts from harvested fish used for other food production	100
Protein IN	33.24
Protein OUT	17.7

Net protein gain or loss (%)		-46.76
	Critical?	NO
F5.2 Net protein Score	**5.00**	

5.3. Feed Footprint

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

Inclusion level of aquatic feed ingredients (%)	17.4
eFCR	1.75
Average Primary Productivity (C) required for aquatic feed ingredients (ton C/ton fish)	*69.7*
Average ocean productivity for continental shelf areas (ton C/ha)	*2.68*
Ocean area appropriated (ha/ton fish)	7.92

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

Inclusion level of crop feed ingredients (%)	35.2
Inclusion level of land animal products (%)	42.8
Conversion ratio of crop ingredients to land animal products	*2.88*
eFCR	1.75
Average yield of major feed ingredient crops (t/ha)	*2.64*
Land area appropriated (ha per ton of fish)	1.05

Value (Ocean + Land Area)	**8.97**

F5.3 Feed Footprint Score	**7.00**

C5 Feed Final Score	**4.96**	**YELLOW**
	Critical?	**NO**

Criterion 6: Escapes

Final C6 Score	**10.00**	**GREEN**
	Critical?	**NO**

Criterion 7: Diseases

Pathogen and parasite parameters	**Score**	
C7 Biosecurity	8.00	
C7 Disease; pathogen and parasite Final Score	**8.00**	**GREEN**

Critical?	NO

Criterion 8: Source of Stock

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

Exceptional Criterion 9X: Wildlife and predator mortalities

Wildlife and predator mortality parameters	Score	
9X Wildlife and Predator Final Score	**-6.00**	**YELLOW**
Critical?	NO	

Exceptional Criterion 10X: Escape of unintentionally introduced species

Escape of unintentionally introduced species parameters	Score	
C10Xa International or trans-waterbody live animal shipments (%)	0.00	
C10Xb Biosecurity of source/destination	10.00	
C10X Escape of unintentionally introduced species Final Score	**-0.80**	**GREEN**

Freshwater farms

Criterion 1: Data quality and availability

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

Total		70

C1 Data Final Score	8.89	GREEN

Criterion 2: Effluents

C2 Effluent Final Score	8.00	GREEN
	Critical?	NO

Criterion 3: Habitat

3.1. Habitat conversion and function

F3.1 Score	10

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

Factor 3.2a - Regulatory or management effectiveness

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

Factor 3.2b - Siting regulatory or management enforcement

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

4.5

F3.2 Score (2.2a*2.2b/2.5)	**7.20**

C3 Habitat Final Score	**9.07**	**GREEN**
	Critical?	NO

Criterion 4: Evidence or Risk of Chemical Use

Chemical Use parameters	**Score**	
C4 Chemical Use Score	**10.00**	
C4 Chemical Use Final Score	**10.00**	**GREEN**
Critical?	NO	

Criterion 5: Feed

5.1. Wild Fish Use

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

Fishmeal inclusion level (%)	20
Fishmeal from byproducts (%)	50
% FM	10
Fish oil inclusion level (%)	6
Fish oil from byproducts (%)	0
% FO	6
Fishmeal yield (%)	22.5
Fish oil yield (%)	5
eFCR	1.4
FIFO fishmeal	0.62
FIFO fish oil	1.68
Greater of the 2 FIFO scores	1.68
FIFO Score	**5.80**

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

SSWF	-4
SSWF Factor	-0.67

F5.1 Wild Fish Use Score	**5.13**

5.2. Net protein Gain or Loss

Protein INPUTS	
Protein content of feed	42
eFCR	1.4
Feed protein from NON-EDIBLE sources (%)	26.8
Feed protein from EDIBLE CROP sources (%)	57.3
Protein OUTPUTS	
Protein content of whole harvested fish (%)	21
Edible yield of harvested fish (%)	62
Non-edible byproducts from harvested fish used for other food production	100
Protein IN	33.41
Protein OUT	21
Net protein gain or loss (%)	-37.14
Critical?	NO
F5.2 Net protein Score	**6.00**

5.3. Feed Footprint

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

Inclusion level of aquatic feed ingredients (%)	26
eFCR	1.4
Average Primary Productivity (C) required for aquatic feed ingredients (ton C/ton fish)	*69.7*
Average ocean productivity for continental shelf areas (ton C/ha)	*2.68*
Ocean area appropriated (ha/ton fish)	9.47

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

Inclusion level of crop feed ingredients (%)	59
Inclusion level of land animal products (%)	15
Conversion ratio of crop ingedients to land animal products	*2.88*
eFCR	1.4
Average yield of major feed ingredient crops (t/ha)	*2.64*
Land area appropriated (ha per ton of fish)	0.54

Value (Ocean + Land Area)	**10.01**

F5.3 Feed Footprint Score	**6.00**

C5 Feed Final Score	**5.56**	**YELLOW**
	Critical?	**NO**

Criterion 6: Escapes

Final C6 Score	**10.00**	**GREEN**
	Critical?	**NO**

Criterion 7: Diseases

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

Criterion 8: Source of Stock

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

Exceptional Criterion 9X: Wildlife and predator mortalities

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

Exceptional Criterion 10X: Escape of unintentionally introduced species

Escape of unintentionally introduced species parameters	**Score**	
C10Xa International or trans-waterbody live animal shipments (%)	8.00	
C10Xb Biosecurity of source/destination	6.00	
C10X Escape of unintentionally introduced species Final Score	**-0.80**	**GREEN**