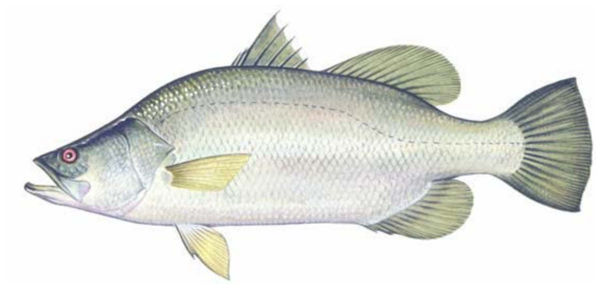
Barramundi

Lates calcifer



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Australis Aquaculture Vietnam

Net Pen

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Disclaimer

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Final Seafood Recommendation

The final numerical score of 6.69 out of 10 is in the "green" range. With no red criteria, the final recommendation is a green "Best Choice."

Barramundi
Australis Aquaculture Vietnam

Criterion	Score (0-10)	Rank	Critical?
C1 Data	9.00	GREEN	
C2 Effluent	6.00	YELLOW	NO
C3 Habitat	6.92	GREEN	NO
C4 Chemicals	7.00	GREEN	NO
C5 Feed	5.63	YELLOW	NO
C6 Escapes	6.00	YELLOW	NO
C7 Disease	5.00	YELLOW	NO
C8 Source	10.00	GREEN	
C9X Wildlife mortalities	-2.00	GREEN	NO
C10X Introduced species escape	0.00	GREEN	
Total	**53.55**		
Final score	**6.69**		

OVERALL RANKING

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

Scoring note –scores range from 0 to 10 where 0 indicates very poor performance and 10 indicates the aquaculture operations have no significant impact. Color ranks: red = 0 to 3.33, yellow = 3.34 to 6.66, green = 6.66 to 10. Criteria 9X and 10X are exceptional criteria, where 0 indicates no impact and a deduction of -10 reflects very poor performance. Two or more red criteria trigger a red final result.

Executive Summary

Australis Aquaculture Vietnam (AAV) is a wholly owned subsidiary of US-based Australis Aquaculture LLC. This farm level assessment report is for net pen barramundi production in Van Phong Bay, Central Vietnam, which began operations in 2007 and currently produces approximately 2,000 tons per annum. The assessment is partially based on two site visits conducted by the author in March 2011 and February 2014.

For this assessment, AAV scored very highly for the Data Availability Criterion and Source of Seed Criterion due to the high quality and transparency of data provided by the company and the use of hatchery based stock. The Habitat Criterion also had a good (green) score largely as a result of low density production on the farm (13 kg/m^3), the isolation of the farm from sensitive habitats by virtue of its location, the age of the farm, good environmental monitoring by the company, and the small scale of the open net pen barramundi industry in Van Phong Bay. Due to AAV's very low and infrequent use of antibiotics and reliance primarily on chemicals with low persistence and toxicity, the Chemical Use Criterion score was also good.

The scores for the Effluent, Feed, Escapes and Disease Criteria were all moderate (yellow). For effluents, AAV operates an open net pen farm with good data monitoring for water quality impacts and additional international regulatory covenants that result in moderately robust regulatory and enforcement system. For feed, AAV has a moderate use of wild fish, protein retention efficiency, and feed footprint; the Fish In: Fish Out ratio is 1.76:1, while the protein loss is 34%. The sustainability score for the source of wild fish used in feeds was good (all Fishsource scores ≥ 6). For escapes, AAV cultures a native species using domesticated broodstock, which originate from native strains and have demonstrably low escape numbers. For disease, AAV monitors infection rates, and data indicate that infections are low and infrequent.

The overall score for AAV operations in Vietnam is 6.69 out of 10, which is a green "Best Choice" according to the Seafood Watch criteria. Justification for the data including monitoring and management protocols has been provided; however, as this is the only open net pen barramundi farm operating in Vietnam, peer-reviewed information about its actual environmental impact is limited. It should be noted that further expansion of the current operation could change the ranking if the degree of impact were to change based on future monitoring results.

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Introduction

Scope of the analysis and ensuing recommendation
Species: Barramundi or Asian sea bass *(Lates calcarifer)*
Geographic coverage: Central Vietnam in Van Phong Bay (see Habitat Criterion for location map).
Production Methods: Land based tanks, offshore net pens

Species Overview
Barramundi or Asian sea bass (*Lates calcarifer*) is an estuarine species of the family Centropomidae (Lates: perches). Barramundi is native to the Indo-Pacific and its range extends as far north as Taiwan, south to the eastern Australian coast, east to Papua New Guinea, and as far west as the Persian Gulf (Greenwood 1976; Tucker et al. 2002). Barramundi is caught commercially and produced by aquaculture. It is a prized sport fish which is capable of reaching up to six and a half feet in length, can live for twenty years, and weigh in excess of 50 kilograms (kg) (Shaklee et al. 1993). Barramundi are catadromous (fish that migrate from fresh water to salt water to spawn or reproduce) and move between fresh and saltwater during various stages of their life cycle.

Mature barramundi commonly live in estuaries and associated coastal waters or in the lower reaches of rivers. Barramundi prefer slow-moving water in rivers, creeks, swamps and estuaries, but are adaptable and may often be found around near-shore islands and reefs. They can tolerate a wide range of environmental conditions as well as high population densities. Farm raised barramundi can reach 500 grams(g) within 12 months, but some studies have suggested that 800 g may be possible within the same time frame at higher temperatures. Large barramundi (2-3 kg) can be grown within 18-24 months (Tucker et al. 2002; Barlow 1997).

Barramundi are protandrous hermaphrodites (i.e., juveniles develop into males first and then into females). Most barramundi start life as males and undergo sexual inversion to become functional females at five to seven years of age. Barramundi are highly fecund; a single female may produce 30–40 million eggs per spawning event (Moore 1982). Consequently, only relatively small numbers of broodstock are necessary to provide adequate numbers of larvae for hatchery production. Barramundi are well suited to aquaculture as they are hardy, fast-growing (Boonyaratpalin 1991), and universally regarded as a fine table fish. Additionally, barramundi have the ability to synthesize long chain omega-3 fatty acids (Tu et al. 2012) whose contribution to human health has been found to be important.

Vietnam Production Information
Australis Aquaculture Vietnam (AAV) has operated an offshore net pen barramundi farm in Van Phong Bay, in Central Vietnam since 2007. According to AAV, since the beginning of the project, the company has taken a measured approach in developing its farm with feasibility studies, comprehensive site selection, and environmental impact studies. The company undertook a pilot production program with four net pens in 2008 and commenced commercial production in 2010.

AAV operates a two-phase system, which includes an initial fingerling phase (1/3 of the production cycle) where 10% of the biomass is produced in land based tanks and a two stage grow-out system in open pens (2/3 of the production cycle) where the remaining 90% of the biomass production takes place in the sea. AAV is currently producing 2,000 metric tons and is licensed to produce up to 6,000 metric tons on its site, subject to ongoing positive environmental monitoring results. While there are no robust statistics on barramundi production in Vietnam (FAO's data are dated), Australis estimates that Vietnam currently produces approximately 8,000 mt/annum. Import statistics confirm that AAV is responsible for approximately 90% of imports to the US. The balance of Vietnamese production, which is mainly produced in coastal ponds, is consumed domestically or exported to Australia, China or EU countries (Piers Import Statistics: www.piers.com).

Market Availability

Common and market names

barramundi, Asian seabass, seabass, giant seabass, two fin seabass, blind seabass, giant palmer, narifish, kokopputih, bektiapahap, palakapong, nokogirihata. In some cases, Nile perch *(Lates niloticus)* from Africa has been mislabeled as barramundi.

Seasonal availability:

Farmed barramundi are generally available year-round.

Product forms:

Barramundi is most frequently sold either as plate-sized fish (1-2lbs) or fillet-sized fish (2 to 6lbs). In Asia, barramundi are most frequently marketed at 500–900 g, although smaller quantities of larger fish (1–4 kg) are also sold. Barramundi are sold live, whole, gilled and gutted, chilled, or smoked.

Import and export sources and statistics:

Although production of farmed barramundi began in Southeast Asia in the late 1960s, barramundi imports into the United States did not begin until the late 1990s. US barramundi imports have risen to approximately 2,000 mt per annum (anonymous pers. comm., Goldman pers. comm.).

The vast majority of barramundi production is consumed within producing countries, with only relatively minor quantities being exported. However, as awareness of barramundi increases, production for export is increasing in Southeast Asia (Vietnam, Indonesia, Singapore), and Taiwan (Goldman pers. comm.).

Availability of Science

Considerable scientific information is available on the production of farmed barramundi in Australia and Southeast Asia, where production has occurred for over 30 years. This literature focuses primarily on production related issues such as reproduction, nutrition, fish health, production systems and management. Far less of the literature addresses environmental impacts of tropical marine aquaculture or barramundi production in particular. As such, the data contained in this report, in conjunction with AAV's commitment to further enhance and share additional data in the future, are expected to make an important contribution to address the deficiency in this area.

Analysis

This assessment is based on a two-day site visit conducted by the author in 2011 and a follow up visit in 2014, data provided by AAV and the available scientific literature.

Scoring guide

- With the exception of the exceptional criteria (3.3x and 6.2X), 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 criteria 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.
- 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

Data Category	Relevance (Y/N)	Data Quality	Score (0-10)
Industry or production statistics	Yes	7.5	7.5
Effluent	Yes	7.5	7.5
Locations/habitats	Yes	7.5	7.5
Predators and wildlife	Yes	7.5	7.5
Chemical use	Yes	10	10
Feed	Yes	10	10
Escapes, animal movements	Yes	10	10
Disease	Yes	10	10
Source of stock	Yes	10	10
Other – (e.g. GHG emissions)	Yes	10	10
Total			**90**

C1 Data Final Score	**9.00**	**GREEN**

AAV scored very highly on most of the criteria given their willingness to provide the data that they are able to collect. For the other factors, more uncertainty and a greater difficulty in generating data resulted in lowered scores. For this criterion, AAV scored 9 out of 10.

Justification of Ranking

Data availability is deemed high as (1) there was specific information on environmental conditions on the site and surrounding environment, (2) the operators were willing and able to provide all of the data requested by the author covering the complete range of impact categories, and (3) this is the only offshore marine barramundi farm operating in Vietnam and the farm produces a significant proportion of the barramundi sold in the US.

The producer provided detailed information on feed, chemical use, escapes, disease, source of stock and energy use. Information on the habitat, predators and wildlife was available from baseline environmental surveys, the Overseas Private Investment Corporation (OPIC) Environmental Assessment, an independent EIA (which was conducted as a condition of site permitting), mapping conducted by the US Navy and Vietnamese Navy's and with additional information available from the national and provincial Fisheries Departments and the University of Nha Trang, as well as environmental monitoring results.

In addition, AAV has legally committed to meet International Finance Corporation (IFC) Environmental, Health and Safety standards for aquaculture, Fish Processing, and environment as an ongoing condition of its financing from the OPIC. The agreement between AAV and OPIC also requires the company to comply with all applicable local environment, health and safety laws as well as international standards outlined OPIC's Environmental Handbook. Failure to comply with these standards will result in the company defaulting on its loans.

Summary

As this is a farm level assessment, the information comes directly from the source—the farm— and there is no way to verify accuracy from a secondary source as yet. The environmental monitoring data are all generated from monitoring conducted by third-party contractors. The data for feed, chemical use, escapes, disease and source of stock and energy use are all robust and thoroughly reported and score of 10. An increased amount of uncertainty around the data on industry or production statistics, effluent, habitat, predators and wildlife resulted in the criterion score of 7.5. The final score assigned was 9.0.

