Sablefish

Anoplopoma fimbria

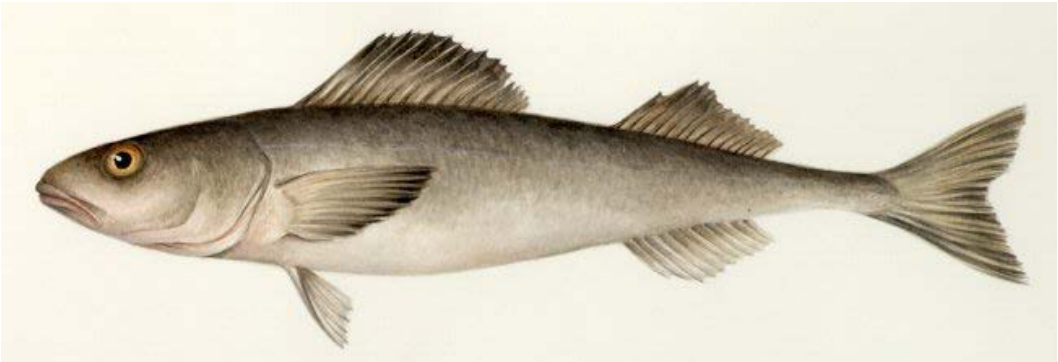

Image courtesy of Monterey Bay Aquarium

Totem Sea Farm Inc.
Jervis Inlet, British Columbia

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.

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

Guiding Principles

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

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

Seafood Watch will:

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

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

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

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

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

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

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

Final Seafood Recommendation

Sablefish
Anoplopoma fimbria
Totem Sea Farm Inc.
Jervis Inlet, British Columbia
Net Pen

Criterion	Score (0-10)	Rank	Critical?
C1 Data	5.28	YELLOW	n/a
C2 Effluent	7.00	GREEN	NO
C3 Habitat	6.74	GREEN	NO
C4 Chemicals	10.00	GREEN	NO
C5 Feed	6.52	YELLOW	NO
C6 Escapes	5.00	YELLOW	NO
C7 Disease	6.00	YELLOW	NO
C8 Source	9.00	GREEN	n/a
9X Wildlife Mortalities	-2.00	GREEN	NO
10X Introduced Species Escape	0.00	GREEN	n/a
Total	52.54		
Final Score	6.69		

OVERALL RANKING

Final Score	6.69
Initial rank	GREEN
Red criteria	0
Interim rank	GREEN
Critical Criteria?	NO

FINAL RANK
GREEN

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

Summary
Sablefish farmed in open net pens at Totem Sea Farm Inc. receives a score of 6.57. No 'red' criteria result in a final green ranking, making sablefish produced at Totem Sea Farm a 'Best Choice.'

Executive Summary

Sablefish farming in British Columbia (BC) began in 1997 and remains a relatively small portion of the province's aquaculture industry, accounting for only 1.2% of the total farmed finfish landings in 2010. At the time of this writing, only two farms were reporting commercial-scale production of sablefish in BC. Due to lack of participation of one of the two farms, this report is limited to a farm-level assessment specific to Totem Sea Farm Inc.

Totem Sea Farm Inc. was first started as an oyster farm in 1977 and in 1999 began stocking sablefish, which is now the predominant species raised on-site. Today, Totem Sea Farm produces approximately 50 to 60 mt of sablefish per year (personal communication with Gus Angus, farm owner). Since May 2012, the farm has been adherent to the Canadian Organic Aquaculture Standards, which are a set of voluntary standards that were published by the Canadian General Standards Board under the sponsorship of DFO. The farm was certified in September 2013 and is subject to annual re-evaluation (the most recent evaluation was in August 2014). This certification allows certain assumptions to be made about farming practices at Totem Sea Farm, which are used as justification of scoring in a number of areas of this assessment.

The data quality and availability criterion (C1) scored 5.28 out of 10 (yellow) and although the farm owners were cooperative in providing farm-specific data required to complete this assessment, most data were not independently verified. By focusing the assessment on a single farm in a small segment of the aquaculture industry, much of the data are not peer-reviewed and are thus prevented from meeting the criteria guidelines for high quality data.

Totem Sea Farm received green rankings for both the Effluent and Habitat criteria, C2 and C3. Although the farm is operating under a government management regime that does not coherently address all potential impacts of aquaculture effluent, farm-level management limits biomass and therefore the amount of effluent discharge. The farm site is also deep and well flushed with similar characteristics to salmon farms that result in minimal benthic impact. The final Effluent score is 7 out of 10. The Habitat Criterion received a final score of 6.74 out of 10 as the farm demonstrates a functioning habitat with minor to moderate impacts (that are reversible) and the established regulatory and management regime for aquaculture siting was found to be moderately effective. Exceptional Criterion 9X (wildlife mortalities) ranked *green* (-2 out of -10) as Totem Sea Farm maintains an effective predator management plan and has only had two cases of wildlife mortalities on site (a kingfisher and a harbor seal), which are not species federally or provincially listed as being at risk in BC.

Totem Sea Farm states that they have a low chemical use on-site and operate in accordance to the Canadian Organic Standards for Aquaculture, which limits the type and quantity of chemicals an aquaculture farm can use. The owner reports no antibiotic or parasiticide use since sablefish were first farmed at the site in 1999, and has supplied evidence via the material use lists the farm submits quarterly to DFO. The only chemicals used at the farm are bleach and

iodophor (both for sanitary purposes) and results of this is a Chemical Criterion (C4) score of 10 out of 10.

The Disease Criterion (C7), scored 6 out of 10 reflecting an effective fish health management plan for a high-risk production system. The species being farmed has proven to be inherently robust to many common pathogens of concern, which in turn has resulted in a low occurrence of on-farm infections. Similar to the chemical criterion, however, the high-risk nature of Totem Sea Farm's production system (open net pen) is of concern for pathogen and parasite interactions. The score for this criterion is intended to reflect the current state of knowledge and should be re-assessed upon the emergence of any new information, as there is no available empirical data of juvenile sablefish monitoring in proximity to the farm.

Although no significant escape events have been reported at Totem Sea Farm, the Escapes Criterion (C6) ranked *yellow* (4 out of 10) due to the high escape risk of the production system and the low invasiveness score of the species being farmed. The Exceptional Criterion 10X (introduced species escapes) ranked *green* (0 deducted from the overall score) because even though all juveniles are technically sourced internationally (from a hatchery in Washington, USA), the movement of live juveniles does not require a trans-waterbody shipment.

The Source of Stock Criterion (C8) ranked *green* (10 out of 10) because although broodfish are wild-caught, the harvest of wild broodfish is managed as part of the Washington commercial sablefish fishery and broodfish landings are included in the overall total allowable catch (TAC) for the fishery, which has been ranked as moderately-highly sustainable (either *yellow* or *green* depending on the catch method) by Monterey Bay Aquarium Seafood Watch.

The Feed Criterion (C5) ranked *green* (6.77 out of 10) due to high byproduct inclusion in the fishmeal and fish oil, which results in an exceptionally low wild fish use, a low net protein loss and a high overall feed footprint score.

Overall, a score of 6.57 out of 10 and a final *yellow* ranking was achieved making sablefish produced at Totem Sea Farm a 'good alternative.'

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Species Overview

Sablefish (*Anoplopoma fimbria)* are a marine cold-water groundfish found in the northwest Pacific Ocean from northern Mexico to the Gulf of Alaska. Part of the family Anoplopomatidae, sablefish are long-lived, can grow to be up to 1.2 meter in length and can weigh up to 57 kg (Sumaila et al. 2005). Mature sablefish typically live on mud bottoms between depths of 300 m to 2700 m, while juveniles tend to inhabit more inshore waters (Sumaila et al. 2005). Two distinct populations of sablefish have been identified: the northern population which inhabits the waters of Alaska and northern British Columbia, and the southern population that extends from southern British Columbia (Vancouver Island) to northern Mexico (National Ocean and Atmospheric Administration (NOAA) 2012).

Most wild fish are processed (headed, gutted, frozen) and sent to market in Japan (Food and Agriculture Organization (FAO) 2012).

Production Statistics
In 2010, five companies in BC reported food market sale harvests that totaled 866 t of farmed sablefish which was valued at over $10 million (Personal communication with Carmen Mathews, BC Ministry of Agriculture). Only two of the five companies are still actively farming this species: Golden Eagle Sable Fish Inc. and Totem Sea Farm Inc.

Totem Sea Farm is the smaller of the two active sablefish aquaculture ventures in BC, producing 50 to 60 tons per year.

