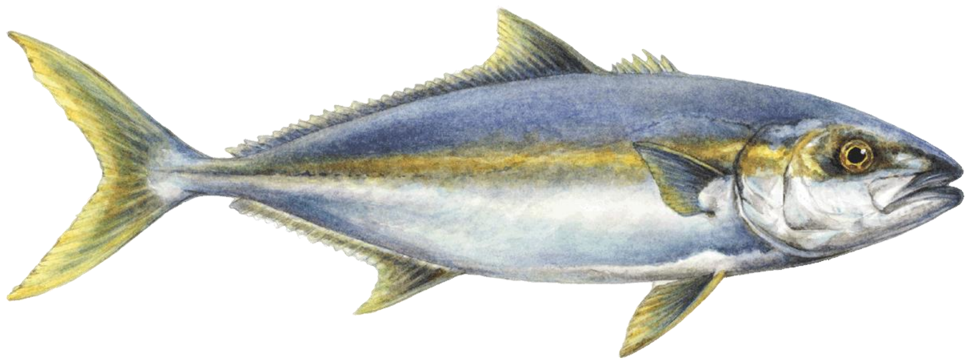
Yellowtail

Seriola spp.



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Japan

Marine Net Pens

Aquaculture Standard Version A2

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Jennifer Gee, Consulting Researcher

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Final Seafood Recommendation

Yellowtail (*Seriola* spp.)

Marine net pens

Japan

Criterion	Score (0-10)	Rank	Critical?
C1 Data	5.00	YELLOW	
C2 Effluent	0.00	CRITICAL	YES
C3 Habitat	5.86	YELLOW	NO
C4 Chemicals	0.00	CRITICAL	YES
C5 Feed	0.08	CRITICAL	YES
C6 Escapes	10.00	GREEN	NO
C7 Disease	2.00	RED	NO
C8 Source	0.00	RED	
C9X Wildlife mortalities	–6.00	YELLOW	NO
C10X Introduced species escape	–8.00	RED	
Total	**8.94**		
Final score	**1.12**		

OVERALL RANKING

Final Score	1.12
Initial rank	RED
Red criteria	6
Interim rank	RED
Critical Criteria?	YES

FINAL RANK
RED

Scoring note: Scores range from 0 to 10 where 0 indicates very poor performance and 10 indicates the aquaculture operations have no significant impact.

Summary

The final numerical score for yellowtail produced in marine net pens in Japan is 1.12, which is in the Red range, and with six Red-ranked criteria (Effluent, Chemicals, Feed, Disease, Source and Introduced Species Escape) and Effluent, Chemicals, and Feed also scoring Critical, the final ranking is Red and a recommendation of “Avoid.”

Executive Summary

This assessment was originally published in December 2016 and reviewed for any significant changes in February 2021.Please see Appendix 2 for details of review.

Japan is the world's largest producer of yellowtail (*Seriola* spp.), while South Korea produces a significantly smaller quantity. Japan is also the main producer of yellowtail imported into the United States, where the species is a popular item for use in sushi and sashimi. From 2003–2013, the Japanese Ministry of Agriculture, Forestry and Fisheries reported production of yellowtail ranging from 100,000 MT to nearly 120,000 MT, with 2012 being the highest-producing year. In 2014, aquaculture production of all *Seriola* spp. in Japan increased significantly to 150,387 MT. This total includes 107,059 MT of *S. quinqueradiata*, 38,770 MT of *S. dumerili*, and 4,558 MT of *S. lalandi*. Although the United States does not report on the import of yellowtail and no country-level data is available, Japan does report on the export of this species. In 2013, it was reported that 5,572 MT were exported to the U.S., an increase over the values for 2011 and 2012 (4,704 MT and 4,872 MT, respectively).

Data: Data for the Japanese yellowtail industry are limited, but through personal communication with an industry expert who provided translations of materials from Japanese, more information became available. This supplemental information marginally improved the confidence in information used to justify scoring, and some peer-reviewed and other public information proved useful. Ultimately, the average data quality assessment was between low to moderate and moderate, and resulted in a final score for Criterion 1 – Data of 5.0 out of 10.