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 farms.*

Criterion 2 Summary

Effluent parameters	Value	Score	
F2.1a Biological waste (nitrogen) production per of fish (kg N ton-1)	76.6		
F2.1b Waste discharged from farm (%)	63		
F2 .1 Waste discharge score (0-10)		5.0	
F2.2a Content of regulations (0-5)	4.5		
F2.2b Enforcement of regulations (0-5)	4.0		
F2.2 Regulatory or management effectiveness score (0-10)		7.2	
C2 Effluent Final Score		**6.0**	**YELLOW**
Critical?	NO		

The full assessment ranking for effluent was utilized in this evaluation, not because the company's data were not considered robust, but rather to ensure that more factors were evaluated, including an assessment of the regulatory structure. The nitrogen waste produced per ton of farmed fish was found to be 76.6 kg and waste discharged from the farm was found to be 63% due the fact that 10% of the production is on land. The overall waste discharge score was 5 out of 10. AAV operates under both local and international regulations that in the latter case are tied to the financial structure of the operation resulting in a 7.2 out of 10 score for the regulatory effectiveness. Overall, AAV scored 6 out of 10 on the Effluent Criterion, indicating that there is a low-moderate risk of significant effluent impacts beyond the immediate area of the farm.

Justification of Ranking

Pollution from fish farming facilities affecting the surrounding environment has been found to have a major impact on aquaculture operations (Gowen et al. 1990; Costa-Pierce 1996; Beveridge 1996). The degree of impact is dependent on the type of system used, feed quality, management practices employed as well as the sensitivity and assimilative capacity of the local environment. Pollution and habitat impacts associated with marine finfish net pen aquaculture derive mainly from nutrient inputs from uneaten fish feed and fish wastes. Studies carried out in Hong Kong indicate that 85% of phosphorus, 80%–88% of carbon, and 52%–95% of nitrogen inputs to open net pens may be lost through uneaten food and fecal wastes (FIRI2006). In severe cases, this can lead to net pen farms exceeding the capacity of the local environment to assimilate wastes and provide dissolved oxygen, which in turn can contribute to fish disease outbreaks.

In tropical regions of Southeast Asia and Australia, where the growth of open net pen culture is the most rapid, the impacts of fish farms on coastal water quality and planktonic processes is virtually unknown (DeSilva 1998; Alongi et al. 2003). One study in Malaysia found increased concentrations of dissolved inorganic and particulate nutrients around barramundi farms, which were located within an estuary (Alongi et al. 2003), but reported no significant impacts on local ecosystem processes. It is possible that the lack of impacts observed (compared to temperate systems) may be due to differences between tropical and temperate systems, as bacterial turnover under tropical conditions may be several orders of magnitude higher than in temperate systems, resulting in a greater assimilation rate of wastes from the farm (Glencross pers. comm.).

Table 1- Summary of Water Quality Monitoring Results at Sea Pen Site

	Control & Pre-Operations Sites			Farm Site Monitoring Results					
	Control Site	**Farm Site (pre Ops)**	**Ave.**	**Ave.**	**Max**	**Δ Farm vs. Ave/Control**	**Std Dev.**	**% Change**	**% Std Dev.**
pH	8.2	8.1	8.2	8.0	8.2	(0.1)	0.2	-1%	2%
DO (mg/l)	6.3	6.9	6.6	6.7	7.1	0.1	0.3	1%	4%
BOD (mg/l)	0.5	0.7	0.6	1.0	1.6	0.4	0.4	24%	23%
TSS (mg/l)	0.4	6.9	3.7	2.4	8.5	(1.3)	2.6	-15%	31%
PO_4-N (µg/l)	20.1	13.6	16.9	30.4	80.0	13.6	26.4	17%	33%
NH_4-N (µg/l)	228.4	92.0	160.2	171.9	257.5	11.7	70.8	5%	27%
Chlorophyll-a (µg/l)	1.1	1.2	1.2	0.5	1.1	(0.7)	0.4	-61%	36%

Table 1 summarizes water quality sampling results that have been collected twice per year (April and October) beginning prior to the commencement of farming operations. Each of the two net pen sites has two designated sampling locations, with location 'A' being directly below a net pen in the center of the mooring grid and location 'B' being 500 m to the south of location 'A.' A control site is located 5 km to the south of both production sites. Environmental monitoring is performed by an independent consultant and covers a four year period. Additional information on the sea pen sampling methodology is presented in Appendix 1 and the data is presented in Appendix II.

The data demonstrate that no significant changes in water quality were evident when compared to the control and/or farm sites prior to the commencement of operations. More specifically, no pattern of deterioration in water quality emerged when comparing the control and farm sites prior to the commencement of operations over the first four years of operations. Water quality appeared to improve moderately for some parameters (DO, TSS, chlorophyll) and decrease moderately for others (BOD, PO_4 and NH_4). Taken together, the degree of change for all parameters appears to fall within the background range of variability, which occurred at the sites over time. Importantly, no water quality parameter fell outside of generally acceptable limits for marine waters (Chapman 1996). Additionally, since the 'farm' samples were collected inside the bounds of the farm, we can reasonably expect water quality to be closer to background levels at the farm perimeter or outside of the allowable zone of effect, which is typically 100 meters from the farm perimeter.

Effluent Management at Land Based Nursery Site

AAV's land based nursery operation is required to achieve compliance with the US Environmental Protection Agency (EPA) standards for aquaculture as a condition of the company's Overseas Private Investment Corporation ('OPIC', a US quasi-governmental agency), loan financing covenants. Effluent from the land based nursery site originates from the screened drains of the culture tanks. The effluent from these tanks flows through a series of sequential effluent treatment ponds with the first providing sedimentation, followed by an aerated pond that provides biological filtration and a final pond that is stocked with seaweed for polishing (i.e., soluble nutrient absorption).

The nursery system is designed to operate with an average four-hour hydraulic retention time (HRT), therefore requiring 3,000 M^3/day (0.8 MGD) of makeup water. A review of the environmental monitoring data generated by consultants to Australis indicate compliance with the company's effluent permit during the first three years of operation (see Table 2).

Table 2 – Summary of Effluent Data from Land Based Nursery Site

Date	Farm System	pH	TSS	Total NH3	BOD5	DO	No of Exceedencies
	Unit:		mg/L	mg/L	mgO2/L	mg/L	
	Limit:	6.5-8.5	<30mg/L	<5mg/L	<30.5mg/L	>4mg/L	0/4
April, 2011	Nursery	7.8	17.6	1.0	8.0	3.6	0/4
May, 2011	Nursery	7.5	6.0	0.9	3.5	6.2	0/4
June, 2011	Nursery	7.7	29.7	0.4	5.6	6.5	0/4
July, 2012	Nursery	8.1	15.9	0.8	0.7	6.0	0/4
August, 2011	Nursery	7.6	20.1	0.9	8.3	5.4	0/4
September, 2011	Nursery	7.9	13.6	1.4	0.9	6.1	0/4
October, 2011	Nursery	7.6	27.9	1.4	2.0	4.5	0/4
November, 2011	Nursery	7.6	9.2	0.8	1.7	5.4	0/4
December, 2011	Nursery	7.6	8.2	0.8	2.3	4.7	0/4
January, 2012	Nursery	8.2	22.8	0.8	4.8	6.3	0/4
February, 2012	Nursery	8.0	x	x	x	5.8	0/4
March, 2012	Nursery	8.2	28.6	1.0	5.9	5.7	0/4
April, 2012	Nursery	8.5	15.9	1.2	9.6	6.2	0/4
May, 2012	Nursery	8.2	4.2	1.3	3.4	6.0	0/4
June, 2012	Nursery	7.9	15.0	1.7	2.4	6.2	0/4
July, 2012	Nursery	7.2	7.7	1.6	1.5	6.8	0/4
August, 2012	Nursery	7.9	5.6	0.8	0.7	4.9	0/4
September, 2012	Nursery	7.8	12.9	1.7	1.1	6.2	0/4
October, 2012	Nursery	8.1	10.2	1.5	1.6	6.4	0/4
November, 2012	Nursery	7.8	11.0	3.8	1.7	5.6	0/4
December, 2012	Nursery	7.8	2.8	0.8	1.8	5.4	0/4
January. 2013	Nursery	7.6	2.4	0.9	0.4	5.6	0/4
February, 2013	Nursery	7.4	2.6	1.2	0.3	5.0	0/4
March, 2013	Nursery	7.9	4.7	2.7	0.7	5.2	0/4
April, 2013	Nursery	8.0	27.6	4.2	1.2	6.3	0/4
May, 2013	Nursery	7.6	5.9	1.0	3.2	6.5	0/4
June, 2013	Nursery	7.5	10.1	1.5	6.1	6.4	0/4
July, 2013	Nursery	7.9	9.1	1.1	3.4	6.3	0/4
August, 2013	Nursery	8.1	5.0	0.8	0.9	7.1	0/4
September, 2013	Nursery	8.2	7.5	0.9	0.3	5.8	0/4

X = *No Data, System was not operational during this period*

Effluent Management at Sea Pen Site

For net pen operations, the company's OPIC covenants require that operations are consistent with World Bank Aquaculture guidelines as well as Vietnamese governmental regulations. As a consequence of this, AAV has committed to undertake regular monitoring of the sea site as well as control sites. Although this does not guarantee compliance, it does create another incentive for AAV's operations. To assess the potential impacts on both water quality and habitat, the plan requires AAV to monitor the following parameters:

- Temperature is measured and recorded at surface—5 m and 10 m intervals—daily
- Secchi disk visibility is measured and recorded at surface—5 m and 10 m intervals—daily

- Dissolved oxygen is measured and recorded at surface—5 m and 10 m intervals—daily
- pH is measured at cage mid-depth and recorded every 6 months
- Chlorophyll A is measured at cage mid-depth and recorded every 6 months
- Biochemical oxygen demand is measured at cage mid-depth and recorded every 6 months
- Soluble phosphorus is measured at cage mid-depth and recorded every 6 months
- Total ammonia nitrogen is measured at cage mid-depth and recorded every 6 months
- Phytoplankton abundance at cage mid-depth and recorded every 6 months

Factor 2.1: Biological waste production per ton of fish and production system discharge score

The basic production discharge score assigned was 0.8 for "net cages." The operation carries out the early rearing phases in tanks and the later stages in net pens / cages resulting in a 10%/ 90% split of weight gain in the fish. An adjustment of -0.1 was made to reflect this split production. The waste score calculated for this factor was 4.0.

Factor 2.2: Management of farm level and cumulative impacts and appropriateness to the scale of the industry

Regulatory and management factor questions[1] were scored as "Yes" and "Mostly" due to the robust nature of AAV's monitoring program and the effluent limits that are in place. The limits are deemed appropriate given the nature of AAV's operations and are consistent with US EPA standards and generally accepted norms. The monitoring program and limits account for the site conditions and cover the full production cycle due to their frequency as well as the non-seasonal nature of the production process. Additionally, it addresses the potential for cumulative impacts given the overall level of farming within the bay. Enforcement of effluent regulations or management scored "Yes" or "Mostly" due to the transparency of the data and the fact that the producer is required to make regular quarterly certifications to OPIC, with respect to environmental compliance, as part of their reporting requirements, which are tied to the companies financing. This results in an additional layer of regulatory enforcement that enhances some of the potential shortfalls of the Vietnamese system. The score for Factor 2.2 was calculated as 7.2 under 2.2a and 2.2b.

Summary

AAV achieved an overall score of 6 (yellow) for this criterion based on the technology and management employed as evidenced by active monitoring for potential impacts. The results to date show no current problems for the land site with farm effluents at the end of the pipe, or within the area of the farm for the marine site. Therefore, effluent impacts beyond the farm sites are considered to be unlikely. This criterion should be carefully monitored as the dataset becomes larger with increasing time in production.