Import and Export Sources and Statistics
Currently, all product is exported with the majority to Japan and, to a lesser extent, the US (personal communication with Gus Angus).

Common and Market Names
Black cod, butterfish, blue cod, bluefish, candlefish, coal cod and coalfish.

Product Forms
Totem Sea Farms sells their sablefish as smoked or fresh fillets.

Analysis

Scoring guide

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

Criterion 1: Data quality and availability

Impact, unit of sustainability and principle

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

Criterion 1 Summary

Justification of Ranking

Data Category	Relevance (Y/N)	Data Quality	Score (0-10)
Industry or production statistics	Yes	5	5
Effluent	Yes	7.5	7.5
Locations/habitats	Yes	5	5
Predators and wildlife	Yes	5	5
Chemical use	Yes	5	5
Feed	Yes	5	5
Escapes, animal movements	Yes	5	5
Disease	Yes	5	5
Source of stock	Yes	5	5
Other – (e.g., GHG emissions)	No	n/a	n/a
Total			**47.5**

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

Brief Summary

The farm owners were cooperative in providing farm-specific data required to complete this assessment, however most of the data were not independently verified. In addition, by focusing the assessment on a single farm in a small segment of the aquaculture industry, much of the data is not peer-reviewed. As such, the Data Quality Criterion scored 5.28 out of 10 and ranked *yellow*.

Justification of Ranking

As this assessment is specific to a single farm, the cooperation of the farm owner/operators was very important in ensuring that the final report is accurate and reflective of on-the-farm-operations. The small scale of the farm presented some challenges for retrieving the quality of data (i.e., independently verified, peer-reviewed etc.) needed to be scored 'high quality' by the assessment criteria. With the exception of the Effluent Criterion, all categories scored 5 out of 10 for data quality because there was some loss of relevant information through data gaps. The farm owners and feed producers provided extensive data for each of the criterion, in addition to some data from relevant peer-reviewed salmon aquaculture research:

- Effluent – eFCR and protein content, compliance with sulfide limits at monitoring stations (30 m and 125 m), site characteristics (depth and current), monitoring of salmon aquaculture benthic impacts, background nutrient load from coastal upwelling, government regulations (re: effluent limits and monitoring)
- Locations/habitats – site characteristics (subtidal, soft-bottomed), compliance with sediment sampling limits, species diversity from dive survey, reversibility of net pen farming impacts, government regulations re: habitat and farm siting
- Predators and wildlife – BC Aquaculture Regulatory Program (BCARP) database reports of predator interactions, farmer reported mortalities, predator prevention mechanisms and deterrents
- Chemical use – farm material use list, Canadian Organic Standards for Aquaculture (COAS) certificate
- Feed – feed declaration from feed company (Taplow Feeds) including protein, fishmeal, fish oil, wild fish source (and byproduct), crop inclusion
- Escapes, animal movements – no reported escapes (farmer and COAS certificate), government regulations regarding escape reporting
- Disease – disease reports from farm, COAS vaccination requirements
- Source of stock – hatchery sourcing information, commercial fishery broodstock allocation, wild stock assessment

Nearly all required details were provided and only minor data gaps exist, but it is not independently verified data and cannot meet the requirements of high quality data. The one exception is the Effluent Criterion, which receives a score of 7.5. A qualified third party is commissioned by the farm to perform sampling and analysis for benthic monitoring (which, although not available in its entirety, is verified by government records) and information used to evaluate regulatory and management effectiveness also satisfies the requirements for a higher quality data score. The score assigned to the majority of categories (5 out of 10) is

intended to reflect high data availability and moderate data quality. Overall, the data quality score was 5.28 and ranked *yellow*.

Criterion 2: Effluents

Impact, unit of sustainability and principle

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

Criterion 2 Summary

Effluent Rapid Assessment

C2 Effluent Final Score	**7.00**	**GREEN**

Brief Summary

This criterion aims to assess the impact of farm effluent on the regional environment (i.e., beyond the immediate farm boundary or allowable zone of effect (AZE)). Impacts of the farming operation on the immediate vicinity of the farm are addressed in the following criterion, C3 'Habitat.' There are regulations in place that require BC fish farms to monitor the benthic impact of particulate wastes up to 140 m away from cage arrays, but no soluble effluent impact monitoring. There is also a substantial amount of research that speaks to the unlikelihood of impact of soluble wastes from fish farms on the regional environment as long as farm locations are not shallow and flush frequently. The Data Criterion scored 7.5, meaning that the quality is robust enough to use the rapid assessment available in the Seafood Watch scoring tool and receives a moderate to high score of 7 out of 10.

Justification of Ranking

This factor aims to address both the local impact of farm effluent discharge and potential contribution to cumulative regional impacts. The Seafood Watch Aquaculture Criteria Guidelines state "impacts beyond the immediate vicinity of the farm or discharge point are suggested as beyond 30 m from the farm boundary or discharge point, or beyond an allowable zone of effect." The flexibility in this definition is necessary due to the diverse language used to describe, manage and regulate aquaculture effluent, but it also inherently suggests a certain degree of overlap with the Habitat Criterion. As such, some clear, justifiable and logical boundaries were made by the assessor (and are outlined in the following sections) to ensure the final assessment is appropriately reflective of on-the-water practices.

Biological waste from finfish aquaculture (i.e., effluent) disperses in two forms once released into the environment: soluble wastes and particulate wastes. Both types of waste have the

potential to impact the regional environment (i.e., beyond the immediate vicinity of the farm) and hence each is considered herein.

Soluble Wastes

The environmental implications of releasing soluble fish waste from aquaculture remains a point of debate within the academic literature. Unfortunately there is no academic literature that speaks directly to effluent impacts from sablefish farming, likely due to the small commercial scale and relatively young history of the industry; however, insights can be drawn from research conducted on salmon farming in the region. Farm site characteristics and nutrient release can be compared with salmon farming values. In the marine environment, one of the main concerns is the ecosystem effects (namely nutrification leading to phytoplankton blooms) that could result from the ongoing release of concentrated nitrogen that is excreted by fish as ammonium either across gill epithelia or as concentrate urea (Brooks 2007). However, Brooks also states that "primary production in the Northeast Pacific is generally light and not nutrient limited and salmon aquaculture has minimal potential to affect phytoplankton production in much of this region."

Brooks (2007) reports that Washington State required monitoring of NO_3, NO_2, and total ammonia for all salmon farms from 1986 to 1995, over which period there were no significant increases in nitrogen observed at any of the 30 m downstream sampling stations. Brooks goes on to conduct a mass balance equation to show that in 2005, salmon farms contributed approximately 15.8 tons of dissolved inorganic nitrogen per day to coastal British Columbia and Puget Sound, which he determines to be negligible in comparison to the approximate 2000 tonnes of dissolved inorganic nitrogen delivered to the coast via upwelling. Relative to the nutrients released from the BC salmon industry and coastal upwelling, one can infer that the roughly 9 kg of nitrogen waste[2] per day from Totem Sea Farm is unlikely to cause further impact. More recent studies conducted on salmon farms in northwest Scotland have noted more persistent ammonium concentrations that extend up to 300 m away from cage arrays, however, at this distance concentrations are not far above background levels (about 1µM) and although there may be increased potential for macroalgal growth at the farm site, it is not likely to trigger increased productivity of mobile organisms like phytoplankton (Sanderson 2006, Sanderson et al. 2008). The review by Brooks and Mahnken (2003) supported a thesis that, with the exception of a few shallow, poorly flushed embayments, the potential for net pen enhancement of phytoplankton populations is remote or nonexistent. With a fairly consistent depth of 125 m (with the north end shallowing to 95 m) and moderate current of 1.5 knots, the Totem Sea Farm site is well flushed and deep, consistent with salmon net pen sites where soluble wastes are a minimal issue (personal communication with Gus Angus).

[2] The daily nitrogen waste amount was calculated using the full assessment scoring tool for effluent. An excess of 66.56 kg of nitrogen is produced per ton of fish raised at Totem Sea Farm and approximately 80% is released (using a basic net pen system). With average annual production of 55 mT, approximately 8.84 kg of nitrogen waste is released on a daily basis.

The variable response of ecosystems to added nutrient waste may reflect geographic differences, as Sanderson (2006) notes that "the distribution [of ammonium concentrations] is heavily influenced by local hydrography" (p.1). Farms act as a point source of wastes and increase the levels of nitrogen close to them, but there is lack of consensus as to whether or not they have an impact above background productivity due to differential case study results. In the context of Totem Sea Farm, which stocks less than 100 mt of fish per year (closer to 50-60 mt) in a deep and frequently flushed site, it is anticipated that the impacts from soluble effluent would be minimal due to the small scale of the operation.