Effluent: The data score for Effluent was not sufficiently high to allow for the Evidence-Based Assessment, so the Risk-based assessment was conducted. Because both extruded and moist pellets are used to feed farmed yellowtail, weighted average values for protein content of feed and FCR were used to determine that there are 152.4 kg of waste nitrogen discharged per ton of production. There appears to be limited scientific robustness to the impact limits set out by the Law to Ensure Sustainable Aquaculture Production, and the law does not specify that monitoring must cover the entire production cycle. The apparent enforcement agency, the Ministry of Agriculture, Forestry and Fisheries, and the regulations it governs, are identifiable. But the lack of evidence of compliance, or penalties for non-compliance, result in a moderately effective control mechanism. Factors 2.1 and 2.2 combine to give a final Criterion 2 – Effluent score of 0 out of 10. Largely driven by a high amount of waste nitrogen released from farm sites and minimal evidence of effective regulation, the final score for Criterion 2 – Effluent is 0 out of 10 and considered Critical.

Habitat: Yellowtail culture occurs in net pens along the coast of Japan. Impacts to the benthic environment and water column from yellowtail culture have been reported, but the nature of the habitat (not sensitive habitat, such as mangroves) and the improvements in impact performance result in a score of 7 out of 10 for Factor 3.1. A system of control at the prefectural level and requirements for EIAs are in place, but there remains uncertainty concerning the effectiveness of enforcement, resulting in a score of 3.575 out of 10 for Factor 3.2. Factors 3.1 and 3.2 combine to result in an overall score of 5.86 out of 10 for Criterion 3 – Habitat.

Chemical Use: Chemical use in Japanese aquaculture falls within the oversight of two laws and is regulated by the Ministry of Agriculture, Forestry and Fisheries for veterinary use. Antibiotics that are approved or reported as being used widely, such as oxytetracycline, florfenicol, and ampicillin, are considered highly or critically important antimicrobials for human health by the World Health Organization. Data on actual usage are absent. Importantly, peer-reviewed literature provides strong evidence of resistance to both ampicillin and oxytetracycline around yellowtail aquaculture sites in Japan, and results in an overall Critical score for Criterion 4 – Chemical Use.

Feed: Feed for yellowtail in Japan consists of a diet of both extruded pellets (EP) and moist pellets (MP). In order to determine the scoring for Criterion 5 – Feed, the scores were determined for both EP and MP, and weighted averages used in the ratio of 67.4% EP and 32.6% MP.

For EP, the FIFO value is 5.90 using an FCR of 2.84. The Factor 5.1 score is Critical due to a FIFO greater than 4. There is an 88.3% net loss of protein, resulting in a Factor 5.2 score of 1 out of 10. Approximately 47.7 hectares of land and ocean are appropriated per ton of fish produced, leading to a Factor 5.3 feed footprint score of 0 out of 10. The final Criterion 5 score for extruded pellets is 0.25 out of 10 and Critical.

For MP, the FCR is an average of 8, which results in a FIFO value of 9.38 due to a combination of both fishmeal and raw/frozen fish being used as ingredients. This value is scored as Critical because the FIFO value is above 4. There is a 92.5% net loss of protein resulting in a Factor 5.2 score of 0 out of 10. Approximately 182.05 hectares of ocean area are appropriated to produce 1 ton of fish, leading to a Factor 5.3 feed footprint score of 0 out of 10. The final Criterion 5 score for moist pellets is 0 out of 10 and Critical.

The weighted average of the extruded pellet and moist pellet scores were used in the final scoring of the feed criterion. Factor 5.1 Wild Fish Use is scored as 0 out of 10, Factor 5.2 Protein Gain/Loss is scored 0.674 out of 10, and Factor 5.3 Feed Footprint is scored as 0 out of 10. These scores lead to a final Criterion 5 score of 0.08 out of 10 and a final ranking of Critical due to the high FIFO value for both types of feed used.

Escapes: The net pen farming systems used to grow yellowtail have an inherently high risk of escape, and with anecdotal evidence suggesting small- and large-scale escapes, the score for Factor 6.1a is 0 out of 10. But because 95%–99% of growout stock are captured from the wild, their escape from farms would not result in any additional competitive or genetic impact than had they remained in the wild. Thus, the final Criterion 6 – Escapes score is 10 out of 10.

Disease: The increasing use of vaccines has helped decrease the occurrence of disease in yellowtail culture, but parasitic and bacterial pathogens still cause frequent diseases that raise serious concerns. The production systems have some biosecurity regulations or protocols in place, yet are still open to introductions and discharge of local pathogens and parasites. Combined with a lack of monitoring or reporting information available, this results in a score of 2 out of 10 for Criterion 7 – Disease.

Source of Stock: Although the life cycle for yellowtail has been closed in commercial hatcheries, the majority of production is still based on the wild capture of juveniles. Anecdotal evidence suggests that 95%–99% of farm stock are wild caught. The final score for Criterion 8 – Source of Stock is 0 of 10.