[1] See Data and Scoring section at the end of this report for the full list of questions

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		7.00	
F3.2a Content of habitat regulations	4.50		
F3.2b Enforcement of habitat regulations	3.75		
F3.2 Regulatory or management effectiveness score		6.75	
C3 Habitat Final Score		**6.92**	**GREEN**
Critical?	NO		

AAV's marine farm is located in Van Phong Bay (Figure 1, below), one of the few protected bays in all of Vietnam. The bay has 41,000 ha of water surface with an average depth of 30 meters and a sand and mud bottom. The surrounding area is characterized by low human population density with no rivers, mangroves or major manufacturing in the bay, resulting in high water quality but without spawning habitat for barramundi. While barramundi are native to this region of Vietnam, the closest suitable barramundi spawning habitat is 600-700 km to the south (around Cau Mau and Bac Lau) and approximately 1,000 km to the north, near Hai Phong (Dr. Dung, personal communication). AAV provided monitoring data that demonstrate no more than moderate impacts are occurring under the net pens, which results in a score of 7 for habitat conversion and function. For enforcement of habitat regulations and management, an overall score of 6.75 was achieved due to the combination of Vietnamese regulations enhanced by the requirements of AAV OPIC certification requirements that are a condition of their financing. The overall score for this criterion was 6.92.

Justification of Ranking

Factor 3.1: Habitat conversion and function—Although floating net pens have little direct habitat impacts, discharges of soluble and particulate wastes from sea can have adverse impacts on water quality and benthic biodiversity beneath the pens. While there are sensitive habitats containing coral and sea grasses within Van Phong Bay, the areas under and in the vicinity of the AAV's site do not contain sensitive habitats per the Environmental Impact Statement, which was completed prior to sitting the farm. The pens are located above a muddy bottom at water depth of 30 meters. The mud bottom is classified as an area of low biodiversity. Additionally, relatively fast current velocities (averaging <10cm per second) results in classification of AAV's site as 'slightly sensitive' to 'not sensitive' in accordance with the sensitivity classification developed by Carroll et al. (2003). Still, at these current velocities the Australis site would be considered 'depositional,' with the vast majority of solid wastes being retained within 100 m of the cage parameter, thereby ensuring that the on-site monitoring captures the 'worse case' scenario of benthic impacts.

Additionally, the farm's management practices reduce the risk of benthic impacts including low stocking densities (13 kg/M^3 max), a wider than traditional grid configuration between the pens and rotational fallowing between production cycles, as well as a benthic monitoring program.

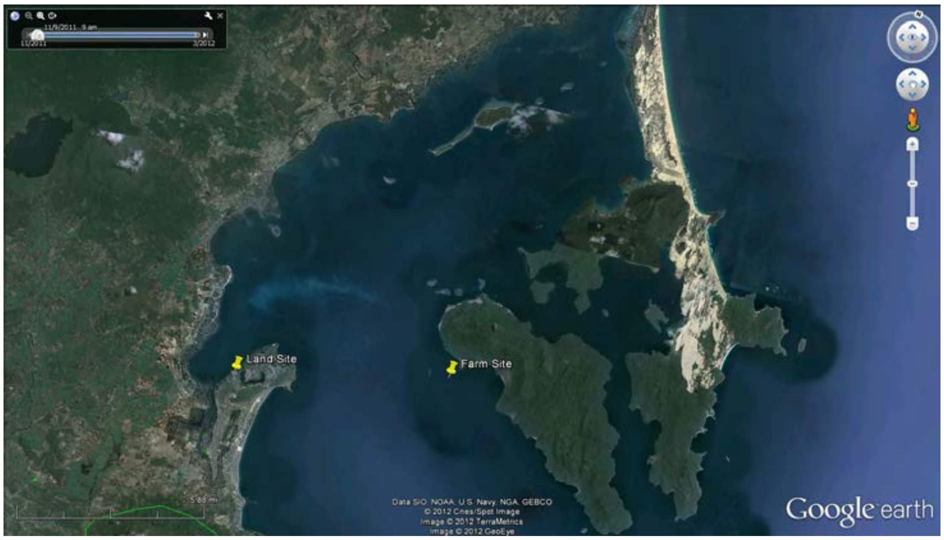

Figure 1 – Satellite image showing AAV land and sea sites in Van Phong Bay, Vietnam

Summary of Benthic Monitoring Results

Impacts on the benthos were assessed in accordance with a legally mandated benthic monitoring plan established by the Vietnamese government. Monitoring stations and frequency are identical to what is described in Section 2 for the sea farm's water quality. This plan specifies sampling and analysis of a variety of parameters at pre-established locations under the farm's pens as well at a control site. The results are summarized in Table 3 below and additional detail is provided in Appendix II.

Table 3 - Summary of Benthic Monitoring Results at Sea Site

	Control & Pre-Operations			Farm Site Monitoring Results				
	Control Site	**Farm Site (pre Ops)**	**Ave.**	**Ave.**	**Farm vs. Ave Control**	**Std Dev.**	**% Change**	**% Std Dev.**
pH	8.2	8.2	8.2	8.1	(0.1)	0.1	-1%	1%
BOD (mg/l)	0.6	0.7	0.6	1.2	0.6	0.3	35%	18%
PO_4-N (µg/l)	49.9	13.6	31.8	39.9	8.2	30.0	9%	33%
NH_4-N (µg/l)	267.0	92.1	179.5	173.0	(6.5)	77.0	-2%	27%
Polychaeta	266.7	213.3	240.0	137.8	(102.2)	88.3	-38%	33%
Mollusca	26.7	6.7	16.7	8.9	(7.8)	10.9	-29%	41%
Crustacea	40.0	153.4	96.7	26.7	(70.0)	23.9	-105%	36%
Echinodermata	13.3	20.0	16.7	4.5	(12.2)	10.9	-46%	41%
Other	-	-	-	11.1	11.1	27.2	17%	41%
Total	346.7	393.3	370.0	188.9	(181.1)	91.8	-65%	33%

pH is a useful means of assessing benthic condition, where a reduction in pH indicates that sediment chemistry is being driven by anoxic biodegradation of carbon rich materials, with a pH below 7.1 being suggested as the boundary below which the risk of sulfide production increases (Schaanning and Hansen 2005). Virtually no change in benthic pH was measured in any of the samples since operations began. The lowest benthic pH was 8.0 vs. 8.15 prior to commencement of operations on the site. This suggests that the benthos remains primarily aerobic and that little or no increase in free sulfide is occurring based on the analysis of Hargrave (2010). Other studies also indicated that sites with benthic pH above 7.6 correlate to 'normal' conditions with little change to sediment chemistry or diminishment of biodiversity (Caroll et al. 2003).

Average benthic phosphorous (PO_4-P) was modestly higher on the control site (49.0 µg/l) compared to the production sites (38.3 µg/l), suggesting that little or no enrichment is occurring. Similarly, average benthic ammonia (NH_4-N) was moderately higher on the control site (267 µg/l) compared to the production sites (173 µg/l), providing further support that little or no benthic enrichment is taking place at the production site. Moderate changes to the number of various benthic life forms was noted between the control and production sites, but changes in these counts are inherently variable over time. Although there are changes (positive and negative) in the numbers of individuals sampled throughout the monitoring period, the consistent presence of all genera are indicative of only minor impacts as this shows that there is a strong ability to recover during the fallow periods. AAV operates with '2 sites off 1 site on,' which means that two thirds or more of the farm site is left fallow at all times. Overall, the monitoring results suggest that no irreversible impacts on benthic communities have occurred to date.

In addition to the results of the monitoring, the farm employs design features and management practices that help reduce the severity of benthic impacts. These include maintenance of low stocking densities (13 kg/M^3 max), a wider than traditional grid configuration, and rotational fallowing between production cycles. AAV scores 7 out of 10 for this factor, which has been classified as a "moderate" impact according to the Seafood Watch criteria.

Future Data

The pH correlational studies referenced above were conducted in much colder water than are present on AAV's site. The lack of impacts observed may, in part, be due to much faster rate of bacterial degradation under tropical conditions (Glencross, pers. comm.). To help address the limited data for tropical marine aquaculture, AAV's benthic monitoring program was expanded in 2013 to include a broader range of parameters than were initially required by the Vietnamese government. These include 'total organic carbon,' 'oxidation reduction potential' and 'free sulfide,' which have been shown to be useful in assessing benthic conditions across a broad range of temperate sites. The resulting data set will be among the first of its kind and should be very valuable in assessing potential benthic impacts on tropical marine sites.

Factor 3.2: Habitat and farm siting management effectiveness

The farm siting and permitting was completed following a formal Environmental Impact Assessment, which ensured that no high value habits were affected by the farm's siting. In addition, the AAV operation is the only commercial marine farm operating within the relatively large and well-flushed bay— the majority of coastal ponds are dormant. Thus, the total size of the farming industry within the bay does not appear to pose a significant risk for cumulative impacts to the marine environment. The government has indicated that no additional large farms will be developed in the bay, which limits future possible cumulative impacts (Australis, personal communication). AAV has stated that it will sustain its existing farming practices, including culture densities as they grow, and that future expansion will continue to be subject to acceptable environmental monitoring results. AAV scores 4.5 out of 5 for this section.

For Factor 3.2b, all questions (with the exception of question two) regarding the enforcement of aquaculture regulations, rank as "moderately" or "mostly" due to the fact that while Vietnam has regulations on the books there are concerns about the robustness of enforcement within the country. Question two of 3.2b "Does the farm siting or permitting process function according to the zoning or other ecosystem-based management plans articulated in the control measures?" was scored "Yes" because the site was selected based on consideration of a site-specific EIA and that there were limited farming industries in the bay. AAV scores 3.75 out of 5 under Factor 3.2b. The overall score for Factor 3.2 is 6.75 out of 10.

Supplemental information for the AAV land based nursery site

The land based site is part of a designated aquaculture development zone that has been used for aquaculture for approximately 20 years. The site is quite arid and was largely devoid of plant or animal life prior to AAV's redevelopment. Minimal removal of vegetation was required and where possible these shrubs were preserved. At the completion of the development process, the site will be planted with native trees and vegetation and will be much greener then it was prior to the commencement of the project. Construction of a 1.5 hectare artificial marsh, using native species to polish effluent after settling, will be a component of the site's redevelopment. The development of the perimeter sea wall serve to minimize impacts from subsequent construction or operating activities by preventing sand, silt or other materials from entering the sea.

The construction of the AAV land site took place outside areas with sensitive wetland vegetation and AAV farms do not discharge effluents to sensitive habits. AAV did not dredge or fill in sensitive wetlands or wetland buffers to increase the area available for construction. AAV's construction was designed to prevent erosion and avoid sedimentation of soil material from effluents downstream from its operations.

AAV's farm construction and operations do not rely on groundwater and as such are not subject to salinization. AAV manages sediment from its land based tanks so that it does not cause salinization or other ecological nuisances in surrounding land or water. Sediment accumulation in settling ponds and canals is reduced by implementing proper earthen infrastructure design to lessen erosion and placing aerators to avoid impingement of water currents on embankments. Erosion prone areas are reinforced with stone or other lining materials. When sediment is stored, it is confined within a dike area so that solids suspended by rainfall are retained. When sediment is removed, where possible, it is reused to repair pond earthworks or applied as fill material. The sediment is given to famers as fertilizer or spread in a thin layer over the land and a vegetative cover is established.

Summary

AAV scored 6.92 under this criterion based on: (1) the absence of ecologically sensitive habitats within or proximal to the farm site as demonstrated by baseline environmental surveys, (2) relatively fast current velocities (averaging <10 cm per second) and adequate water depth (30 meters) result in classification of AAV's site as 'slightly sensitive' to 'not sensitive' in accordance with the classification system developed by Carroll et. al. (2003), (3) low culture densities, wide pen spacing, and rotational fallowing between production cycles, and (4) monitored results indicate acceptable levels of chemical and biological changes on the farm site such that all benthic genera remain present which were found prior the commencement of farm operations. Together, these factors suggest that no irreversible habitat impacts are likely to occur either within or outside of the mixing zone.