Particulate Wastes

As of 2010, the aquaculture industry in BC has been regulated by DFO under the BC Aquaculture Regulatory Program (BCARP). The BCARP does monitor and regulate the release of particulate wastes from aquaculture under their benthic monitoring program. These regulations are primarily applicable to the Habitat criterion (C3), which aims to assess the environmental impact within the immediate vicinity of the farm. However, under the benthic monitoring program, sampling may be required up to 140 m away from the cage edge, which is beyond the immediate vicinity of the farm and hence must be acknowledged within this criterion as well. Totem is a soft-bottom site and the furthest monitoring station required is 125 m.

The BCARP states "the majority of [aquaculture derived] organic waste ends up in an area fairly close to the farm; often within 30 meters. This is referred to as the 'near-field area'" (DFO 2013*a*). Despite this acknowledgement, aquaculture license holders are required to conduct benthic sampling at distances of 0 m, 30 m and 125 m away from the cage array for farms at soft-bottom sites. In the case of farms at hard-bottom sites, license holders must conduct visual monitoring of the benthos using video transects between 100 m and 124 m away from the cage array. If required, BCARP may request farms at hard-bottom sites to extend the video transect from 124 m to 140 m away from the cage array—an area called the "Post-Compliance Zone" (DFO 2013*a*). This suggests that, although limited, there is some effort by the regulatory and management regime to address effluent impacts beyond the immediate vicinity of the farm site. Additionally, the design of the regulatory system is based on the premise that if the majority of wastes are deposited in the near-field area and monitoring indicates that if there are no significant impacts at 30 m, impacts at greater distances from the farm are unlikely (and therefore benthic samplings are required only in certain circumstances).

Totem Sea Farm is sited on soft-bottom and, hence, is required to conduct sediment samples at peak biomass at 0 m, 30 m, and 125 m away from the cage array extending in two different directions and to self-report the sediment sulfide concentrations to BCARP. The most recent sampling was conducted in November 2012 and showed that all sampling stations were in compliance with set sulfide limits, suggesting that the particulate wastes from the farm are having minimal far-field effects. All 30 m monitoring stations were <1300 µmol and all 125 m stations were <700 µmol. Although exact values are not available, it should be noted that a third party is commissioned by the farm to conduct sampling and analysis for benthic monitoring. And while the third party company is not identified in public records, they must

follow specified sampling protocols outlined by DFO. The third party is then responsible to report the results to the farm and to BCARP.

Enforcement of the benthic monitoring regulations is carried out by DFO staff working in the Conservation and Protection (C&P) Unit, which was created under BCARP. The primary role of the C&P Unit is to enforce compliance with the *Fisheries Act* and the *Pacific Aquaculture Regulations* and they have staff stationed throughout the regional offices on Vancouver Island who are identifiable and whose contact information is available online[3]. In addition to assessing the industry-reported benthic monitoring data, the staff is supposed to be conducting field audits to ensure compliance with set limits. The BCARP Benthic Monitoring webpage states "the results of DFO's benthic monitoring audits will be made available on an annual basis" (DFO 2013*a*), however, such data are not available online and were not made available to the author despite numerous requests to DFO staff.

All data collected and reported under the benthic monitoring program are made publicly available quarterly on the BCARP website[4]. In 2013, 16% of marine finfish farm reports showed benthic impacts greater than the allowable limit and required a subsequent pre-stock survey to be completed. With the exception of one instance, all sites that conducted a subsequent pre-stock survey showed site recovery to allowable limits and were hence able to re-stock. This would suggest that, in most cases, monitoring data and available information demonstrate active enforcement of the set control measures.

Overall, the management and regulatory system in place does not effectively address all potential regional impacts of aquaculture effluents (namely the omission of regulations around soluble wastes), control measures for far-field particulate wastes do not cover all aspects of the production cycle (monitoring is only required at peak biomass), and there is no evidence of active enforcement or robust penalties at this time. However, the effluent score examines management (government and farm-level) as well as the actual impact of farm effluent discharges. Totem Sea Farm is a single farm site with a low level of production. Monitoring data demonstrates compliance with regulations and third party monitoring suggests minimal far-field impacts after 15 years of producing sablefish at the farm site. Totem Sea Farms is managed in a way that intentionally and effectively limits their potential contribution to regional or cumulative impacts.

The final score for the Effluent Criterion is 7 out of 10 (*green*) as data show no evidence that Totem Sea Farm discharges cause or contribute to local or regional impacts beyond the immediate vicinity of the farm at current production levels.

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[3] http://www.pac.dfo-mpo.gc.ca/locations-bureaux-eng.html
[4] http://www.pac.dfo-mpo.gc.ca/aquaculture/reporting-rapports/benth-eng.html

Criterion 3: Habitat

Impact, unit of sustainability and principle

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

Criterion 3 Summary

Habitat parameters	Value	Score	
F3.1 Habitat conversion and function		8.00	
F3.2a Content of habitat regulations	3.25		
F3.2b Enforcement of habitat regulations	3.25		
F3.2 Regulatory or management effectiveness score		4.23	
C3 Habitat Final Score		**6.74**	**YELLOW**
Critical?	NO		

Brief Summary

Aquaculture can have significant impacts on the habitat in which farms are sited and may result in loss of ecosystem services. This criterion aims to assess the impacts that the farm is having on the habitat functionality within the *immediate* vicinity of the farm site. The final score of 6.74 results from a combination of a moderately high habitat conversion score (8) and a moderate habitat management score (4.23).

Justification of Ranking Factor 3.1. Habitat Conversion and Function

Totem Sea Farm is sited in a coastal subtidal zone in British Columbia, which is deemed to have a moderate habitat value according to the Seafood Watch scoring tool. The farm, sited over soft-bottom sediments, is required by DFO to conduct sediment sampling at six prescribed locations around the farm site at peak biomass. Results from sediment sampling are made publicly available online[5] and the most recent survey at Totem Sea Farm, conducted in November 2012, showed that all sampling stations were in compliance with set sulfide limits (as reported in the Effluent section, C2). In addition to this industry self-reporting required by DFO, some randomized dives have taken place at Totem Sea Farm by the Fish Research Group at the Vancouver Aquarium. These dives have anecdotally shown that a significant amount of life is still supported on and below the farm's nets, but as they were not conducted using proper transect sampling they do not provide concrete results on how species diversity and abundance

[5] http://www.pac.dfo-mpo.gc.ca/aquaculture/reporting-rapports/docs/benth/2012/Q4-T4-eng.html

differs from that of a reference plot (personal communication Jeff Marliave, Vancouver Aquarium).

There is significant evidence in the literature that open net pen farming in BC causes substantive loss of habitat functionality within the farm boundary (Johannessen et al. 2007, Haggarty 2003, Sutherland et al. 2001). The reversibility of these impacts, however, appears to be largely site-dependent. A 2009 study released by the BC Ministry of Environment reported long-term habitat impacts at Center Cove, in Kyuquot Sound on the west coast of Vancouver Island, resultant from a salmon farm operation that was sited in the area from the mid-1980s through to 2002 (Obee 2009). The study found that after six years of fallowing, sulfide concentrations were declining gradually but the site remained organically enriched and metal concentrations remained relatively high. However, it is noted that this site is believed to be "atypical" (Obee 2009, p.2) in BC and other research has shown that chemical and biological remediation can occur within six months of harvest (Brooks et al. 2003). Brooks et al. (2004) estimate that only 5%–10% of historic farms in the Pacific Northwest have created "significant negative effects that have proven long-lasting." Overall, the main point of consensus is that recovery rates for near-field impacts of marine net pen fish farm sites are highly site-dependent and often slower in regions exhibiting high depositional environments and finer silt-clay sediments below the cage (Black et al. 2011, Obee 2009, Brooks 2007; Brooks et al. 2003, Pearson & Black 2001).

It is known that Totem Sea Farm is sited over a soft-sediment bottom, however, specific details about sediment size or depositional environment are not available. There is a high rate of biological abundance and diversity anecdotally observed during randomized dives. Recent (third party) sediment samples demonstrate that sulfide concentrations remain below threshold limits set out by DFO. From this information, it can be deducted that the site is maintaining habitat functionality with only moderate observable impacts (nutrient enrichment and biological community shifts). The depth of the site and current (surging is seen at high tide), there is likely to be some, but limited, impacts below the cage sites with major impacts reversed within 1 to 2 years (similar to farmed salmon sites in New Zealand; Black 2013, Keeley et al. 2014). Although there is uncertainty in the recovery rate for the site given its location over soft-sediment seafloor, the farm has been producing sablefish at this location for 15 years with no evidence of significant impacts or ecosystem functionality loss, resulting in a score of 8.