Wildlife Interactions: Personal communication with an industry expert suggested that interactions between wildlife species and yellowtail aquaculture operations do not result in mortality. But no reporting data are available for verification, and predator control strategies cannot be found in academic or other published literature. As such, it is considered that wildlife mortalities may result from interactions with yellowtail farms in Japan. The final score for Criterion 9X – Wildlife Mortalities is –6 out of –10.

Escape of Unintentionally Introduced Species: Juvenile yellowtail are collected from the wild for rearing in the waters around Japan, but are also imported from other countries, including South Korea, Vietnam, and China. The exact percentage is unknown, but indications suggest a high reliance, perhaps as much as 75% in a given year. The biosecurity of the source is 0 out of 10 (wild-sourced), and the destination (i.e., open net pens) are open to exchange with the surrounding ecosystem. This results in a score of –8 out of –10 for Criterion 10X – Escape of unintentionally introduced species.

Summary

The final numerical score for yellowtail produced in marine net pens in Japan is 1.12, which is in the Red range, and with six Red-ranked criteria (Effluent, Chemicals, Feed, Disease, Source, and Introduced Species Escape) and Effluent, Chemicals, and Feed also scoring Critical, the final ranking is Red and a recommendation of “Avoid.”

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Species
Seriola spp.

Geographic Coverage
Japan

Production Method(s)
Marine net pens

Species Overview

Brief overview of the species
Japanese yellowtail *(S. quinqueradiata)* has a more limited and regional distribution than other species of Seriola and is endemic to the waters around Japan, from the eastern Korean Peninsula to Hawaii. As juveniles, the species congregates around seaweed, and drifts northward while feeding on microorganisms and small fish, eventually becoming highly piscivorous. Maturity is reached between 3 and 5 years (FAO 2005).

The three names used in Japan for the species (Mojako, Hamachi, and Buri) reflect the life stage/size at which they are captured. Mojako are juveniles under 50 g; Hamachi are juveniles between 50-5,000 g; Buri are adults greater than 5,000 g (FAO 2005).

Yellowtail kingfish *(S. lalandi)* and greater amberjack *(S. dumerili)* are the other Seriola species farmed in Japan, and are circumtropical and circumglobal, respectively (including around Japan). *S. lalandi* schools as juveniles in offshore waters, moving to coastal and oceanic waters near kelp beds, reefs, and rocky shores as adults. It reaches reproductive maturity at 2–3 years and feeds on small fish, squid, and crustaceans. *S. dumerili* juveniles can be found either singularly or in small schools around floating plants in oceanic or offshore waters. Maturity is reached at 4 years and, although primarily piscivorous, it also feeds on invertebrates (Nakada 2008).

Production system
The majority of production systems are open net pens (i.e., cages) in marine waters with a small percentage operating as net enclosures (Nakada 2008). This assessment focuses on marine net pen production only. The majority of production is still based on the wild capture of juveniles. In 2008, the Japanese government regulated the number of Mojako that can be captured for rearing in aquaculture, setting the limit at approximately 25 million (Nakada 2008).

Net-pen farms are primarily located in nine prefectures: Kagoshima, Ehime, Ooita, Miyazaki, Nagasaki, Kagawa, Kochi, Kumamoto, and Tokushima (Ministry of Agriculture Forestry and Fisheries, courtesy of Ichiro Nagano, 2015).

Production Statistics

From 2003–2013, the Japanese Ministry of Agriculture, Forestry and Fisheries (pers. comm., Ichiro Nagano 2014) reported production of yellowtail ranging from 100,000 MT to nearly 120,000 MT in 2012. The average annual production was reported as 103,835 MT (pers. comm., Ichiro Nagano 2014). In 2014, aquaculture production of all *Seriola* spp. in Japan was 150,387 MT. This total includes 107,059 MT of *S. quinqueradiata*, 38,770 MT of *S. dumerili*, and 4,558 MT of *S. lalandi* (Sicuro and Luzzana 2016). Three companies and one cooperative organization are responsible for 30% of the total production in Japan (pers. comm., Ichiro Nagano 2014).

Import and Export Sources and Statistics

Although the United States does not report on the import of yellowtail, Japan does report on its production and export of this species to the United States. Globally, Japan produces more than 99% of the commercially reported yellowtail (FAO 2014).