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	**7.0**	
C4 Chemical Use Final Score	**7.0**	**GREEN**
Critical?	NO	

AAV scores 7 out of 10 on chemical use due to very low and infrequent antibiotic use which is restricted to the tank-based nursery stage. The treatments used have not recently included antibiotics listed as highly- or critically-important to human health by the World Health Organization. In addition, parasite control is limited to non-persistent treatments in the net pen growout stage of production that pose a low risk to the environment.

Justification of Ranking

AAV has a health management plan designed to avoid the introduction of disease, protocols to maintain water quality, and fish health-monitoring and diagnostic programs. All chemical use by AAV complies with US and Vietnamese regulations. Records of disease diagnoses and treatments are maintained and AAV also receives statements from feed and fingerling suppliers that declare no prohibited drugs or chemicals were applied to feed or seed stock.

Chemical use for AAV can be summarized as follows:

1. AAV uses in situ net cleaning methods, rather than chemical (copper based) anti-foulants.
2. Female broodstock may receive gonadotropin-releasing hormone (GnRH) implants to synchronize ovulation prior to spawning. No hormones are used on edible products.
3. Formalin is used for ectoparasite control to maintain parasites at low levels at all times (Table4). Within the net pens, nylon tarps are used to minimize the volume required. Formalin is not likely to harm non-target organisms or the environment as it is diluted approximately 92% below the level that can legally be discharged from aquaculture facilities in the US.

The author was provided with records of treatments and disease organisms observed in AAV's monitoring program. These records demonstrate that the farm has been able to operate with minimal chemical and antibiotic use during its first four years of operations (Table 4 and Figure 2). AAV relies on 'low risk' chemicals (formalin and hydrogen peroxide), which are known to have minimal impacts on the marine environment due to their low persistence and toxicity (U.S. National Library of Medicine 2014, Western Chemical Inc. 1995). Formalin concentrations at the point of discharge from the producers land based farm and at the farm boundary for the sea pens are always < 2 PPM, which is more than an order of magnitude below the US EPA's 25 PPM threshold for which they determined a "Finding of No Significant Impact" for formalin. Rapid environmental degradation and further dilution can reasonably be expected to reduce the concentration below a level that causes adverse effects on aquatic organisms. Use of these ectoparacitides, in conjunction with routine fish health monitoring, has been shown to maintain ectoparasite loading at low levels, reducing the risk of transfer to wild stocks.

Table 4 – Formalin Usage / Treatment Volumes for 10--13YC

Batch	Land Site (liters per Batch)	Discharge Concentration: Land Site	Sea Cages (liters per Batch)	Discharge Concentration: Sea Cage Site (periphery of grid)
10A001	208	< 2 PPM	420	< 2 PPM
10A002a	120	< 2 PPM	1,080	< 2 PPM
10A002b	236	< 2 PPM	660	< 2 PPM
10A003a	200	< 2 PPM	420	< 2 PPM
10A003b	200	< 2 PPM	720	< 2 PPM
10A004	228	< 2 PPM	440	< 2 PPM
10A005	228	< 2 PPM	640	< 2 PPM
10A006	228	< 2 PPM	580	< 2 PPM
10A007	200	< 2 PPM	380	< 2 PPM
10A008	200	< 2 PPM	440	< 2 PPM
10A009	190	< 2 PPM	530	< 2 PPM
10A010	200	< 2 PPM	555	< 2 PPM
2010 Total	**2,438**	**N/A**	**6,865**	**N/A**
2010 Average	**203**	**< 2 PPM**	**572**	**< 2 PPM**
11A01	160	< 2 PPM	280	< 2 PPM
11A02	220	< 2 PPM	460	< 2 PPM
11A03	270	< 2 PPM	540	< 2 PPM
11A04	221	< 2 PPM	392	< 2 PPM
11A05	190	< 2 PPM	410	< 2 PPM
11A06	280	< 2 PPM	560	< 2 PPM
11A07	270	< 2 PPM	540	< 2 PPM
11A08	230	< 2 PPM	460	< 2 PPM
11A09	190	< 2 PPM	380	< 2 PPM
11A10	240	< 2 PPM	510	< 2 PPM
11A11	280	< 2 PPM	560	< 2 PPM
11A12	190	< 2 PPM	380	< 2 PPM
11A13	260	< 2 PPM	465	< 2 PPM
2011 Total	**3,001**	**N/A**	**5,937**	**N/A**
2011 Average	**231**	**< 2 PPM**	**457**	**< 2 PPM**
12A01	240	< 2 PPM	1,298	< 2 PPM
12A02	200	< 2 PPM	1,112	< 2 PPM
12A03	260	< 2 PPM	1,291	< 2 PPM
12A04	220	< 2 PPM	1,416	< 2 PPM
12A05	250	< 2 PPM	1,406	< 2 PPM
12A06	230	< 2 PPM	1,322	< 2 PPM
12A07	240	< 2 PPM	1,330	< 2 PPM
12A08	230	< 2 PPM	1,150	< 2 PPM
12A09	240	< 2 PPM	1,310	< 2 PPM
12A10	240	< 2 PPM	1,310	< 2 PPM
12A11	260	< 2 PPM	1,260	< 2 PPM
12A12	240	< 2 PPM	1,290	< 2 PPM
12A13	240	< 2 PPM	1,370	< 2 PPM
12A14	240	< 2 PPM	1,340	< 2 PPM
2012 Total	**3,330**	**N/A**	**18,204**	**N/A**
2012 Average	**238**	**< 2 PPM**	**1,537**	**< 2 PPM**
13A001	270	< 2 PPM	1,260	< 2 PPM
13A002	300	< 2 PPM	1,150	< 2 PPM
13A003	260	< 2 PPM	1,390	< 2 PPM
13A004	240	< 2 PPM	1,280	< 2 PPM
13A005	250	< 2 PPM	1,400	< 2 PPM
13A006	260	< 2 PPM	1,240	< 2 PPM
13A007	280	< 2 PPM	1,190	< 2 PPM
13A008	300	< 2 PPM	1,230	< 2 PPM
Sep 30, 2013 Total	**2,160**	**N/A**	**10,140**	**N/A**
Sep 30, 2013 Average	**270**	**< 2 PPM**	**1,268**	**< 2 PPM**

Annual antibiotic usage has steadily declined each year since start-up and has reached low rates over the past two years (Figure 2). The types of antibiotics used are consistent with US regulations on approved therapeutants for aquaculture. Oxytetracycline (OTC) was used to treat juvenile fish at the land based nursery site early in the production cycle. In 2013, medicated feed represented less than 0.000002% of the total feed use as validated by two independent audits (IMO on behalf of Whole Foods Market and Global Gap). OTC is listed as highly-important to human health by the World Health

Organisation[2], but was not used in 2013, and overall antibiotic use dropped further to include a single florfenicol treatment of fingerlings. The potential impact on non-target organisms are minimized by the fact that antibiotic use was restricted to the land based tank systems where the effluent is treated prior to discharge. OTC residuals are known to be strongly absorbed by suspended solids and sediment and are biologically available only when unchelated and in a freely dissolved form (Schmidt et. al. 2007). The effluent treatment system removes approximately 90% of the TSS discharged from the culture tanks, and thus can be expected to remove a similarly high fraction of any OTC residuals prior to release.

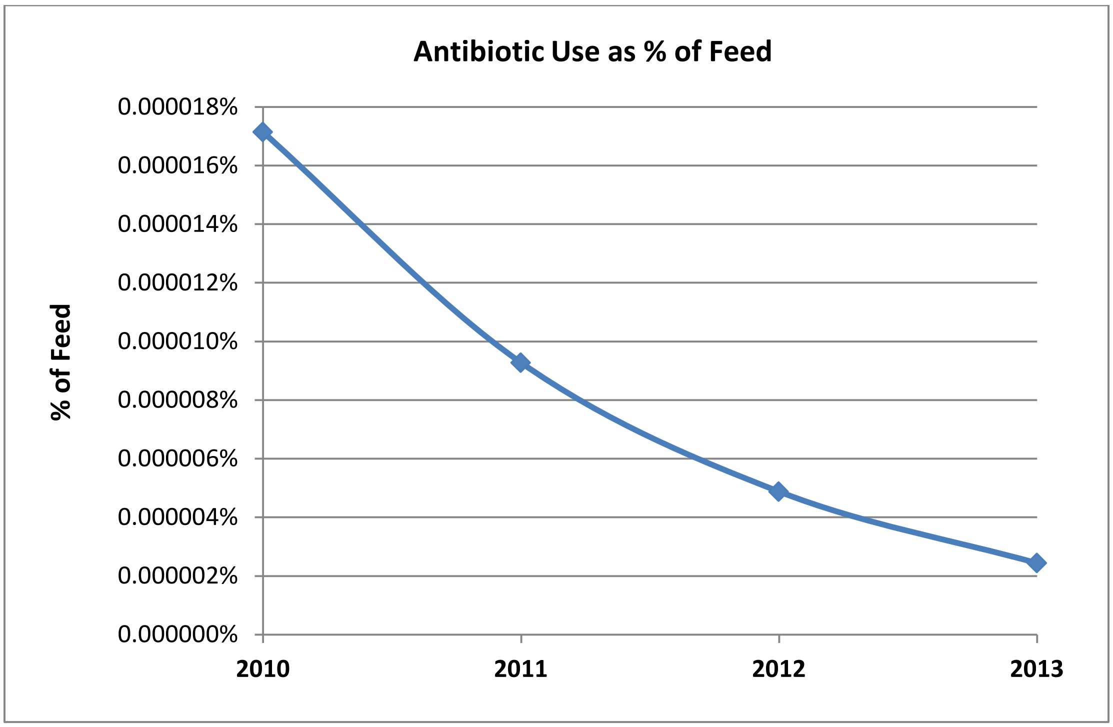

Figure 2 – Antibiotic Usage as a % of Feed

Summary

AAV scores 7 out of 10 on this criterion due to a low and decreasing use of antibiotics that is supported with data and a low use of chemicals that pose little risk or evidence of impacts on non-target organisms. The removal of residuals for the land site through settling ponds also reduces the risk of impact from the land based component of the operations.

[2] WHO antibiotic list - http://apps.who.int/iris/bitstream/10665/77376/1/9789241504485_eng.pdf

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

Feed parameters	Value	Score	
F5.1a Fish In: Fish Out ratio (FIFO)	1.76	5.61	
F5.1b Source fishery sustainability score		-2.00	
F5.1: Wild Fish Use		5.26	
F5.2a Protein IN	28.19		
F5.2b Protein OUT	18.50		
F5.2: Net Protein Gain or Loss (%)	-34.38	6	
F5.3: Feed Footprint (hectares)	11.17	6	
C5 Feed Final Score		**5.63**	**YELLOW**
Critical?	NO		

AAV has a moderate use of wild fish, protein retention efficiency, and feed footprint; the Fish In: Fish Out ratio is 1.76. The sustainability score for the source of wild fish used in feeds was also good as all FishSource scores were ≥ 6. The protein loss is 34% and the feed footprint is 11.17 hectares, which scores a 6 out of 10 for both factors.

Justification of Ranking

Factor 5.1. Wild Fish Use

AAV accurately monitors feed inputs and the fish in: fish out ratio for AAV's feed is 1.28 for fishmeal and 1.76 for fish oil. They have inclusion rates of 22% rates for fishmeal (with 2.72% from byproducts) and 8% for fish oil (and 18.75% from byproducts) and an economic FCR of 1.35.

AAV has continued to reduce the inclusion rates for fishmeal and oil, particularly in the larger sized feeds, which are most critical to determining the fish in: fish out ratio, and has begun to use locally produced feed manufactured by large international feed companies who have recently begun operations in Vietnam. Given seasonal temperature fluctuations and a larger harvest weight in Vietnam, AAV achieves a somewhat higher FCR than Australis' US production operation. The net result is a FIFO ratio calculated at 1.76:1. This means that 1.76 tons of wild fish will need to be caught to supply the fish oil necessary to grow one ton of farmed barramundi.