Factor 3.2. Habitat and Farm Siting Management Effectiveness (Appropriate to the Scale of the Industry)

As of 2010, DFO has been the primary responsible authority for licensing, monitoring and enforcement of aquaculture management in British Columbia. Transport Canada (TC) is also responsible for reviewing aquaculture applications under the Navigable Waters Protection Program. The province of British Columbia remains responsible for authorizing tenure of provincial crown land, which is a process overseen by the Ministry of Forests, Lands and Natural Resource Operations (FLNRO). Under these various agencies, aquaculture siting and management must adhere to the *Fisheries Act,* the *Navigable Waters Protection Act (R.S.C.*

1985, c. N-22), the *Pacific Aquaculture Regulations (SOR/2010-270*), the *Canadian Environmental Assessment Act 2012 (S.C. 2012, c.19, s.52)*, and the BC *Land Act [RSBC 1996]*.

Until 2012, applications for new aquaculture sites or expansions of previously existing sites were typically required to undergo an environmental assessment or screening, which was carried out in accordance to the *Canadian Environmental Assessment Act*. The requirement to perform an environmental assessment or screening was typically triggered by either one or both of the following applicable legislative components:

1) Under subsections 5(1) and/or 6(4) of the *Navigable Waters Protection Act* (NWPA) any proposed work that has the potential to interfere with navigation requires approval by the Navigable Waters Protection Program (NWPP). A 2004 document authored by Transport Canada states "[m]ost aquaculture works have the potential to interfere with navigation and require conditions of approval under the NWPA and thus trigger a thorough environmental review under CEAA" (p.13, Transport Canada 2004).
2) Under subsection 35 of the *Fisheries Act,* which prohibits any person to carry out work that results in "serious harm to fish that are part of a commercial, recreational or Aboriginal fishery, or to fish that support such a fishery" (S.35, 1985).

The environmental assessments or screenings would be carried out by either Transport Canada in the case of scenario 1 above or by DFO in the case of scenario 2. The Canadian Environmental Assessment Agency (CEAA) maintains an online, publicly available database[6] of all ongoing and completed environmental assessments (of which there are 149 archived files available specific to aquaculture siting in BC).

In 2012, however, the federal government made significant changes to the *Canadian Environmental Assessment Act* (now known as the *Canadian Environmental Assessment Act 2012),* the *Navigable Waters Protection Act* (now the *Navigation Protection Act*), and to the *Fisheries Act.*

Staff from the Canadian Environmental Assessment Agency confirmed that the new environmental assessment act, *CEAA 2012*, does not directly apply to aquaculture-type projects, however, authorizations pursuant to the *Fisheries Act* and *Navigation Protection Act* may still trigger an assessment (personal communication, Zoltan Fabian, Canadian Environmental Assessment Agency project manager). Amendments to the *Fisheries Act* were approved and made publicly available in June 2012. These amendments resulted in significant changes in the language of Section 35 of the *Fisheries Act* such that a number of exceptions are now acceptable as long as they are in accordance with "the regulations." A DFO Fisheries Protection Policy Statement states that "serious harm" provision will be triggered in any of the following circumstances as of November 2013:

- The death of fish
- A permanent alteration to fish habitat of a spatial scale, duration or intensity that limits or diminishes the ability of fish to use such habitats as spawning grounds, or as nursery,

[6] Canadian Environmental Assessment Registry: http://www.ceaa-acee.gc.ca/050/index-eng.cfm

rearing, or food supply areas, or as a migration corridor, or any other area in order to carry out one or more of their life processes

- The destruction of fish habitat of a spatial scale, duration, or intensity that fish can no longer rely upon such habitats for use as spawning grounds, or as nursery, rearing, or food supply areas, or as a migration corridor, or any other area in order to carry out one or more of their life processes. (DFO 2013b)

Under the revisions to the *Fisheries Act,* DFO has proposed Aquaculture Activities Regulations (AAR), which have been developed to reconcile and clarify existing conditions from provincial and federal policy regarding therapeutic treatment of fish and deposition of organic matter (DFO 2014a). The AAR defines a deleterious substance to include biochemical oxygen-demanding matter and is designed to monitor and minimize the impact from aquaculture releases of fish feces, unconsumed feed, or organic matter resulting from biofouling control. A draft was published in August 2014, with the final AAR anticipated in early 2015, at which point further clarification of requirements will be possible.

Evidently, the Canadian management and regulatory regime for aquaculture is currently in a transition period. As recent changes to applicable legislation are newly coming into force, it is challenging to assess the effectiveness of the management and regulatory regime. A conservative approach was taken herein that is informed by how the management regimes have operated to date and conscientious of forthcoming changes.

As it stands currently, a proposed application for a new or extended aquaculture site must, at a minimum, provide the following: a general location map, detailed location map, top view operational diagram, side view operational diagram, and habitat map[7]. The habitat map must provide detailed habitat characteristics that are to be determined by conducting a habitat assessment. In addition, under the *Pacific Aquaculture Regulations*, all new farms are required to provide a study of farm-waste impacts carried out using a computer particle-tracking model called DEPOMOD (DFO 2013*a*). The effectiveness of the DEPOMOD model has been recently called into question, however, after internal DFO emails submitted to the Cohen Commission enquiry anecdotally reported that the model was not identifying the areas of highest waste concentration at approximately 25% of farm[8].

The industry's total size, ongoing expansion and potential cumulative impacts are partially addressed by the licensing process. Sites that underwent an environmental assessment or screening under the old *Canadian Environmental Assessment Act (CEAA)* were required to include a review of cumulative impacts as per section 19(a) of the *CEAA*. The new *Canadian Environmental Assessment Act 2012 (CEAA 2012)* upholds clause 19(a), however, it is uncertain

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[7] Pacific Marine Finfish Aquaculture Application http://www.for.gov.bc.ca/land_tenures/tenure_programs/programs/aquaculture/documents/PACIFIC_MARINE_FINFISH_AQUACULTURE_APPLICATION.pdf

[8] Cohen Commission document reference \\Nats01 \NSD\CDCI NCR lnquiry\Second Review\Sharon Ford\Aquaculture Regulation & Policy\Email\cohen_ sharon_ford - 2011 0613.pst\cohen_sharon_ford\lnbox \Cohen_ Commision_Found\

at this time whether future aquaculture applications will have to undergo an environmental assessment. It should be noted that the current licensing process under the *Pacific Aquaculture Regulations* ensures that farms are not to be sited within 3 km of one another[5]. A map of all active marine finfish aquaculture tenures in 2011 is available through the BC Ministry of Agriculture[9].

As described in the justification of criterion 2, BCARP is the responsible enforcement authority for enforcement and regulatory oversight of the aquaculture industry in BC and enforcement staff are stationed across Vancouver Island in a number of DFO's regional offices. These offices are all clearly identifiable and all contact information is provided online. As part of the BCARP and in accordance with the *Pacific Aquaculture Regulations*, benthic impacts are regulated and monitored in an effort "to avoid impacts to eelgrass beds, kelp beds, shellfish beds, glass sponge reefs, juvenile rockfish nurseries and other sensitive habitats" (DFO 2013*a*). In accordance with the *BC Lands Use Operational Policy (Aquaculture)*, upon decommissioning of a site the tenure hold must ensure the site is left in a "clean, sanitary and safe manner" (Section 9.5.2). A video transect of the site must be provided to the authorizing agency to demonstrate the state of the site and the Ministry of Forests, Lands and Natural Resource Operations is tasked with conducting audits of the site. If a company fails to clean up a given site and the company is no longer operative, then the province works with the BC Salmon Farmers Association or the British Columbia Shellfish Growers association to address outstanding clean up.

No environmental impact assessment was performed on the Totem site when the farm was first established in 1977, and it is uncertain whether expansion will trigger one. Overall, there is evidence that a management regime appropriate to the current scale of the industry is in place, with recent changes bringing into question whether licensing and future expansion of the industry will take an ecological/ecosystem-based approach. However, the small total area of impact of sablefish farm sites in BC (only 2 farms operating at a commercial level out of the 41 with a permit), indicate that the potential for cumulative direct habitat impacts from the industry as a whole or in the future is limited. As such, the BC aquaculture siting regulatory and management effectiveness and enforcement both score 3.25, resulting in a Final Management score of 4.23 out of 10.