Year of export to U.S.	2011	2012	2013
Quantity (MT)	4,704	4,872	5,572

Source: Jetro Agrotrade Handbook 2014, pp. 317–318 via Ichiro Nagano, personal communication, March 2015

Common and Market Names

Scientific Name	*Seriola quinqueradiata*, *S. lalandi*, *S. dumerili*
Common Name	Yellowtail, Japanese yellowtail, Japanese amberjack *(S. quinqueradiata),* yellowtail kingfish, yellowtail amberjack, gold-striped amberjack *(S. lalandi),* greater amberjack *(S. dumerili)*
United States	Amberjack
Spanish	Medregal del Japón
French	Sériole du Japon
Japanese	Buri, hamachi

Names from (FAO 2005) (Sicuro and Luzzana 2016)

Product forms

The product forms are whole or frozen fillets. The majority of the product is exported to the United States as frozen fillets for use in sushi or sashimi.

Analysis

Scoring guide

- Except for the exceptional criteria 9X and 10X, all scores resulted in a 0 to 10 final score for the criterion and the overall final rank. A 0 score indicates poor performance, while a score of 10 indicates high performance. In contrast, the two exceptional criteria result in negative scores from 0 to –10, and in these cases 0 indicates no negative impact.
- The full Seafood Watch Aquaculture Criteria are available on the Seafood Watch website.
- The full data values and scoring calculations are available in Appendix 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	10	10
Effluent	Yes	5	5
Locations/habitats	Yes	5	5
Chemical use	Yes	2.5	2.5
Feed	Yes	7.5	7.5
Escapes, animal movements	Yes	2.5	2.5
Disease	Yes	2.5	2.5
Source of stock	Yes	7.5	7.5
Predators and wildlife	Yes	2.5	2.5
Other – (e.g. GHG emissions)	No	Not relevant	n/a
Total			**45**

C1 Data Final Score	**5.00**	**YELLOW**

Brief Summary

Data for the Japanese yellowtail industry are limited, but through personal communication with an industry expert who provided translations of materials from Japanese, a larger body of information became available. This supplemental information marginally improved the confidence in information used to justify scoring, and some peer-reviewed and other public information proved useful. Ultimately, the average data quality assessment was between low to moderate and moderate, and resulted in a final score for Criterion 1 – Data of 5.0 out of 10.

Justification of Ranking

Industry/Farm Statistics: Industry or production statistics are very robust and score 10 of 10. They are up to date, within reason, and available in whole form for the entire industry, but also for the major producers, including data for each prefecture. Production quantities and values were also available from the FAO database (FAO 2014) (Jetro Agrotrade Handbook 2014, pp. 317–318 via pers. comm., Ichiro Nagano 2015).

Effluent: Effluent scored 5 of 10, with moderate data availability. Information was not available on the discharge of effluent from farm sites or the industry as a whole, and this prevented the utilization of the Evidence Based Assessment. The Risk-Based Assessment requires the input of data on feed protein content, eFCR, and the design of the production system, and these data were available in the literature (Miura et al. 2014) (Skretting 2015) and provided by an industry expert (pers. comm., Ichiro Nagano 2015). Information was also provided on the regulatory and management framework (pers. comm., Ichiro Nagano 2015).

Habitat: Locations/habitat scored 5 of 10. Basic information was available concerning farm habitats (FAO 2005) and damage that had occurred, particularly to the benthic environment (Yokoyama 2003) (Takeda 2009). Some detailed information is available in Japanese, but extensive data are not available nor does it appear to be collected (Takeda 2009). The laws governing farm siting and the licensing process are clear (Fisheries Law of 1949) (FAO 2004) (Basic Environmental Law 1993). The aquaculture industry in Japan is controlled by regulations at the prefecture level rather than at the national level (Yokoyama 2003), but prefectures do not publish data on enforcement (pers. comm., Ichiro Nagano 2015). The Law to Ensure Sustainable Aquaculture Production was enacted by the Ministry of Aquaculture, Forestry, and Fisheries, with enforcement at the prefecture level. There are no regulations limiting future development size, or monitoring and enforcement efficacy.

Chemical Use: The data for Chemical Use scored 2.5 out of 10. The use of several chemicals listed by the WHO as being critically and highly important for human medicine were reported (Maita 2012) (Wilder 2000) (Yoshimizu et al. 2016) (pers. comm., Ichiro Nagano 2014). Regulations on the use and application of chemicals are set by two laws: Agricultural Chemicals Regulation Law (1948, as amended) and the Pharmaceutical Affairs Law (1960) (FAO 2004); both administered by the Ministry of Health and Welfare and MAFF. However, the actual amounts of chemicals used and treatment frequency are not available, and information is out of date (with the exception of Yoshimizu et al. 2016), reducing the data score.