The source of these fisheries' ingredients is a combination of Peruvian anchovy, Icelandic capelin and Canadian herring which all score ≥6 with FishSource. AAV has a company policy in place to not source from any reduction fishery classified by relevant national or international fisheries authorities as overfished, depleted, or having overfishing occurring, outside precautionary limits.

Factor 5.2 (Net Protein Gain or Loss)

The average protein content of the feed that AAV uses is 45% and the majority of feed ingredients are from edible crops (65%). Overall, there is a 34% loss of protein with the production of AAV due largely to the 100% re-use of trimmings from processing (i.e., from the harvested barramundi), which results in a score of 6 under this criterion.

5.3 (Feed Footprint)

The Feed Footprint score is 6 based on the ratios of marine, land animal byproduct and crop ingredients used in AAV's feed. This results in a calculated ocean area requirement of 10.5 hectors/ton of farmed fish and 0.65 hectors of land areas for an overall value of 11.16 hectors/ ton.

Summary

Overall, the Feed Criterion score is 5.63 out of 10, or a "moderate" conservation concern. This is due to moderate use of wild fish in the feed, moderate protein retention efficiency, and also a moderate 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		3.0	
F6.1a Recapture and mortality (%)	30		
F6.1b Invasiveness		7.0	
C6 Escape Final Score		**6.0**	**YELLOW**
Critical?	NO		

AAV scored 3 out of 10 for the escape risk based on the inherent vulnerability of the net pen production system, but also taking account of their use of best practices to prevent escapes as well as data that indicate that they have operated escape free since inception. Barramundi are native to the region and the nearest suitable spawning grounds are at least 600 km away and it is unlikely that escapes from the AAV would congregate in that location in significant enough numbers to cause a negative impact on other wild stocks. The escape score also reflects the mitigation risk, which accrues from the low tidal energy and limited exposure to storm risk afforded by the geography of the bay as well as the low predator intensity on this site. Given these factors, the invasiveness score was found to be 7.0 and the overall score for the escape criterion was found to be a 6.

Justification of Ranking

Factor 6.1a: Escape risk

AAV is scored 3 out of 10 or between a moderate to moderate-high risk due to the inherent vulnerability of the net pen production system, which takes into account their use of best practices for design, construction, and management of escape prevention at their farming operations and their four year history of operating without any escape incidents. The inherent escape risk of the net pens is mitigated by the use of tanks for production of advanced juveniles prior to stocking the pens (to minimizes 'leakage' that frequently occurs when small marine fish are stocked in pen systems) as is common practice in every industry (except salmon), there is little to no predators capable of causing escapes, there is also siting protection from storms, and an escape free operating history. Furthermore, while the extent of recapture and post-escape mortality is unknown, there are 85,000 fishing boats operating on the coast of Vietnam including a large local fishing fleet, which works the waters around the farm and they would be contracted by AAV to undertake recapture in the event of a significant escape event, which provides a certain degree of mitigation. An assumed recapture and mortality rate of 30% was used although no data are available to support this assumption; we believe this is a conservative estimate based on the factors described above.

Land based production phase

AAV operates a land based hatchery and nursery adjacent to the bay. These facilities use tanks to rear juveniles prior to stocking the sea pens. AAV stocks larger juveniles relative to most tropical marine aquaculture, which minimizes the escape risk during the highest risk phase of the process. This eliminates the need for fine mesh nets, which require frequent changes, and allows for stocking of more uniform (and thus easy to contain) fish.

Marine-based production phase

The marine farm occupies one nursery and one grow-out site. Fish are typically transferred from the nursery tanks to 1,500 M^3nursery pens at 50 grams and grown to 250 grams before being transferred (via brail net or fish pump) to 7,500 M^3grow out pens where they are grown to a 1.0-1.1 kg harvest weight. The use of two stages in the sea operations reduces escape risk by allowing for a better fit between the fish and net size and results in shortening the overall fish residency so that the frequency of net changes is reduced.

AAV has implemented the following precautionary measures to minimize escapes:

- Production facilities are constructed to prevent overtopping by storm surges, waves or floodwater. The nets extend 1 m above the sea surface on all sea pens. In comparison with most salmon farming sites, AAV’s site is a low energy site with reduced tidal and wave action.
- Net pens are stocked with larger juveniles, which facilitates accurate counting and numerical assessment. Stocking larger sizes significantly enhances the effectiveness of pre-stocking grading to achieve a coefficient of variation in the population, which is sufficient in size to virtually eliminate leakage of small fish. This is in contrast with most marine farms, which stock 5–10 gram juveniles and require far more handling and are much more difficult to reliably contain.
- The stocking strategy employed (large fish, two pen sizes) enables use of a single mesh net size for each of the two size pens, reducing the need for net changes with fish in the pens.
- AAV‘s minimum breaking strain for nets is 200 kg on any one bar. All nets are tagged with the following information included: net size, mesh size, manufactured date and an individual ID number. All net pens are maintained in good condition, and records of repairs are kept.
- The nets are cleaned via in situ (underwater) washing, reducing the need for net changes while fish are resident.
- The sea site is very well protected on the leeward (southwest) side of Lon Island and also within the leeward side of Van Phong (see Figure 1 in the introduction).
- All nets are inspected daily, and before and after fish transfers, to provide continual verification of the integrity of containment.
- Annual inspections of mooring lines are documented.

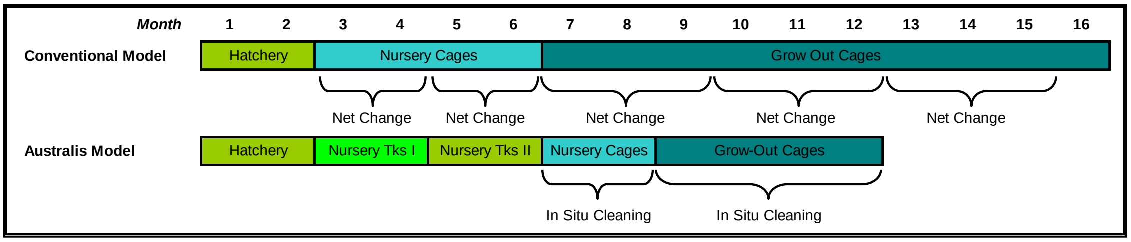

Figure 3 - Comparison of Australis and Conventional Marine Production Strategy

Escape Performance to Date

In its first four years of operation, AAV has been able to operate with no known and/or measureable fish escapes. This is evidenced by the records generated by daily inspection of the pens and numerical evaluation of stocking and harvest records that constantly demonstrate levels of variability consistent with low level cannibalism as seen in closed containment tanks. Cannibalism is an important challenge for barramundi farming, which encourages producers to utilize tanks for the early stages of production.

Table 5 – Stocking, Harvest and Escape Summary: 2010, 2011 and 2012 Year Class

2010 YC	Bach Code	No. Fish Stocked (Wt. Samples)	Less Mortalities (counted)	Less Allocation for Cannibalism (6% of # stocked)	Predicted No. at Harvest	Actual No. Harvested (Counted)	Delta	Delta %	Net Damage Note	Cage Damage Noted	Escape Event Noted
Cage 1	10A001	69,367	(7,363)	(4,162)	57,842	56,811	(1,031)	-1.49%	No	No	No
Cage 2	10A002a	34,790	(4,156)	(2,087)	28,546	26,404	(2,142)	-6.16%	No	No	No
Cage 3	10A002b	90,511	(6,432)	(5,431)	78,649	77,908	(741)	-0.82%	No	No	No
Cage 4	10A003a	62,030	(4,855)	(3,722)	53,453	54,697	1,244	2.01%	No	No	No
Cage 5	10A003b	98,973	(4,353)	(5,938)	88,682	92,070	3,388	3.42%	No	No	No
Cage 6	10A004	73,883	(4,070)	(4,433)	65,380	63,383	(1,997)	-2.70%	No	No	No
Cage 7	10A005	62,861	(4,473)	(3,772)	54,616	55,875	1,259	2.00%	No	No	No
Cage 8	10A006	123,094	(8,281)	(7,386)	107,427	105,273	(2,154)	-1.75%	No	No	No
Cage 9	10A007	120,031	(8,873)	(7,202)	103,956	102,134	(1,822)	-1.52%	No	No	No
Cage 10	10A008	120,508	(8,600)	(7,230)	104,678	106,584	1,906	1.58%	No	No	No
Cage 11	10A009	131,214	(8,112)	(7,873)	115,230	112,096	(3,134)	-2.39%	No	No	No
Cage 12	10A010	118,362	(8,968)	(7,102)	102,292	99,947	(2,345)	-1.98%	No	No	No
YC Average		**92,135**	**(6,545)**	**(5,528)**	**80,063**	**79,432**	**-631**	**-0.82%**			
YC SD		**31,202**	**2,033**	**1,872**	**27,719**	**27,499**	**2,066**	**0.03**			
2011 YC											
Cage 1	11A001	82,482	(5,610)	(4,949)	71,923	70,689	(1,234)	-1.50%	No	No	No
Cage 2	11A002	118,140	(7,248)	(7,088)	103,804	102,963	(841)	-0.71%	No	No	No
Cage 3	11A003	136,738	(7,996)	(8,204)	120,538	122,884	2,346	1.72%	No	No	No
Cage 4	11A004	122,086	(17,344)	(7,325)	97,417	101,144	3,727	3.05%	No	No	No
Cage 5	11A005	113,079	(14,035)	(6,785)	92,259	95,397	3,138	2.77%	No	No	No
Cage 6	11A006	133,785	(13,278)	(8,027)	112,480	116,881	4,401	3.29%	No	No	No
Cage 7	11A007	136,748	(4,915)	(8,205)	123,628	125,926	2,298	1.68%	No	No	No
Cage 8	11A008	113,495	(19,375)	(6,810)	87,310	88,996	1,686	1.49%	No	No	No
Cage 9	11A009	92,983	(3,244)	(5,579)	84,160	80,299	(3,861)	-4.15%	No	No	No
Cage 10	11A010	129,232	(4,231)	(7,754)	117,247	118,008	761	0.59%	No	No	No
Cage 11	11A011	103,346	(18,798)	(6,201)	78,347	73,035	(5,312)	-5.14%	No	No	No
Cage 12	11A012	125,725	(39,017)	(7,544)	79,165	79,550	385	0.31%	No	No	No
Cage 13	11A013	139,043	(16,775)	(8,343)	113,925	115,496	1,571	1.13%	No	No	No
YC Average		**118,991**	**-13,220**	**-7,139**	**98,631**	**99,328**	**697**	**0.3%**			
YC SD		**17,633**	**9,725**	**1,058**	**17,765**	**19,545**	**2,872**	**2.6%**			
2012 YC											
Cage 1	12A001	59,865	(11,579)	(3,592)	44,694	46,270	1,576	2.63%	No	No	No
Cage 2	12A002	98,644	(758)	(5,919)	91,967	88,714	(3,253)	-3.30%	No	No	No
Cage 3	12A005	85,062	(3,322)	(5,104)	76,636	77,513	877	1.03%	No	No	No
YC Average		**81,190**	**-5,220**	**-4,871**	**71,099**	**70,832**	**-267**	**0.1%**			
YC SD		**19,677**	**5,654**	**1,181**	**24,118**	**21,997**	**2,610**	**3.1%**			

Note: Accuracy of counting methods for small fish is verifed at ± 2% based on hand counts validating weights sampling and enumeration methods.

Factor 6.1- Invasiveness

Barramundi are native to the area and are therefore not considered to be an invasive species. AAV uses broodstock native to Vietnam and has recently moved away from the sole use of wild broodstock. The broodstock are P1 and P2 (first and second generation domestic fish) produced originally from native strains collected within Vietnam, which results in a score of 3 for the first part of the criteria. Barramundi are thought to have relatively low levels of genetic differentiation and have high levels of gene flow between populations, and show little evidence of adaptation or "out breeding depression" in Australia (Keenan 2000).