The final score for the Habitat Criterion was 6.74 out of 10 and ranked *yellow*, which resulted from a high habitat conversion score (8) and a moderate habitat management score (4.23).

[9] Map of Finfish aquaculture tenures http://www.al.gov.bc.ca/fisheries/cabinet/finfish_tenures2011.pdf

Criterion 4: Evidence or Risk of Chemical Use

Impact, unit of sustainability and principle

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

Criterion 4 Summary

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

Brief Summary

Totem Sea Farm voluntarily complies with the Canadian Organic Standards for Aquaculture, which restricts the application of antibiotics and parasiticides to exceptional circumstances, which results in non-certified product if an appropriate withdrawal period cannot be applied. Only disinfectants are reportedly used on the farm (chlorine and Virkon®) and with no other chemical therapeutants applied, Totem receives a high score of 10 out of 10.

Justification of Ranking

There are little to no publicly available data regarding on-site chemical use at sablefish farms due to the small scale of the industry and the emphasis in the literature on salmon farming in BC. Totem Sea Farm vaccinates their fish against vibrosis (*Vibrio anguillarum*) and furunculosis (*Aeromonas salmonicidia)*, and also maintains a low stocking density in order to minimize pathogen transfer and decrease fish stress (personal communication with Gus Angus). The farm owner has stated that there is no antibiotic or parasiticide use on site due to low pathogen outbreaks. Furthermore, they do not use antifouling chemicals, but rather clean their nets by hand. The only two chemicals reported to be used on site were chlorine and a Virkon® Aquatic chemical footbath, both of which are used for sanitation purposes.

Additionally, Totem Sea Farm operates in accordance to the Canadian Organic Standards for Aquaculture (COSA), which outline acceptable types, quantities and withdrawal periods for chemical use. Although these standards represent a step in the right direction, they do still allow for the use of conventional chemicals (antibiotics and parasiticides) to be applied under the authority of a licensed veterinarian in required circumstances. According to section 6.5.15 of the COSA, treatment with conventional chemicals is limited to one treatment for slaughter

aquaculture animals up to one year old and to two treatments for older animals; if additional treatment is required, then the farm loses its organic certification for that stream of fish. COSA list antibiotics and parasiticides as prohibited except if alternative treatment or management practices do not exist, then synthetic medications (including antibiotics) and/or chemical allopathic veterinary drugs can be administered.

The COSA standards demonstrate a concerted effort to address chemical use in aquaculture, however the 'soft' requirements and lack of robust enforcements practices (as these are voluntary measures) suggest they are not strong enough to verify minimal and safe chemical use practices. There is no evidence of chemical use (other than Virkon® and chlorine), which is supported by the material usage list supplied by the farmer, which results in a high score of 10 out of 10 for this criterion.

Criterion 5: Feed

Impact, unit of sustainability and principle

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

Criterion 5 Summary

Feed parameters	Value	Score	
F5.1a Fish In: Fish Out ratio (FIFO)	0.31	9.22	
F5.1b Source fishery sustainability score		-6.00	
F5.1: Wild Fish Use		9.04	
F5.2a Protein IN	15.48		
F5.2b Protein OUT	12.00		
F5.2: Net Protein Gain or Loss (%)	-22.5	7	
F5.3: Feed Footprint (hectares)	24.21	1	
C5 Feed Final Score		**6.52**	**YELLOW**
Critical?	NO		

Brief Summary

As a carnivorous finfish, sablefish have high dietary protein requirements. Formulated feeds for sablefish are comprised mostly of fishmeal (50%) and fish oil (16%), but high use of byproduct offsets both the wild fish use and potential protein loss. As all raw ingredients are included in the feed footprint calculation, the large proportion of marine ingredients results in a substantial appropriation of primary productivity. The Wild Fish Use score (9.04), Net Protein Gain/Loss score (7) and Feed Footprint score (1) combine for an overall score of 6.52 out of 10.

Justification of Ranking

Factor 5.1. Wild Fish Use

All feed used at Totem Sea Farm is produced by Taplow Feeds and the data for Criterion 5 was obtained through personal communication with Brad Hicks of Taplow Feeds. The feed used at Totem Sea Farm has fishmeal and fish oil content of 50% and 16%, respectively. Approximately 90% of the fishmeal is sourced from herring byproduct of the BC roe herring fishery (*yellow* ranked as per the Monterey Bay Aquarium Seafood Watch criterion), while the remainder is

from anchovy, mackerel, and/or sardine of the Pacific pelagic fishery. Fish oil is sourced primarily (95%) from hot-pressed byproduct of the herring, anchovy, mackerel, sardine and hake fisheries. All of these source fisheries purport to be compliant with the FAO code of conduct, however, none have been assessed by a third party and thus the sustainability of the source of wild feed is unknown and scored -6. Overall, the high level of byproduct inclusion and eFCR of 1.4 resulted in a fish in: fish out (FIFO) score of 0.31 based on the FIFO value for fish meal, and a final score of 9.04 for factor 5.1.

Factor 5.2. Net Protein Gain or Loss

The feed used at Totem Sea Farm has a protein content of 44%, but, as stated above, a vast majority of fishmeal (90%) is sourced from nonedible sources and 0% of protein from edible crop sources. However, as no list of nonedible crop sources provided by the feed producer, it is assumed they are edible. This results in 68% of feed protein from fishmeal byproduct and 24% protein in feed from edible crop sources. The remaining 8% of protein in feed is from whole fish. Sablefish have a protein content of 20% and an average edible yield of 60% (personal communication with Gus Angus). In addition, all nonedible byproducts from harvest and processing are used in the production of secondary products such as fertilizer, but not used directly for further feed production (personal communication with Gus Angus). The calculation of edible protein in (15.48) to protein out (12) results in a net protein loss of 22.5% and a F5.2 score of 7 out of 10.

Factor 5.3. Feed Footprint

The ingredients of the feed used at Totem Sea Farm are primarily from aquatic origin (i.e., fishmeal and fish oil). As Totem Sea Farm operates in accordance with the Canadian Organic Aquaculture Standards and their feed is certified according to the same standards, no land animal products are used in the feed (CGSB 2012). Any additional ingredients are derived from land crops. Although byproducts offset fishmeal and fish oil use in the previous factors, all raw ingredients are included to estimate the feed footprint. As a result, the feed composition used at Totem Sea Farm requires the relatively large appropriation of 24.03 hectares of ocean area and 0.18 hectares of land area per ton of farmed fish produced, which results in a score of 1 out of 10 for factor 5.3.

Combined, these three factors lead to a moderately high overall score for the feed criterion of 6.52 (*yellow*). This resulted namely from the high byproduct inclusion rate in the fishmeal and fish oil, which results in a low wild fish use and net protein loss, but a relatively high overall feed footprint.

Criterion 6: Escapes

Impact, unit of sustainability and principle

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

Criterion 6 Summary

Escape parameters	Value	Score	
F6.1 Escape Risk		2.00	
F6.1a Recapture and mortality (%)	0		
F6.1b Invasiveness		8	
C6 Escape Final Score		**5.00**	**YELLOW**
Critical?	NO		

Brief Summary

Despite escape prevention measures, the use of net pen production systems presents a high risk for escapes, both through trickle losses and large-scale events. The fish raised at Totem Sea Farms are a native species without much risk of genetic differentiation from wild populations due to their relatively short history in cultivation (70% of broodstock is sourced from wild native populations). There have been no reported escapes, and due to low production levels (50-60 mt annually) and genetic similarity between farmed stock and wild populations it is considered that any unnoticed trickle losses from the farm would not have any significant impact on the surrounding ecosystem. While sablefish aquaculture is a relatively young industry without evidence to prove that escapees would not compete with wild populations or act as additional predation pressure, due to the factors mentioned above, the combination of a low escape risk score of 2 and a high (low risk) invasiveness score of 8 results in an overall Escape Criterion score of 5 out of 10, and indicates a moderate concern for escapes.

Justification of Ranking

Factor 6.1a. Escape Risk

Totem Sea Farm operates an open net pen production system, which is deemed to be 'high risk' according to the Seafood Watch scoring tool criteria. In accordance with the Pacific Aquaculture Regulations, the farm does have Best Management Practices in place which appear to be effective, as no reported escape events have occurred (personal communication, Gus Angus and COAS certificate).