Feed: The data for Feed scored 7.5 out of 10. Data are available for the mixed use of moist pellets and extruded pellets (pers. comm., Ichiro Nagano 2015). Fishmeal and fish oil inclusion rates and yield rates are also publicly available (Miura et al. 2014) (Statistical yearbook of fish oil 2013, via pers. comm., Ichiro Nagano 2015). Protein compositions were available from an older publication (Torry Research Station 1989) (Hertrampf and Piedad-Pascual 2000), but this information is unlikely to become outdated.

Escapes: The data for the Escapes criterion is poor, and scored 2.5 out of 10. Information about the type of culture structures and improvements to reduce escapes was available (FAO 2004) (Ecosea 2009), but no monitoring or reporting is conducted for escape events (pers. comm., Ichiro Nagano 2015). Information about live animal movement is also limited to personal communication for anything more recent than 2008 (FAO 2005) (Nakada 2008) (pers. comm., Ichiro Nagano 2014).

Disease: Disease data quality received a score of 2.5 out of 10. Some information on the most prevalent diseases is reported and available (FAO 2005) (pers. comm., Ichiro Nagano 2014), but disease occurrence monitoring or reports are not available.

Source of Stock: The data for Source of Stock scored 7.5 out of 10. Between 95% and 99% of the stock is sourced from the wild, and this is widely reported in the literature and confirmed by experts (FAO 2005) (Nakada 2008) (pers. comm., Ichiro Nagano 2014). But there is limited specific information about the origin of the wild stock (domestic vs. imported), and thus does not meet the qualifications for a high data score.

Predator and Wildlife Mortalities: Predators and Wildlife Mortalities received a data score of 0 out of 10. The information used for this data category was limited to personal communication, with no other figures available (pers. comm., Ichiro Nagano 2014).

The final numerical score for Criterion 1 – Data is 5.0 out of 10.

Criterion 2: Effluent

Impact, unit of sustainability and principle

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

Criterion 2 Summary

Risk-Based Assessment

Effluent parameters	Value	Score	
F2.1a Biological waste (nitrogen) production per of fish (kg N ton-1)	190.5		
F2.1b Waste discharged from farm (%)	80		
F2 .1 Waste discharge score (0-10)		0	
F2.2a Content of regulations (0-5)	2.75		
F2.2b Enforcement of regulations (0-5)	1.5		
F2.2 Regulatory or management effectiveness score (0-10)		1.65	
C2 Effluent Final Score		**0.00**	**CRITICAL**
Critical?	YES		

Brief Summary

The data score for Effluent was not sufficiently high to allow for the Evidence-Based Assessment, so the Risk-based assessment was conducted. Because both extruded and moist pellets are used to feed farmed yellowtail, weighted average values for protein content of feed and FCR were used to determine that there are 152.4 kg of waste nitrogen discharged per ton of production. There appears to be limited scientific robustness to the impact limits set out by the Law to Ensure Sustainable Aquaculture Production, and the law does not specify that monitoring must cover the entire production cycle. The apparent enforcement agency, the Ministry of Agriculture, Forestry and Fisheries, and the regulations it governs are identifiable, but the lack of evidence of compliance, or penalties for non-compliance, results in a moderately effective control mechanism. Factors 2.1 and 2.2 combine to give a final Criterion 2 – Effluent score of 0 out of 10. Largely driven by a high amount of waste nitrogen released from farm sites and minimal evidence of effective regulation, the final score for Criterion 2 – Effluent is 0 out of 10 and considered Critical.

Justification of Ranking

Factor 2.1 Waste discharged per ton of fish

Factor 2.1a Biological waste production

The feed utilized in the culture of yellowtail is a mixture of extruded pellets (EP) and moist pellets (MP). The protein content of the EP used is 44% (pers. comm., Nagano 2015) (Miura et al. 2014) (Skretting 2015), which combines with an eFCR of 2.84 for nitrogen production of 199.9 kg per ton of yellowtail produced. The protein content of the MP used is 24.95%, calculated using the 12.5% fishmeal (66.5% protein) plus the 70% of MP from raw/frozen fish (average protein of 18.7%) and 12.5% crop ingredients (average protein of 28.4%; pers. comm., Ichiro Nagano 2014). MP use has a higher eFCR of 8 and results in 282.88 kg per ton of yellowtail produced (pers. comm., Nagano 2015).