Factor 6.1b- Native and Non-Native Species

The potential impacts of escapes from the farm on native fish populations is associated primarily with the potential for escapees to compete with native populations for food and/or to increase the levels of predation on select native populations. Given the lack of suitable barramundi breeding habitat within approximately two hundred kilometers of the farm, it is unlikely that escapes would compete with native populations for breeding partners or disrupt the breeding behavior of native barramundi in any significant way. Given the lack of suitable breeding habitat in the region, it is likely that the impacts of any escape event would be relatively short lived.

Summary

AAV scores 6 out of 10 for the overall escape criterion score due to the high escape risk associated with the use of net pens, which is partially mitigated by: (i) the use of tanks for production of advanced juveniles prior to stocking the pens, (ii) a history of escape-free production, and (iii) a low invasiveness score based on use local domestic broodstock which are native to the region. Additional risk mitigation accrues from the farm's location being hundreds of kilometers from the nearest spawning habitat and the potential for recapture in the event of a major escape.

Criterion 7: 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	5.0	
C7 Disease; pathogen and parasite Final Score	**5.0**	**YELLOW**
Critical?	**NO**	

AAV scores 5 out of 10 for this criterion as the operational data shows low incidence of disease and no evidence that disease amplification is occurring, although the data is limited by the age of the farm. AAV employs a range of preventive strategies to mitigate the risk of disease amplification, including: (1) use of disease free hatchery reared stocks, (2) maintaining low culture densities on the pens, (3) rotational fallowing of the site, (4) wide spacing of the pens and between mooring grids, (5) independent disease monitoring, and (6) AAV is the only major barramundi farm in the bay.

Justification of Ranking

Barramundi can experience bacterial, fungal, viral and parasitic diseases usually associated with stress, such as extremes of temperature, low dissolved oxygen, poor nutrition, or poor handling of the fish. The expansion of open net pen barramundi culture in Southeast Asia has resulted in several outbreaks of infectious diseases (Leong 1992; Tendencia 2002). Bacterial infection is the most common cause of disease in barramundi aquaculture (Barlow 1997). Columnaris disease is common in small fingerlings held in water below about 25^{o}C (Barlow 1997). Many diseases affect juvenile barramundi during their rearing stages, so the use of tanks generally helps to improve monitoring, control and treatment, when necessary.

The bacterium *Vibrio harveyi*, is widely distributed in the marine environment in the region and is an opportunistic pathogen that infects fish when they are stressed and has been reported in net pen cultured barramundi (Tendencia2002). Although parasites often occur in small numbers on barramundi farms, outbreaks are uncommon; though when they do occur they must be rapidly assessed and treated if large losses are to be avoided. The most common parasitic disease is white spot in broodstock held in salt water, which is caused by *Crypotocaryon irritans* (Barlow 1997).

Deveney *et al.* (2001) reported the first outbreak of another parasite, *Neobenedenia melleni*, which occurred on barramundi cultivated in northern Australia. The outbreak resulted in the loss of 200,000 fish and had not been previously documented in either wild or farmed species. The authors (i.e. Deveney et al.) suggest that the disease was from the wild and their study serves as an example of transfer of a native parasite from wild to farmed stocks which may have resulted in amplification of the parasite.

The most important bacterial species affecting the culture of barramundi is *streptococcus iniae*. The bacterium has resulted in losses up to 70% (Bromage *et al.* 1999) in unvaccinated populations and has become a limiting factor in the successful culture of a variety of temperate fish species (Bromage *et al.* 1999; Bromage and Owens 2002). Fortunately, vaccines for *S. iniae* are now commercial available and are being used to mitigate the risk of *streptococcus* infections by AAV.

The biggest theoretical risk to wild fish from farmed barramundi may be the nodavirus (virulence phalopathy and retinopathy or VNN), which effects their nervous system and spinal cord, and is most prevalent in young juvenile fish. Little information exists on the prevalence of the nodavirus in wild populations, however, making it difficult to assess this risk (ANON 1999; Jones pers. comm.).

AAV has a well-developed monitoring program in place for disease and parasites and data for 2012 and 2013 is presented in Appendix III. The results show that disease incidences or symptoms were limited to the hatchery phases and did not appear in the net pen stages.

Disease History in Van Phong Bay

In the five years that barramundi have been cultured in central Vietnam, Nha Trang Fisheries University has provided fish health consultation to farmers and regional monitoring for disease. Over this period, there have been no incidences of disease that have caused significant mortality events. The AAV site benefits from the low density of farms in the area and water quality in the bay remains within the acceptable range for barramundi on a year-round basis. All diseases reported in barramundi aquaculture are stress-mediated opportunistic bacterial pathogens such as Columnaris. Due to lower stocking rates and a less intensive system, diseases common to tank reared fish have not been seen, to date, on extensively reared barramundi[3]. Viral diseases (noda virus) have been reported in Vietnam hatcheries and can affect fingerlings below 45-day post hatch. Noda virus appears to be very common in the environment and does not appear be pathogenic beyond the larval stage.

Summary

AAV has a robust disease mitigation strategy in place and a disease monitoring program that shows very low infections occurred on the farm in 2012 and 2013. Further, the types of disease organisms identified were exclusively opportunistic organisms endemic to that environment. Because the impact of these pathogens on 'on-farm' mortality has been very low, the risk of disease magnification is also considered low. The data set covers more than 3 million fish and shows "low, infrequent and temporary occurrence of on-farm infections" which is consistent with the score of 5 out of 10 for this criterion.

[3] http://www.fish.wa.gov.au/docs/aqwa/Barramundi/FarmingBarramundiPage07.php?0308

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 broodstock 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	100	
C8 Source of stock Final Score	**10.0**	**GREEN**

AAV scores 10 out of 10 on this criterion, as 100% of the fingerlings are hatchery raised. The current broodstock populations used to produce these juveniles are F2 domestics (farm raised). The availability of the existing broodstock populations coupled with the high fecundity of barramundi ensure that any future collections of wild brood fish which may occur to supplement the population would occur at levels well below the threshold of impacting the abundance of wild populations.

Justification of Ranking

100% of the fish raised by AAV are hatchery reared. The broodstock used are one generation from the wild. Therefore no wild barramundi are used for either broodstock or for ongrowing and the score is 10 out 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, the evaluation 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	**-2.0**	**GREEN**
Critical?	NO	

AAV ranks as a -2 on this criterion based on the design and management of the farming site and their record of no predator mortalities to date.

Justification of Ranking

C9X Wildlife and predator score

–The score for this criterion is a small penalty of -2 out of -10 as the operation has the potential to attract predators but has thus far proven to be able to operate without any negative interactions. Over the initial four years of production there has never been an attack on the farm from predators in any form. The company has implemented practices which have eliminated all significant predator interactions, including: (1) use of high quality (<250 kg breaking strength) nets, (2) use of a proprietary net tensioning system to ensure the panels remain tight which minimizes the ability of predators to grip the net, and (3) birds nets are used for fish under 50g.

AAV will not destroy birds or other predators. If predator management becomes necessary, AAV will employ humane, non-lethal measures for control, even if lethal methods are permitted.

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.

Exceptional Factor 10X: Escape of unintentionally introduced species

Escape of unintentionally introduced species parameters	Score	
F6.2Xa International or trans-waterbody live animal shipments (%)	10.00	
F6.2Xb Biosecurity of source/destination	10.00	
C6 Escape of unintentionally introduced species Final Score	**0.00**	**GREEN**

Justification of Ranking

Factor 10Xa International or trans-waterbody live animal shipments

There are no live international or trans-waterbody live animal movements because the hatchery and farm are located in the same bay in Vietnam.

Factor 10Xb Biosecurity of source/destination

Biosecurity of source/destination are not scored because of the 0% trans-waterbody live animal shipments.

The final score for this exceptional criterion (i.e. scored 0 to -10) is a deduction of zero.

Overall Recommendation

The overall recommendation is as follows:

The overall final score is the average of the individual criterion scores (after the two exceptional scores have been deducted from the total). The overall ranking is decided according to the final score, the number of red criteria, and the number of critical criteria as follows:

– **Best Choice** = Final score ≥6.6 AND no individual criteria are Red (i.e. <3.3)

– **Good Alternative** = Final score ≥3.3 AND<6.6, OR Final score ≥ 6.6 and there is one individual "Red" criterion

– **Red**= Final score <3.3, OR there is more than one individual Red criterion, OR there is one or more Critical criteria

Criterion	Score (0-10)	Rank	Critical?
C1 Data	9.00	GREEN	
C2 Effluent	6.00	YELLOW	NO
C3 Habitat	6.92	GREEN	NO
C4 Chemicals	7.00	GREEN	NO
C5 Feed	5.63	YELLOW	NO
C6 Escapes	6.00	YELLOW	NO
C7 Disease	5.00	YELLOW	NO
C8 Source	10.00	GREEN	
C9X Wildlife mortalities	-2.00	GREEN	NO
C10X Introduced species escape	0.00	GREEN	
Total	**53.55**		
Final score	**6.69**		

OVERALL RANKING

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

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Appendix I - Methodology for sea pen sampling

A minimum of three sampling stations are established. One is in the approximate center of the farm. The 2nd station is 150m from the center of the farm and the 3rd station acts as a control station 500m from the farm.

Water is collected with a Kemmerer or Van Dorn water sampler, or by use of a weighted bottle from which the stopper can be removed by jerking the calibrated line. Samples are transferred to clean plastic bottles and placed on ice in a closed, insulated chest to avoid exposure to light.

Benthic monitoring is done by taking photographic imagery every 5m along 2 x 150m transects. 1 transect is from the 1st sampling station at the center of the farm to the 2nd sampling station. The 2nd transect is from the control site sampling station running perpendicular to the site. All parameters measured on a periodic basis are averaged based on annually production outputs.

Annual effluent loads for sea pen operations

The loads of nitrogen and phosphorus imposed by net pens on receiving water bodies can be estimated as follows:

Calculation 1

Nitrogen load (kg/yr) = [Total feed (kg) x Nitrogen (% in feed) / 100] – [Harvested fish (kg) x Nitrogen (% in fish)/100]

Calculation 2

Phosphorus load (kg/yr) = [Total feed (kg) x Phosphorus (% in feed)/100] – [Harvested fish (kg) x Phosphorus (% in fish)/100]

Calculation 3

Nitrogen load index (kg/ton fish) = Nitrogen load (kg/yr)/Fish production (ton/yr)

Calculation 4

Phosphorus load index (kg/ton fish) = Phosphorus load (kg/yr)/ Fish production (ton/yr).

The percentage nitrogen in AAV’s feed is 16% and phosphorus is 1% of the total protein content.

AAV strategies to reduce potential for effluent impacts

The most reliable way of reducing nutrient outputs from net pen culture is to increase feed use efficiency. This is done by hand feeding high quality feed that contains the lowest levels of nitrogen and phosphorus necessary and by assuring that fish consume all of the feed offered. AAV uses a semi-floating feed to ensure good feed management and feeding rates are set each day and carefully monitored to avoid overfeeding. Divers periodically go beneath the pens to determine if uneaten feed is accumulating on the bottom and dead fish are removed promptly and disposed of on land by responsible procedures; carcasses are never discarded in waterbodies. When nets are removed they are cleaned on a concrete slab on shore and waste is then diverted into a sedimentation pond.

AAV's main precaution against pollution is to locate the culture units in open water areas where current and water circulation are sufficient to transport wastes away from pens and to rapidly dilute dissolved metabolites. The sidewall of the nets are 10 meters deep and are deployed in 20 meters of water providing sufficient area and water movement under the pens to promote dispersion. Currents and tidal flushing enhance dispersion. Average exchange rates are in the order of 100x/hour, which provides a great deal of new water to the fish while also acting to effectively disperse nutrients generated from the pens to levels below the threshold of detection for water quality or other ecological effects.