In addition to requiring all farms to implement escape prevention measures, the *Pacific Aquaculture Regulations* require all aquaculture license holders to report any incidents of escapes to DFO. The BC marine finfish aquaculture industry is responsible for self-reporting escape events that are publicly reported online annually[10], however DFO does not conduct any active monitoring of escapes. Concerns have been raised with regards to the accuracy of these self-reported data due to inconsistencies in industry-reported data, data made publicly available by DFO, and the small amount of academic literature available (Sumaila et al. 2005, Morton & Volpe 2002). One commonly cited reason for these inconsistencies has been the potential cumulative impact of small-scale ongoing escapes from farm sites, referred to as 'leakages' (Morton & Volpe 2002) or 'trickle losses' (Weir & Flemming 2006), which go unreported. Although the concerns described above are aimed at the Atlantic salmon farming industry, the issue of trickle losses is relevant to the use of net pen production systems.

It is unknown whether trickle losses are occurring at Totem Sea Farm, however, it is not unjustifiable to assume that they may be. The consequences of potential sablefish escapees present new and different challenges because, unlike farmed salmon of which a vast majority of the culture is the exotic species Atlantic salmon (*Salmo salar*), escapees would not be easily identifiable from their wild con-specifics (Sumaila et al, 2005). For this reason, DFO does not require the recapture of escapes if they are a native species and, as such, if an escape event were to occur at Totem Sea Farm it is unlikely that there would be any recapture efforts. Overall, despite the lack of reported escape events on site from Totem Sea Farm, the high-risk nature of the farming system and fact that escape events are self-reported result in an escape risk score of 2.

Factor 6.1b. Invasiveness

Sablefish are native to BC's coast and all current farmed stock at Totem Sea Farm is sourced from wild broodstock or recently domesticated (F1) brood fish (personal communication, Gus Angus), which results in a score of 4 out of 5 according to the Seafood Watch criteria for a small genetic difference from wild populations.

There is little to no literature available on the ecosystem impacts of sablefish escapes, however, due to the low levels of production at Totem Sea Farm, no recorded or reported escape events, and the genetic similarity of farmed stock to wild populations, it is considered that there is a low concern of impact to surrounding ecosystems. This assessment is a snapshot of current practices at Totem Sea Farm, and as of now, no escape events have been reported (personal communication, Gus Angus, DFO 2015 and COAS certificate). While it can be assumed that some trickle losses do occur, the small scale of the industry and the genetic similarity of the farmed stock to the wild populations results in a very low risk of impact from these potential escapes. Based on basic life-history characteristics of the species it is anticipated that escapees from trickle losses may, to some extent, compete with wild native populations for food and/or habitat, and/or act as additional predation pressure on wild native populations, however, it is not considered that this competition will be at a scale that will have any significant impact to

[10] http://www.pac.dfo-mpo.gc.ca/aquaculture/reporting-rapports/escape-evasion-eng.html

the wild populations, as the majority species that are consumed by wild sablefish in the region have sustainable populations. In the wild, sablefish generally eat pollock, eulachon, capelin, herring, sand lance, pacific cod, squid, jellyfish and krill (AFSC 2010), almost all of which are assessed by Seafood Watch in that region as either *yellow* or *green*. The exceptions are eulachon which is *red*, and squid which is not assessed for the region. Although competition for breeding partners is unlikely to occur in the same way that escaped native salmon can interact with wild salmon (in very spatially restricted spawning areas), it is a possibility and, given the lack of evidence, it is cautiously assumed that it may occur to some extent. The genetic similarity of current farmed stock to wild populations means that these ecosystem impacts are likely to be minimal, and will remain so until residence duration in captivity is increased beyond F1s. Given the past lack of large-scale escapes it is highly unlikely that any increased habitat modification will occur due to any escaped fish because an increase in escapes is unlikely, and any escapes are likely to be just trickle losses. Overall, these characteristics result in a high invasiveness score of 8 of 10 (indicating a low level of concern).

The combination of a low escape risk score of 2 and a high invasiveness score of 8 results in an overall Escape criterion score of 5 out of 10, and indicates a moderate concern for escapes.

Criterion 7: Disease; Pathogen and Parasite Interactions

Impact, unit of sustainability and principle

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

Criterion 7 Summary

Pathogen and parasite parameters	Score	
C7 Biosecurity	6.00	
C7 Disease; pathogen and parasite Final Score	**6.00**	**YELLOW**
Critical?	**NO**	

Brief Summary

The disease, pathogen and parasite interaction criterion takes into consideration a combination of both the risk level of the production system and evidence or risk of pathogen outbreaks. The open net pens used at Totem Sea Farm do not prevent the amplification of pathogens and transfers to wild populations, but a low occurrence of on-farm infections reduces the risk of the farmed sablefish increasing the wild pathogen load. Totem Sea Farm receives a moderate score of 6 out of 10.

Justification of Ranking

Totem Sea Farm operates an open net pen production system, which has an inherently high risk of pathogen and parasite introduction and discharge. In accordance with *Pacific Aquaculture Regulations*, Totem Sea Farm maintains a fish health management plan (FHMP), which was last updated in August 2012 (personal communication with Dana Angus). Further to this, compliance with COSA requires the preventative use of vaccinations for vibrosis and furunculosis rather than treatments after infection (as noted in the Chemical Criterion). The farm owner, Gus Angus, has reported a very low incidence of on-farm infections that he anecdotally attributes to the robustness of the species as well as to the farm's tendency to maintain a low stocking density. From his observations, sablefish are not susceptible to sea lice, a major concern for salmon aquaculture in British Columbia. There are a number of pathogens and parasites associated with sablefish and no research has been conducted to assess the transfer to or occurrence of pathogens in wild sablefish juveniles. No OIE listed diseases have occurred on the farm and there have not been major issues since a vibriosis occurrence prior to 2000 (when vaccination began). Some mortality (<1%) is observed in high heat times due to gram-positive bacteria. Overall, this criterion received a moderate score of 6 as data show low, temporary or infrequent occurrences of on-farm infections or mortalities.

Criterion 8: Source of Stock – Independence from Wild Fisheries

Impact, unit of sustainability and principle

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

Criterion 8 Summary

Source of stock parameters	Score	
C8 % of production from hatchery-raised broodstock or natural (passive) settlement	90	
C8 Source of stock Final Score	**9.00**	**GREEN**

Brief Summary

The hatchery that supplies juveniles to Totem Sea Farm sources approximately 70% of their broodstock from wild sablefish populations. Although this represents a large portion of stock, it is sourced from a moderately sustainable fishery (Washington sablefish ranks *yellow* in the Seafood Watch Program) with a very small amount of the TAC allocated to aquaculturists. The potential impact of wild broodstock sourcing is considered minor and receives a score of 9 out of 10.

Justification of Ranking

Advances in the domestication of sablefish brood stock have been slow and, up until recently, all brood fish were wild-caught from commercial fisheries (Huppert and Best 2004). Totem Sea Farm sources their juveniles from a Washington-based hatchery, Troutlodge Marine, which confirmed that approximately 30% of their broodstock are an F1 generation, while the remainder is sourced from the Washington commercial sablefish fishery. In order to receive these broodfish, Troutlodge Marine contracts a commercial hook and line fisherman in southwestern Washington with a valid sablefish license. The Washington sablefish fishery as a whole is considered to be moderately sustainable due to the use of bottom trawls and bottom longlines and ranks yellow in the MBA Seafood Watch Program. The wild-caught fish allocated to aquaculturists for brood stock are considered part of the commercial total allowable catch (TAC) and are likely to represent a very small portion of the overall landings. Although specific values could not be found for the Washington commercial fishery, a similar practice is carried out in BC whereby only 0.1% of the TAC is made available to aquaculturists (personal communication Gabrielle Kosmider, Fisheries and Oceans Canada). A recent review of sablefish population structure in the Northeast Pacific Ocean suggests there is a single biological population throughout their known range in the area due to the large amount of movement and exchange that occurs (DFO 2013c). Similar broodstock sourcing practices in Washington and British Columbia limits the potential impact of sablefish aquaculture on wild populations.

This factor has been assessed using all of the above information. As such, because the wild source of the broodstock is relatively sustainable (the single-generation domesticated broodstock also come from this source, and only a small percentage of the TAC is allotted to collection of wild broodstock for aquaculture), it is determined that the collection of wild broodstock for production of growout stock at Totem Sea Farm has negligible environmental impacts and scores a 9 of 10 for Criterion 8.