	Quantity (MT)	% of feed	FCR	Yellowtail production (MT)	% of production
EP	233,042	42.4%	2.84	82,057	67.4%
MP	317,081	57.6%	8.00	39,635	32.6%
Raw/Frozen (70% of MP)	221,957				
Total	**550,123**			**121,692**	

Table 1: Pelleted feed proportions—highlighted cells contain information from Japanese Ministry of Agriculture, Forestry and Fisheries 2012 (via pers. comm, Nagano 2015)

The protein content of whole harvested yellowtail was reported as 22.8% in a dated publication (Torry Research Station 1989), but more recent information was not available in the literature and this value is not likely to vary markedly, so this value was retained and reduces each nitrogen output by 36.48 kg per ton of production.

Using the calculated proportions of production by feed type from Table 1 (67.4% EP, 32.6% MP) a weighted average of nitrogen output is calculated at 190.5 kg of nitrogen per ton of yellowtail produced.

2.1b Production system discharge

The production of yellowtail in Japan is conducted with open net pen systems resulting in a production System Discharge score of 0.8 (80% waste discharged, or 152.41 kg nitrogen per ton of fish produced).

Factor 2.2 Management of farm-level and cumulative effluent

Factor 2.2a Regulatory or management effectiveness

Primarily, the aquaculture industry in Japan is under the umbrella of two long-standing laws: the Fisheries Law (1949, revised in 1962) and the Fisheries Cooperative Association Law (1948) (FAO 2004). Most specifically, the Law to Ensure Sustainable Aquaculture Production (1999) was created to address environmental deterioration around fish farms (FAO 2004) by the Ministry of Agriculture, Forestry and Fisheries (MAFF). In 2004, it was reported that 85% of finfish aquaculture sites are covered under the Aquaculture Ground Improvement Program (Takeda 2004) that falls under the Law to Ensure Sustainable Aquaculture Production.

The Fisheries Law grants demarcated rights for aquaculture operations in specific areas, which are generally valid for 5-year periods (FAO 2004). These rights are granted to Fisheries Cooperative Associations (FCA) through the relevant prefecture government. The construction of new structures or alterations to habitat are subject to Environmental Impact Assessment (EIA) under the Basic Environmental Law (1993). The law does not specifically address aquaculture sites, but if an aquaculture project triggered the need for an EIA, the project would then be subject to further ordinances (FAO 2004). But it is not clear what aquaculture project would trigger an EIA. There are effluent limits outlined by the 1999 Law to Ensure Sustainable Aquaculture Production, but are generalized and not set according to site (FAO 2004) (Yokoyama 2003).

The rights granted by the prefecture government to FCAs include two categories: special demarcated fisheries rights and demarcated fishery rights (FAO 2004). Special demarcated fisheries rights are granted in the case of multiple operators wanting to engage in aquaculture in an area that is sheltered and is therefore pollution-prone. The rights require that the activities be managed to take into account all activity and the total impact. But not all areas are covered by these regulations—only the highest risk areas. Demarcated rights are granted only for the operation of pond culture and do not apply in this assessment.

The Law to Ensure Sustainable Aquaculture Production (FAO 2004) (Yokoyama 2003) set out three indicators (dissolved oxygen, acid volatile sulfide content, and occurrence of microfauna under the fish cages) with acceptable thresholds and critical values being established.

Indicator	Criteria for Identifying Healthy Farms	Criteria for Identifying Critical Farms
Dissolved oxygen	> 4.0 ml/L	< 2.5 ml/L
Sulfide	Less than the value at the point where the benthic oxygen uptake rate is maximum	> 2.5mg/g dry sediment
Benthos	Occurrence of macrobenthos throughout the year	Azoic conditions for > 6 months

Table adapted from Yokoyama 2003.

The limits were set based on scientific studies carried out to support the new regulations (Yokoyama 2003), but a call for improvement of these ranges was made more than a decade ago (Yokoyama 2003) and it is unclear if changes have been made. Further, the presence of macrofauna is the only factor requested, but the importance of diversity is not included.

The Law to Ensure Sustainable Aquaculture Production (FAO 2004) (Yokoyama 2003) does not spell out specifically that monitoring must occur throughout the production cycle, nor be conducted at peak biomass or other times. Although monitoring is supposed to be continuous, the lack of a clearly defined schedule results in a moderately effective control mechanism.

There are specific regulations and control measures for the aquaculture industry in Japan, but they only part;y address site-specific effluent limits through the monitoring and (potential) EIA assessment. Factor 2.2a 1 and 2 score “Yes” (1) and “Partly” (0.25) respectively. The impacts of multiple farms are considered in management for high-risk, pollution-prone areas, but not all farming is subject to cumulative impact management. Factor 2.2a 3 scores “Mostly” (0.75). Specific indicators are monitored for certain thresholds, but are dated and may no longer be considered scientifically robust. No monitoring schedule is defined, but it is expected to be continuous, and so capture all points of the production cycle. Factors 2.2a 4 and 5 score “Partly” (0.25) and “Moderately” (0.5), respectively. In summary, the final score for the factors in 2.2a is 2.75 of 5.