High biomass in a particular location can obviously increase the likelihood of *eutrophication* or other negative impacts. AAV's maximum terminal stocking density is 13 $kg/m^3$and the pens are deployed in an open grid with approximately 3-pen diameters between each pen, resulting in low overall biomass densities across the site equal to a maximum of 15T/H or 0.007 kg/M^2 at full capacity. This strategy reduces nutrient and solids loading per unit area to well below typical levels for other marine farms. The pens are also operated on a rotational basis with two production cycles on, followed by two cycles of fallowing. Given high year round water temperatures, it is expected that this will be sufficient to eliminate any long-term deposition or changes to the benthic environment.

AAV hired a qualified expert to undertake baseline water quality and benthic surveys to characterize water quality, benthic chemistry and species diversity and abundance in and around the sea sites. The monitoring program will be updated every six months. Data gained from the surveys coupled with per site feed rate were incorporated into the development of a Best Management Plan for the site, minimizing the environmental impacts. Undertaking the surveys was a required component of a more complete Environmental Impact Assessment undertaken by AAV as part of the provincial government's site permitting process. Data from the baseline survey is being used on an annual basis to determine site carrying capacity without negatively impacting water quality or the benthic environment.

Limitations

In situations where the influent water maintains levels below the effluent targets outlined above, AAV ensures effluent components outlined above at least match the levels of the back ground/influent water.

Sampling methodology for land based nursery

Samples are collected near the point where effluents enter natural water bodies or exit the farm property. A water control structure at the sampling site or other suitable sampling method is used to prevent mixing of effluent and water from the receiving body.

Water is collected directly from the discharge stream of pipes with a clean plastic bottle. The sample is placed on ice in a closed, insulated chest to prevent exposure to light. Samples or direct measurements for temperature, dissolved oxygen and pH are obtained between 0500 and 0700 hours, and 1300 and 1500 hours on the same day. The average of the two measurements for each variable is used for verification of compliance.

Samples for other variables are collected between 0500 and 0700 hours. The number of grow-out units being drained at the time of sampling is recorded. Source water samples are collected every 6 months from directly in front of the pump station.

Data Analyses

Analysis is conducted by a private or government laboratory. Measurements for temperature, dissolved oxygen and pH are taken in situ with portable meters.

Annual effluent loads for land based nursery operations

Loads of water quality variables are more indicative of the pollution potential of farm effluents than separate measurements of concentrations of these variables and effluent volume. After the first year of effluent monitoring, annual effluent loads for total suspended solids, soluble phosphorus, total ammonia nitrogen and biochemical oxygen demand are calculated as follows:

Calculation 6

Load of variable (kg/yr) = Farm discharge (m^3/yr) x [Mean annual concentration in effluent – mean annual concentration in source water (mg/L, same as g/m^3] x 10-3 kg/g

Water Use and Load Indices—It is possible to comply with numerical water quality criteria by increasing the amount of water passing through a farm to dilute the concentrations of tested variables. Compliance with the water use index assures that AAV meets water quality criteria through good management rather than by diluting effluents before they are released into natural waters. After the first year of effluent monitoring, AAV's water use and load indices are estimated using the following calculations:

Calculation 7

Water use index (m3/kg fish) = Annual effluent volume (m3) / Annual fish production (kg)

Calculation 8

Load index (kg variable/ton fish) = Annual load of variable (kg/yr)/Annual fish production (ton/yr)

Appendix II –Sea Pen Environmental Monitoring Data

		Control Site			HON ME FARM (Activated 2009)														HON DEN FARM (Activated Aug 2011)					
Parameters	Surface/Bot	2012	2013		2010				2011				2012				2013 - Fallow		2012				2013	
		Oct	Apr	Oct	Jan - pre-farming		Oct		Apr		Oct		Apr		Oct		Apr		Apr		Oct		Apr	
					HM - A	HM - B	HM - A	HM - B	HM - A	HM - B	HM - A	HM - B	HM - A	HM - B	HM - A	HM - B	HM - A	HM-B	HD - A	HD - B	HD - A	HD - B	HD - A	HD - B
Biomass (MT)							64,123		82,404		74,639		49,680		45,363				650,349		837,267		1,082,214	
pH	S	8.22			8.1	8.1	7.9	7.9	8.1	8.1	7.8	7.9	8.1	8.2	8.2	8.2			7.9	8.0	8.2	8.2		
	B	8.17	8.36		8.2	8.2	8.0	8.1	8.1	8.1	8.0	8.2	8.2	8.2	8.1	8.1	8.4	8.3	8.1	8.2	8.2	8.1	8.3	8.3
Temperature (0C)	S	27.2			29.1	29.0	29.1	29.0	28.1	28.0	29.2	29.0	29.5	29.7	27.8	27.8			29.6	29.4	27.9	28.0		
	B	27.1			28.4	27.5	27.5	27.7	26.4	26.4	27.4	27.1	27.1	27.3	27.5	27.7	29.4	29.1	27.5	26.9	27.5	28.1		
DO (mgO2/L)	S	6.34			6.8	7.1	6.4	6.5	6.9	7.1	6.9	6.5	7.1	6.9	6.6	6.3			6.6	6.9	6.6	6.3		
	B	6.25	6.29		6.2	6.5	6.2	6.2	7.4	7.4	7.3	7.2	6.5	6.4	6.3	6.2	6.4	6.4	6.5	6.4	6.3	6.2	6.4	6.3
Salinity (‰)	S	32.8			32.0	32.0	31.7	31.8	32.5	32.0	32.1	32.5	33.2	33.3	33.0	32.7			33.0	33.2	33.1	33.0		
	B	33.2			33.0	33.0	32.0	32.1	33.0	33.0	32.4	32.7	33.4	33.5	33.1	32.7	32.8	33.0	33.2	33.4	33.2	33.0		
BOD5 (mgO2/L)	S	0.5			0.6	0.7	1.6	1.5	1.1	0.9	1.6	1.2	0.7	0.7	0.6	0.6			1.2	1.0	0.8	0.5		
	B	0.59	0.49		0.3	0.5	1.6	1.6	0.9	0.8	1.6	1.4	1.2	1.1	0.9	0.7	0.6	0.4	1.5	1.3	1.0	0.7	0.6	0.4
NH3-N (µg/l)	S	0.008			0.0	0.0	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0			0.0	0.0	0.0	0.0		
	B	0.02			0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0			0.0	0.0	0.0	0.0		
PO4-P (µg/l)	S	20.1			11.6	15.6	80.0	68.0	5.6	9.3	3.3	7.6	41.5	46.8	72.5	18.2			20.9	19.3	17.7	16.1		
	B	49.9			15.3	16.6	90.0	82.0	13.9	8.9	13.6	15.3	55.0	61.0	90.1	39.3			9.0	16.0	27.0	38.0		
N-NH4 (µg/l)	S	228.4			98.5	85.6	83.5	75.6	257.5	242.6	238.0	227.1	214.7	201.5	208.3	206.1			78.0	65.0	188.6	120.6		
	B	268.0	100.55		86.1	79.7	79.0	73.0	261.1	285.3	251.4	236.0	229.8	209.5	216.7	181.6	108.0	93.6	84.5	78.2	141.1	105.4	95.5	105.8
Chlorophyll_a (µg/L)	S	0.47			1.2	1.3	1.1	1.3	0.5	0.4	0.3	0.5	0.5	0.4	0.4	0.3			0.3	0.4	0.4	0.5		
	B	0.54			2.2	1.7	1.4	1.6	0.6	0.2	0.4	0.6	0.5	0.4	0.4	0.4			0.5	0.5	0.5	0.5		
TSS (mg/l)	S	0.4			7.3	6.6	8.5	7.4	1.6	1.9	5.7	4.5	1.5	1.2	0.9	0.7	1.8	1.4	1.1	1.5	0.4	0.9	0.8	0.7
	B	1.68	3.1		9.8	8.9	9.4	8.6	1.1	1.9	1.9	3.7	18.1	13.4	8.8	4.1			3.6	4.2	4.7	13.5		
Redox	S																							
	B		-95.67														(96.3)	(94.7)					(92.3)	(89.7)
Free Suphide	S																							
	B		116.33														60.1	109.9					29.3	86.3
TOC	S		18.08														17.7	15.8					16.7	16.8
	B		0.96														2.3	1.8					1.7	1.9
TON	S		333.03														283.2	255.7					246.5	182.2
	B		0.09														0.2	0.2					0.2	0.2
Zn (µg/l)	S																							
	B		20.8														9.4	29.4					23.1	22.1
Cu (µg/l)	S																							
	B		16.8														8.2	26.1					56.3	20.1
TOP	S		23.33														15.8	25.0					16.8	13.8
	B		0.03														0.1	0.1					0.1	0.1
Polychaeta	ind/m2	267			347	80			67	13					267	147					173	160		
Mollusca	ind/m2	27			13	-			27	-					-	13					13	-		
Crustacea	ind/m2	40			187	120			27	-					13	67					40	13		
Echinodermata	ind/m2	13			-	40			-	-					-	-					-	27		
Other	ind/m2	-			-	-			67	-					-	-					-	-		
Total	ind/m2	347			547	240			187	13					280	227					227	200		

Key:

HM - A	Location directly below production cage position at 50m nursery site
HM - B	Location 500m south of HM - A production cage position at 50m nursery site
HD - A	Location directly below production cage position at 100m growout site
HD - B	Location 500m south of HM - A production cage position at 100m grow out site
Control site	Location 5 km south of both production sites

Appendix III–Sea Pen Disease Monitoring Data

	03-Jan-13		10-Jan-13		17-Jan-13		24-Jan-13		31-Jan-13		07-Feb-13	
Stage I Nursery	Test result	Clinical observation	Test result	Clinical observation	Test result	Clinical observation	Test result	Clinical observation	Test result	Clinical observation	Test result	Clinical observation
Strep			+	deformity							-	
Vibrio	+	darken body		rotten tail							-	
General bacteria	+	darken body	+						+		-	
VNN												
Monogenea												
Trichodina	+	necrosis gill										
Ceratomyxa												
Ciliate												
Cyst												
Heneguya												
Others												
Stage II Nursery												
Strep					+	ulcerative	+	darken body			-	
Vibrio					+						-	
General bacteria					+		+	ulcer			-	
VNN												
Monogenea												
Trichodina												
Ceratomyxa												
Ciliate												
Cyst					+		+					
Heneguya												
Others												
Stage I Cage												
Strep												
Vibrio												
General bacteria												
VNN												
Monogenea												
Trichodina												
Ceratomyxa												
Ciliate												
Cyst												
Heneguya												
Others												
Stage II Cage												
Strep												
Vibrio												
General bacteria												
VNN												
Monogenea												
Trichodina												
Ceratomyxa												
Ciliate												
Cyst												
Heneguya												
Others												

	21-Feb-13		07-Mar-13		07-Mar-13		11-Apr-13		25-Apr-13		29-Apr-13	
Stage I Nursery	Test result	Clinical observation	Test result	Clinical observation	Test result	Clinical observation	Test result	Clinical observation	Test result	Clinical observation	Test result	Clinical observation
Strep											+	
Vibrio	+				+		+	ragged tail				
General bacteria	+						+	gill ulceration			+	
VNN												
Monogenea												
Trichodina												
Ceratomyxa												
Ciliate												
Cyst												
Heneguya												
Others												gill fillaments
Stage II Nursery												
Strep			+									
Vibrio			+		+		+	ulceration	+	ulceration		
General bacteria							+	blind	+	ragged fin		
VNN												
Monogenea												
Trichodina												
Ceratomyxa												
Ciliate												
Cyst							+					
Heneguya												
Others												
Stage I Cage												
Strep												
Vibrio												
General bacteria												
VNN												
Monogenea												
Trichodina												
Ceratomyxa												
Ciliate												
Cyst												
Heneguya												
Others												
Stage II Cage												
Strep												
Vibrio												
General bacteria												
VNN												
Monogenea												
Trichodina												
Ceratomyxa												
Ciliate												
Cyst												
Heneguya												
Others												