Criterion 9X: Wildlife and Predator Mortalities

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

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

Criterion 9X Summary

Wildlife and predator mortality parameters	Score	
C9X Wildlife and predator mortality Final Score	**-2.00**	**GREEN**
Critical?	NO	

Summary

Totem's predatory management plan means that the farm has passive mechanisms in place to prevent lethal wildlife interactions outside of exceptional cases. Over the past eight years, only two predator mortalities have occurred (and none during the most recent four years). This results in a score of -2 for the Wildlife and Predator Mortality Criterion.

Justification of Ranking

C9X Wildlife and Predator Score

As a condition to all aquaculture licenses in BC, all farms must have a predatory management plan in place (DFO 2014b). The BCARP maintains an online, publicly available database of all reported predator interactions that occur on BC aquaculture sites. No predator interactions have been listed for Totem Sea Farm on the BCARP reporting website during the past four years (2011–September 2014, DFO 2014b). The BCARP database includes both authorized marine mammal control activities as well as accidental drownings. Totem Sea Farm employs electric fences to deter sea otters, as well as seasonal bird nets and predator nets to minimize wildlife and predator interactions on the farm (personal communication with Gus Angus). With these mechanisms in place, Totem Sea Farm has seen only two predator mortalities (a kingfisher and a harbor seal, neither of which are listed as endangered or threatened on the Canadian Species at Risk registry[11]) on-site over the past eight years (personal communication with Gus Angus). This suggests that the concern for wildlife and predator mortalities is limited to exceptional cases, which results in a score of -2 for this criterion.

[11] http://www.registrelep-sararegistry.gc.ca

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.

Criterion 10X Summary

Escape of unintentionally introduced species parameters	Score	
C10Xa International or trans-waterbody live animal shipments (%)	10.00	
C10Xb Biosecurity of source/destination	0	
C10X Escape of unintentionally introduced species Final Score	**0.00**	**GREEN**

Justification of Ranking

Factor 10Xa International or Trans-waterbody Live Animal Shipments

The sablefish farming industry remains relatively young and therefore there are only a few sources for juveniles. Totem Sea Farm currently sources all of their juveniles from Troutlodge Marine, which is a hatchery facility in Tacoma, Washington. Although technically this represents an international shipment of live animals, the hatchery is in fact less than 700 km away from the farm site and is set within the same eco-region and does not represent a trans-waterbody shipment. Additionally, as noted in Criterion 8 evidence suggests that the sablefish population in the northeast Pacific Ocean is a single biological population throughout its known range. As such, no penalty was awarded for this factor.

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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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References

Alaska Fisheries Science Center of National Oceanic and Atmospheric Administration. (2010). Sablefish Fact Sheet. Retrieved from http://www.afsc.noaa.gov/Education/ factsheets/10_Sablefish_fs.pdf

B.C. Land Use Operational Policy (Aquaculture). (2011). Retrieved from http://www.for.gov.bc.ca/land_tenures/documents/policies/aquaculture.pdf

Black, K., Cromey, C., Nickell, T. (2011). Benthic Recovery Project. Retrieved from http://www.sarf.org.uk/cms-assets/documents/43892-181648.sarf030.pdf

Black, K. (2013). Scientific Peer-review of monitoring results from New Zealand King Salmon Farms, SRSL, Scottish Marine Institute.

Brooks, K.M., Stierns, A.R., Mahnken, C.V.W., Blackburn, D.B. (2003). Chemical and biological remediation of the benthos near Atlantic salmon farms. *Aquaculture, 219*, 1-4, 355-377.

Brooks, K. and C. Mahnken 2003. Interactions of Atlantic salmon in the Pacific Northwest environment III Accumulation of zinc and copper. Fisheries Res 62: 295-305.

Brooks, K.M., Stierns, A., Backman, C. (2004). Seven-year remediation study at the Carrie Bay Atlantic salmon (*Salmo salar*) farm in the Broughton Archipelago, British Columbia, Canada. *Aquaculture,* 239, 81-123.

Brooks, K.M. 2007. Assessing the environmental costs of Atlantic salmon cage culture in the Northeast Pacific in perspective with the costs associated with other forms of food production. In D.M. Bartley, C. Brugère, D. Soto, P. Gerber and B. Harvey (eds). Comparative assessment of the environmental costs of aquaculture and other food production sectors: methods for meaningful comparisons. FAO/WFT Expert Workshop. 24-28 April 2006, Vancouver, Canada. FAO Fisheries Proceedings. No. 10. Rome, FAO. 2007. pp. 137–182

Canadian Environmental Assessment Act, S.C. 1992, c. 37. (Canada Department of Justice)

Canadian General Standards Board (CGSB). 2012. *Organic aquaculture standards*. (Government of Canada Publication No. CAN/CGSB-32.312-2012). Gatineau, QC: Canada.

Fisheries Act, R.S.C. 1985, c. F-14. (Canada Department of Justice)

Fisheries and Oceans Canada (DFO). (2005). Frequently Asked Questions. Retrieved from http://www.dfo-mpo.gc.ca/aquaculture/faq-eng.htm

Fisheries and Oceans Canada (DFO). (2011). Public reporting on aquaculture in the pacific region. Retrieved from http://www.pac.dfo-mpo.gc.ca/aquaculture/reporting-rapports/index-eng.htm

Fisheries and Oceans Canada (DFO). (2012*a*). Preliminary summary commercial statistics 1996-2012. Retrieved from http://www.pac.dfo-mpo.gc.ca/stats/comm/summ-somm/index-eng.htm

Fisheries and Oceans Canada (DFO). (2012*b*). Marine finfish aquaculture licensing in the pacific region. Retrieved from http://www.pac.dfo-mpo.gc.ca/aquaculture/licence-permis/mar-eng.htm

Fisheries and Oceans Canada (DFO). (2013*a*). Benthic impacts from aquaculture sites. Retrieved from http://www.pac.dfo-mpo.gc.ca/aquaculture/reporting-rapports/benth-eng.html

Fisheries and Oceans Canada (DFO). (2013*b*). Fisheries Protection Policy Statement. Retrieved from http://www.dfo-mpo.gc.ca/pnw-ppe/pol/index-eng.html

Fisheries and Oceans Canada (DFO). (2013*c*). A review of sablefish population structure in the Northeast Pacific Ocean and implications for Canadian seamount fisheries. Retrieved from http://www.dfo-mpo.gc.ca/Library/349898.pdf

Fisheries and Oceans Canada (DFO). (2014a). Aquaculture Activities Regulations. Retrieved from http://www.gazette.gc.ca/rp-pr/p1/2014/2014-08-23/html/reg1-eng.php

Fisheries and Oceans Canada (DFO). (2014b). Public reporting on aquaculture in the pacific region – marine mammal interactions. Retrieved from http://www.pac.dfo-mpo.gc.ca/aquaculture/reporting-rapports/mar_mamm-eng.htm

Haggarty, D.R., McCorquodale, B., Johannessen, D.I., Levings, C.D., and Ross, P.S. (2003). Marine environmental quality in the central coast of British Columbia: A review of contaminant sources, types and risks. *Canadian Technical Report of Fisheries and Aquatic Sciences,* 2507.

Huppert, D.D. & Best, B. (2004). Final report: Study of supply effects on sablefish market price. Retrieved from http://www.fvoa.org/SablefishMarket-FinalReport.pdf

Johannessen, D.I., Harris, K.A., Macdonald, J.S., & Ross, P.S. (2007). Marine environmental quality in the North Coast and Queen Charlotte Islands, British Columbia, Canada: A review of contaminant sources, types and risks. *Canadian Technical Report of Fisheries and Aquatic Sciences, 2717*.

Keeley, C. M., Grant A. Hopkins, Barrie M. Forrest (2014). Spatial and temporal dynamics in macrobenthos during recovery from salmon farm induced organic enrichment: When is recovery complete? Marine Pollution Bulletin 80: 250-262.

Krkosek, M., Connors, B.M., Morton, A., Lewis, M.A., Dill, L.M., Hilborn, R. (2011) *Effects of parasites from salmon farms on productivity of wild salmon*. Proceedings of the National Academy of Science. 108(35): 14700-14704.

Morton, A. & Volpe, J. (2002). A description of escaped farmed Atlantic salmon *Salmo salar* captures and their characteristics in one Pacific salmon fishery area in British Columbia, Canada, in 2000. *Alaska Fishery Research Bulletin*, 9, 102-110.