<u>Factor 2.2b Enforcement level of effluent regulations or management</u>
The enforcement of the regulations is set at the prefecture government level, and this is aligned with the scale of the industry (FAO 2004) (Yokoyama 2003). The Law to Ensure Sustainable Aquaculture Production was enacted by the Ministry of Aquaculture, Forestry, and Fisheries (MAFF). It states that fisheries cooperatives should put in place the Aquaculture Ground Improvement Program, but this is a voluntary measure. But if a cooperative has not enacted the Ground Improvement Program and the environment around the farm sites is found to be degraded, the prefectural governor may enforce the use of the Ground Improvement (Yokoyama 2003). If the cooperative does not follow the program, the governor may then make their environmental status public (Yokoyama 2003).

The Law to Ensure Sustainable Aquaculture Production (FAO 2004) (Yokoyama 2003) does not spell out specifically that monitoring must occur throughout the production cycle, nor be conducted at peak biomass or other times. As with monitoring, the enforcement is supposed to be continuous but there is no clear definition of a schedule or specific requirements. But no monitoring data were available in the literature surveyed, including that which discussed the rules, regulations, and management bodies, and no other evidence could be found to demonstrate active enforcement (FAO 2004) (Yokoyama 2003) (Takeda 2009). Similarly, surveyed literature also contained no evidence of compliance with set effluent limits or penalties for infringements (Takeda 2009) (FAO 2004) (Yokoyama 2003).

The prefecture government is clearly identified and can be contacted, resulting in a “Yes” score (1) for 2.2b 1. Enforcement of effluent monitoring is supposed to be continuous, but the lack of a clearly defined schedule results in a score of “Moderately” (0.5) for 2.2b 3. Without evidence of monitoring data, compliance with set limits, or penalties for infringements, the remaining questions in factor 2.2b all scored “No” (0). The final score for the factors in 2.2b is 1.5 of 5.

The final combined score for Factor 2.2 is 1.65 of 10.

Conclusions and Final Score

Yellowtail are fed both extruded and moist pelleted feed, and a weighted average of these determined that there are 152.4 kg of waste nitrogen discharged per ton of production. The limits to impacts set out by the Law to Ensure Sustainable Aquaculture Production are based on a narrow and dated scope of science, and the law does not specify that monitoring cover the entire production cycle. The lack of clearly defined monitoring schedule and a lack of evidence for compliance, or penalties for non-compliance, result in a moderately effective control mechanism. Factors 2.1 and 2.2 combine to give a final Criterion 2 – Effluent score of 0 out of 10.

Criterion 3: Habitat

Impact, unit of sustainability and principle

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

Criterion 3 Summary

Habitat parameters	Value	Score	
F3.1 Habitat conversion and function		7.00	
F3.2a Content of habitat regulations	2.75		
F3.2b Enforcement of habitat regulations	3.25		
F3.2 Regulatory or management effectiveness score		3.58	
C3 Habitat Final Score		**5.86**	**YELLOW**
Critical?	NO		

Brief Summary

Yellowtail culture occurs in net pens along the coastline of Japan. Impacts to the benthic environment and water column from yellowtail culture have been reported, but the nature of the habitat (not sensitive habitat, such as mangroves) and the improvements in impact performance results in a score of 7 out of 10 for Factor 3.1. A system of control at the prefectural level and requirements for EIAs are in place, but there remains uncertainty around the effectiveness of enforcement, resulting in a score of 3.575 out of 10 for Factor 3.2. Factors 3.1 and 3.2 combine to result in an overall score of 5.86 out of 10 for Criterion 3 – Habitat.

Justification of Ranking

Factor 3.1. Habitat conversion and function

Yellowtail culture occurs in net pens along the coastline of Japan (FAO 2005). The infrastructure of net pens typically results in little direct impact to the habitat in which they are sited; however, physical, chemical, and biological impacts to the benthos may occur through deposition of uneaten feed, fish waste, and other particulate matter. Impacts to the benthic environment from yellowtail culture have been reported (e.g., (Takeda 2009) (Yokoyama 2003) (Yokoyama 2010)). The most common impacts of yellowtail aquaculture include organic enrichment of sediment below net pens, deoxygenation of seawater near the bottom, and occurrence of sulfides (Yokoyama 2010).