	09-May-13		16-May-13		22-May-13		30-May-13		06-Jun-13		13-Jun-13	
Stage I Nursery	Test result	Clinical observation	Test result	Clinical observation	Test result	Clinical observation	Test result	Clinical observation	Test result	Clinical observation	Test result	Clinical observation
Strep							+	ragged tail				
Vibrio	+	ulceration					+	ulceration				
General bacteria	+	ulceration					+	ulceration				
VNN												
Monogenea												
Trichodina												
Ceratomyxa												
Ciliate												
Cyst												
Heneguya												
Others		gill fillaments										
Stage II Nursery												
Strep			+	Blind	+	ragged tail						
Vibrio					+	ulceration			+	ragged fin	+	ragged fin
General bacteria			+	pale liver	+	necrosis gill			+	ragged fin	+	ragged fin
VNN												
Monogenea												
Trichodina												
Ceratomyxa												
Ciliate												
Cyst	+		+									
Heneguya												
Others		gill fillaments		gill fillaments				gill fillaments				
Stage I Cage												
Strep												
Vibrio												
General bacteria												
VNN												
Monogenea												
Trichodina												
Ceratomyxa												
Ciliate												
Cyst												
Heneguya												
Others												
Stage II Cage												
Strep												
Vibrio												
General bacteria												
VNN												
Monogenea												
Trichodina												
Ceratomyxa												
Ciliate												
Cyst												
Heneguya												
Others												

	27-Jun-13		04-Jul-13		11-Jul-13		18-Jul-13		25-Jul-13		01-Aug-13	
Stage I Nursery	Test result	Clinical observation	Test result	Clinical observation	Test result	Clinical observation	Test result	Clinical observation	Test result	Clinical observation	Test result	Clinical observation
Strep					-							
Vibrio			+	deformity	-							
General bacteria			+	deformity	-		+					
VNN												
Monogenea												
Trichodina							+					
Ceratomyxa												
Ciliate												
Cyst												
Heneguya												
Others												
Stage II Nursery												
Strep					-				+		+	darken body
Vibrio	+	ulceration			-				+		+	haemorrhage
General bacteria	+	Blind			-				+		+	
VNN												
Monogenea												
Trichodina	+											
Ceratomyxa												
Ciliate												
Cyst												
Heneguya												
Others										gill fillaments		gill fillaments
Stage I Cage												
Strep												
Vibrio												
General bacteria												
VNN												
Monogenea												
Trichodina												
Ceratomyxa												
Ciliate												
Cyst												
Heneguya												
Others												
Stage II Cage												
Strep												
Vibrio												
General bacteria												
VNN												
Monogenea												
Trichodina												
Ceratomyxa												
Ciliate												
Cyst												
Heneguya												
Others												

	08-Aug-13		16-Aug-13		22-Aug-13		29-Aug-13		05-Sep-13		13-Sep-13	
Stage I Nursery	Test result	Clinical observation	Test result	Clinical observation	Test result	Clinical observation	Test result	Clinical observation	Test result	Clinical observation	Test result	Clinical observation
Strep			+									
Vibrio							+		+			
General bacteria			+				+		+			
VNN												
Monogenea											+	
Trichodina												
Ceratomyxa												
Ciliate												
Cyst												
Heneguya												
Others												
Stage II Nursery												
Strep			+									
Vibrio	+	ulceration			+	drop scale						
General bacteria	+	ulceration	+	ulceration	+	drop scale					+	
VNN												
Monogenea												
Trichodina												
Ceratomyxa												
Ciliate												
Cyst												
Heneguya												
Others												
Stage I Cage												
Strep												
Vibrio												
General bacteria												
VNN												
Monogenea												
Trichodina												
Ceratomyxa												
Ciliate												
Cyst												
Heneguya												
Others												
Stage II Cage												
Strep												
Vibrio												
General bacteria												
VNN												
Monogenea												
Trichodina												
Ceratomyxa												
Ciliate												
Cyst												
Heneguya												
Others												

	20-Sep-13		26-Sep-13		04-Oct-13		22-Nov-13		06-Oct-13		27-Dec-13	
Stage I Nursery	Test result	Clinical observation	Test result	Clinical observation	Test result	Clinical observation	Test result	Clinical observation	Test result	Clinical observation	Test result	Clinical observation
Strep												
Vibrio			+		+		+		+			
General bacteria			+		+		+		+			
VNN												
Monogenea												
Trichodina												
Ceratomyxa												
Ciliate												
Cyst												
Heneguya												
Others												
Stage II Nursery												
Strep												
Vibrio					+							
General bacteria	+	pop eye	+		+							
VNN												
Monogenea												
Trichodina												
Ceratomyxa												
Ciliate												
Cyst											+	
Heneguya												
Others												
Stage I Cage												
Strep												
Vibrio												
General bacteria												
VNN												
Monogenea												
Trichodina												
Ceratomyxa												
Ciliate												
Cyst												
Heneguya												
Others												
Stage II Cage												
Strep												
Vibrio												
General bacteria												
VNN												
Monogenea												
Trichodina												
Ceratomyxa												
Ciliate												
Cyst												
Heneguya												
Others												

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[4] 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

4 "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.

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.

C1 - Data

Data Category	Relevance (Y/N)	Data Quality	Score (0-10)
Industry or production statistics	*Yes*	7.5	7.5
Effluent	Yes	7.5	7.5
Locations/habitats	Yes	7.5	7.5
Predators and wildlife	Yes	7.5	7.5
Chemical use	Yes	10	10
Feed	Yes	10	10
Escapes, animal movements	Yes	10	10
Disease	Yes	10	10
Source of stock	Yes	10	10
Other – (e.g., GHG emissions)	Yes	10	10
Total			**90**

C1 Data Final Score	9	GREEN

C2 - Effluent

Rapid Assessment? No

Factor 2.1a - Biological waste production score

Protein content of feed (%)	45
eFCR	1.35
Fertilizer N input (kg N/ton fish)	9
Protein content of harvested fish (%)	18.5
N content factor (fixed)	*0.16*
N input per ton of fish produced (kg)	106.2
N in each ton of fish harvested (kg)	29.6
Waste N produced per ton of fish (kg)	**76.6**

Factor 2.1b - Production System discharge score

Basic production system score	1

Adjustment 1 (if applicable)	-0.17
Adjustment 2 (if applicable)	-0.2
Adjustment 3 (if applicable)	0
Discharge (Factor 2.1b) score	**0.63**

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

Factor 2.2a - Regulatory or management effectiveness

Question	Scoring	Score
1 - Are effluent regulations or control measures present that are designed for, or are applicable to aquaculture?	Yes	1
2 - Are the control measures applied according to site-specific conditions and/or do they lead to site-specific effluent, biomass or other discharge limits?	Yes	1
3 - Do the control measures address or relate to the cumulative impacts of multiple farms?	Mostly	0.75
4 - Are the limits considered scientifically robust and set according to the ecological status of the receiving waterbody?	Mostly	0.75
5 - Do the control measures cover or prescribe including peak biomass, harvest, sludge disposal, cleaning etc.?	Yes	1
		4.5

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?	Moderately	0.5
3 - Does enforcement cover the entire production cycle (i.e., are peak discharges such as peak biomass, harvest, sludge disposal, cleaning included)?	Yes	1
4 - Does enforcement demonstrably result in compliance with set limits?	Mostly	0.75
5 - Is there evidence of robust penalties for infringements?	Mostly	0.75
		4

F2.2 Score (2.2a*2.2b/2.5)	**7.2**

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

C3 - Habitat

C3.1 Habitat Conversion and Function

F3.1 Score	**7**

C3.2 – Farm siting management effectiveness

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?	Mostly	0.75
		4.5

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.?	Moderately	0.5
5 - Is there evidence that the restrictions or limits defined in the control measures are being achieved?	Moderately	0.5
		3.75

F3.2 Score (2.2a*2.2b/2.5)	**6.75**

C3 Habitat Final Score	**6.92**	**GREEN**
	Critical?	NO

C4 – Chemical Use

Chemical Use parameters	Score	
C4 Chemical Use Score	**7.00**	
C4 Chemical Use Final Score	**7.00**	**GREEN**
Critical?	NO	

C5 - Feed

C5.1 – Wild Fish Use

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

Fishmeal inclusion level (%)	22
Fishmeal from byproducts (%)	2.72
% FM	21.4016
Fish oil inclusion level (%)	8
Fish oil from byproducts (%)	18.75
% FO	6.5
Fishmeal yield (%)	22.5
Fish oil yield (%)	5
eFCR	1.35
FIFO fishmeal	1.28
FIFO fish oil	1.76
Greater of the 2 FIFO scores	1.76
FIFO Score	**5.61**

Factor 5.1b - Source Fishery Sustainability

	Score
SSWF	-2
SSWF Factor	-0.351

F5.1 Wild Fish Use Score	**5.26**

5.2. Net protein Gain or Loss

Protein INPUTS	
Protein content of feed	45
eFCR	1.35
Feed protein from NON-EDIBLE sources (%)	35
Feed protein from EDIBLE CROP sources (%)	65
Protein OUTPUTS	
Protein content of whole harvested fish (%)	18.5
Edible yield of harvested fish (%)	61
Non-edible by-products from harvested fish used for other food production	100
Protein IN	28.19
Protein OUT	18.5
Net protein gain or loss (%)	-34.38337665
Critical?	NO

F5.2 Net protein Score	**6.00**

C5.3 – Feed footprint

Factor 5.3a – Ocean area	Units
Inclusion level of aquatic feed ingredients (%)	30
eFCR	1.35

Average Primary Productivity (C) required for aquatic feed ingredients (ton C/ton fish)	*69.7*
Average ocean productivity for continental shelf areas (ton C/ha)	*2.68*
Ocean area appropriated (ha/ton fish)	10.53

Factor 5.3b – Land area	Units
Inclusion level of crop feed ingredients (%)	38
Inclusion level of land animal products (%)	30
Conversion ratio of crop ingredients to land animal products	*2.88*
eFCR	1.35
Average yield of major feed ingredient crops (t/ha)	*2.64*
Land area appropriated (ha per ton of fish)	0.64

Value (Ocean + Land Area)	**11.17**

F5.3 Feed Footprint Score	**6.00**

C5 Feed Final Score	**5.63**	**YELLOW**
	Critical?	**NO**

The Feed Criterion is Critical if:

- Wild Fish use score is zero
- Net protein gain/loss score is 0, OR
- FI:FO value >3 AND Net Protein score <=1.

C6 - Escapes

C6.1 – Escape of principle farmed species

Factor 6.1a Escape risk score	Score
Escape Risk	**3**
Recapture & Mortality Score (RMS)	
Estimated % recapture rate or direct mortality at the escape site	30
Recapture & Mortality Score	.3
Factor 6.1a Escape Risk Score	**5.1**

Factor 6.1b – Invasiveness	Value (0-10)
Part A	3

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

F 6.1b Score		**7**
Final C6 Score	**6**	**YELLOW**
	Critical?	**NO**

C7 - Disease

C7 – Pathogen and parasite interaction risk	**Score**	
Pathogen and parasite parameters	**Score**	
C7 Biosecurity	5.00	
C7 Disease; pathogen and parasite Final Score	**5.00**	**YELLOW**
Critical?	NO	

C8 – Source of Stock

C8 – Independence from wild capture fisheries	**Value**	
Source of stock parameters		
C8 % of production from hatchery raised broodstock or natural (passive) settlement	100	
C8 Source of stock Final Score	**10**	**GREEN**

C9X Predator and Wildlife Mortalities

Exceptional criterion (i.e., negative score)

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

C9X Predator and Wildlife Final Score =-2 (0-10)

C10X - Escape of unintentionally introduced species

Exceptional criterion (i.e. negative score)

Escape of unintentionally introduced species parameters	**Score**	
F10Xa International or trans-waterbody live animal shipments (%)	0	
F10Xb Biosecurity of source/destination	10.00	
F10X Escape of unintentionally introduced species Final Score	**10.00**	**GREEN**