National Oceans and Atmospheric Administration (NOAA). (2013). Sablefish. Retrieved from http://www.fishwatch.gov/seafood_profiles/species/cod/species_pages/sablefish.htm

Navigable Waters Protection Act, R.S.C., 1985, c. N-22. (Canada Department of Justice)

Obee, N. (2009). Chemical and Biological Remediation of Marine Sediments at a Fallowed Salmon Farm, Centre Cove, Kyuquot Sound, B.C. Retrieved from http://www.env.gov.bc.ca/epd/industrial/aquaculture/pdf/remediation_aquaculture.pdf

Sanderson, JC (2006) *Reducing the environmental impact of seacage fish farming through cultivation of seaweed.* PhD thesis, The Open University, UK & UHI Millenium Institute.

Sanderson, J.C., Cromey, C., Dring, M.J. and Kelly, M.S. (2008). Distribution of nutrients for seaweed cultivation around salmon cages at farm sites in north-west Scotland. *Aquaculture,* 278, 60-68.

Sumaila, U.R., Volpe, J.P., & Liu, Y. (2005). Ecological and economic impact assessment of sablefish aquaculture in British Columbia. Fisheries Centre Research Reports, 13(3), 1-33.

Sutherland, T.F., Matin, A.J., & Levings, C.D. (2001). Characterization of suspended particulate matter surrounding a salmonid net-pen in the Broughton Archipelago, British Columbia. *ICES Journal of Marine Science, 58*, 404-410.

Transport Canada. (2004). Application and site marking requirement for aquaculture projects in Canada – An overview. Retrieved from http://www.tc.gc.ca/media/documents/marinesafety/requirements.pdf

Weir, L.K., Hutchings, J.A., Fleming, I.A., & Einum, S. (2005). Spawning behavior and success of mature male Atlantic salmon (*Salmo salar*) parr of farmed and wild origin. *Canadian Journal of Fisheries and Aquatic Sciences*, 62, 1153-1160.

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.

Criterion 1: Data quality and availability

Data Category	Relevance (Y/N)	Data Quality	Score (0-10)
Industry or production statistics	*Yes*	5	5
Effluent	Yes	7.5	7.5
Locations/habitats	Yes	5	5
Predators and wildlife	Yes	5	5
Chemical use	Yes	5	5
Feed	Yes	5	5
Escapes, animal movements	Yes	5	5
Disease	Yes	5	5
Source of stock	Yes	5	5
Other – (e.g., GHG emissions)	no	0	n/a
Total			**47.5**

C1 Data Final Score	5.28	YELLOW

Criterion 2: Effluents

Factor 2.1a–Biological waste production score

Protein content of feed (%)	44
eFCR	1.4
Fertilizer N input (kg N/ton fish)	0
Protein content of harvested fish (%)	20
N content factor (fixed)	*0.16*
N input per ton of fish produced (kg)	98.56
N in each ton of fish harvested (kg)	32
Waste N produced per ton of fish (kg)	**66.56**

Factor 2.1b–Production System discharge score

Basic production system score	0.8
Adjustment 1 (if applicable)	0
Adjustment 2 (if applicable)	0
Adjustment 3 (if applicable)	0

Discharge (Factor 2.1b) score	0.8

80 % of the waste produced by the fish is discharged from the farm

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

Factor 2.2a–Regulatory or management effectiveness

Question	Scoring	Score
1 - Are effluent regulations or control measures present that are designed for, or are applicable to aquaculture?	Mostly	0.75
2 - Are the control measures applied according to site-specific conditions and/or do they lead to site-specific effluent, biomass or other discharge limits?	Moderately	0.5
3 - Do the control measures address or relate to the cumulative impacts of multiple farms?	Moderately	0.5
4 - Are the limits considered scientifically robust and set according to the ecological status of the receiving water body?	Partly	0.25
5 - Do the control measures cover or prescribe including peak biomass, harvest, sludge disposal, cleaning etc.?	Moderately	0.5
		2.5

Factor 2.2b–Enforcement level of effluent regulations or management

Question	Scoring	Score
1 - Are the enforcement organizations and/or resources identifiable and contactable, and appropriate to the scale of the industry?	yes	1
2 - Does monitoring data or other available information demonstrate active enforcement of the control measures?	mostly	0.75
3 - Does enforcement cover the entire production cycle (i.e., are peak discharges such as peak biomass, harvest, sludge disposal, cleaning included)?	Mostly	0.75
4 - Does enforcement demonstrably result in compliance with set limits?	Mostly	0.75
5 - Is there evidence of robust penalties for infringements?	Moderately	0.5
		3.75

F2.2 Score (2.2a*2.2b/2.5)	3.75

C2 Effluent Final Score	7.00	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?	partly	0.25
2 - Is the industry's total size and concentration based on its cumulative impacts and the maintenance of ecosystem function?	partly	0.25
3 – Is the industry's ongoing and future expansion appropriate locations, and thereby preventing the future loss of ecosystem services?	Mostly	0.75
4 - Are high-value habitats being avoided for aquaculture siting? (i.e., avoidance of areas critical to vulnerable wild populations; effective zoning, or compliance with international agreements such as the Ramsar treaty)	yes	1
5 - Do control measures include requirements for the restoration of important or critical habitats or ecosystem services?	yes	1
		3.25

Factor 3.2b–Siting regulatory or management enforcement

Question	Scoring	Score
1 - Are enforcement organizations or individuals identifiable and contactable, and are they appropriate to the scale of the industry?	yes	1
2 - Does the farm siting or permitting process function according to the zoning or other ecosystem-based management plans articulated in the control measures?	moderately	0.5
3 - Does the farm siting or permitting process take account of other farms and their cumulative impacts?	partly	0.25
4 - Is the enforcement process transparent - e.g., public availability of farm locations and sizes, EIA reports, zoning plans, etc.?	mostly	0.75
5 - Is there evidence that the restrictions or limits defined in the control measures are being achieved?	mostly	0.75
		3.25

F3.2 Score (2.2a*2.2b/2.5)	**4.225**

C3 Habitat Final Score	**6.74**	**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 (%)	50
Fishmeal from byproducts (%)	90
% FM	5
Fish oil inclusion level (%)	16
Fish oil from byproducts (%)	95
% FO	0.8
Fishmeal yield (%)	22.5
Fish oil yield (%)	5
eFCR	1.4
FIFO fishmeal	0.31
FIFO fish oil	0.22
Greater of the 2 FIFO scores	0.31
FIFO Score	**9.22**

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

SSWF	-6
SSWF Factor	-0.187

F5.1 Wild Fish Use Score	**9.04**

5.2. Net protein Gain or Loss

Protein INPUTS	
Protein content of feed	44
eFCR	1.4
Feed protein from NON-EDIBLE sources (%)	68
Feed protein from EDIBLE CROP sources (%)	24

Protein OUTPUTS		
Protein content of whole harvested fish (%)		20
Edible yield of harvested fish (%)		60
Non-edible byproducts from harvested fish used for other food production		0
Protein IN		15.48
Protein OUT		12
Net protein gain or loss (%)		-22.5
	Critical?	NO
F5.2 Net protein Score	**7.00**	

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 (%)	66
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)	24.03

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

Inclusion level of crop feed ingredients (%)	34
Inclusion level of land animal products (%)	0
Conversion ratio of crop ingredients 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)	0.18

Value (Ocean + Land Area)	**24.21**

F5.3 Feed Footprint Score	**1.00**

C5 Feed Final Score	**6.52**	**YELLOW**
	Critical?	**NO**

Criterion 6: Escapes

6.1a. Escape Risk

Escape Risk	**2**

Recapture & Mortality Score (RMS)	
Estimated % recapture rate or direct mortality at the escape site	0
Recapture & Mortality Score	0
Factor 6.1a Escape Risk Score	**2**

6.1b. Invasiveness

Part A – Native species

Score	4

Part B – Non-Native species

Score	**0**

Part C – Native and Non-native species

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

F 6.1b Score	**8**

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

Criterion 7: Diseases

Pathogen and parasite parameters	Score	
C7 Biosecurity	6.00	
C7 Disease; pathogen and parasite Final Score	**6.00**	**YELLOW**

Critical?	NO

Criterion 8: Source of Stock

Source of stock parameters	Score	
C8 % of production from hatchery-raised broodstock or natural (passive) settlement	90	
C8 Source of stock Final Score	**9**	**GREEN**

Exceptional Factor 9X: Wildlife and predator mortalities

Wildlife and predator mortality parameters	Score	
F9X Wildlife and Predator Final Score	**-2.00**	**GREEN**
Critical?	NO	

Exceptional Factor 10X: Escape of unintentionally introduced species

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