The Law to Ensure Sustainable Aquaculture Production was established in 1999, which required the development of guidelines to ensure sustainable utilization of aquaculture grounds with criteria regarding:

1. Water quality
2. Sediment condition on the bottom of aquaculture grounds
3. Health condition of cultured fish, including mortality rate of cultured fish by diseases (Takeda 2009)

As of 2009, almost 85% of Japan's fish aquaculture was conducted in waters where the aquaculture ground improvement program had been established. Compliance with this program has resulted in a substantial decrease in the acid volatile sulfide in the sediments under net pen farms (Takeda 2009). The details of the ground improvement program (i.e., what methods are used, specific information pertaining to yellowtail farms) were not available, but research of other carnivorous finfish species indicates that benthic impacts are reversible if fallowing is done properly (Kelley et al. 2015) (Morata et al. 2014).

Evidence suggests that rapid and unmanaged growth of finfish aquaculture in Japan (of which yellowtail has dominated) resulted in eutrophication and pollution of coastal habitats (Yokoyama 2003) (Takeda 2009). But it appears control measures have improved ecological conditions, and the surveyed literature does not demonstrate evidence of continued habitat functionality loss. Without further data to prove the maintenance of full ecological functionality, the numerical score for Factor 3.1 is 7 out of 10.

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

<u>Factor 3.2a Regulatory or management effectiveness</u>

The Fisheries Law (1949) grants demarcated rights for aquaculture operations in specific areas, which are generally valid for 5-year periods (FAO 2004). These rights are granted to Fisheries Cooperative Associations (FCA) through the relevant prefectural government. The construction of new structures or alterations to habitat is subject to Environmental Impact Assessment (EIA) under the Basic Environmental Law (1993). The law does not specifically address aquaculture sites, but if a proposed aquaculture project triggered the need for an EIA, the project would then be subject to further ordinances (FAO 2004). The law mandates that the EIA results must be taken into consideration when determining the approval or rejection of a proposed project. The FCAs themselves are responsible for the evaluating the need for an EIA, but importantly, the content of the requirements are unknown.

The aquaculture industry in Japan is regulated at the prefectural level, rather than at the national level (Yokoyama 2003). Within each prefecture, the industry is regulated for the number of farms. The demarcated rights granted by the prefectural government to FCAs include two categories: special demarcated fisheries rights and demarcated fishery rights (FAO 2004). Special demarcated fisheries rights are granted in the case of multiple operators wanting to engage in aquaculture in an area that is sheltered and is therefore pollution-prone. The rights require that the activities be managed to take into account all activity and the total impact. Thus, the impacts of multiple farms are managed together in high-risk areas, but this cumulative approach does not necessarily extend to the industry as a whole or areas where it is not considered pollution-prone.

No specific limits to future expansion were reported in the literature surveyed (FAO 2004) (Yokoyama 2003) (Takeda 2009), but the (potential) requirement for EIAs, special demarcated rights, and the enactment of the Law to Ensure Sustainable Aquaculture Production indicate that this is likely. Information about avoidance of high-value habitats was also unavailable. Because net pens are not typically sited in high-value habitats, it is not likely that such habitats are significantly affected by the yellowtail aquaculture industry. In the event that a site has become deteriorated, the prefectural governor can recommend that the FCA responsible undertake measures necessary to improve it (Yokoyama 2003). The details about what is considered deterioration or what methods are recommended are not available.

FCAs are required to govern aquaculture grounds in a sustainable manner, but without further details about management or environmental impact assessment requirements, Factor 3.2a 1 scores “Moderately” (0.5). Similarly, although high-risk areas are governed collectively and the Law to Ensure Sustainable Aquaculture Production contains basic guidelines to direct the industry, without more detail regarding cumulative impact management and future expansion, Factors 3.2a 2 and 3 score “Moderately” (0.5). Since net pen farms aren’t typically sited in high value habitats, the score for 3.2a 4 is “Mostly” (0.75), and because the aquaculture ground improvement program has resulted in a reversal of some historically observed benthic impacts, 3.2a 5 is scored “Moderately” (0.5). The final score calculated for F3.2a was 2.75 of 5.

<u>F3.2b Siting regulatory or management enforcement</u>
The enforcement of the regulations is set at the prefectural government level, and this is aligned with the scale of the industry (FAO 2004) (Yokoyama 2003). The Ministry of Aquaculture, Forestry, and Fisheries (MAFF) enacted the Law to Ensure Sustainable Aquaculture Production. Under this law, Fisheries Cooperative Associations (which are granted rights to aquaculture grounds) are the main mechanism for environmental management and monitoring and putting in place appropriate local regulations, with the prefectural government’s authorization.

Within each prefecture, the industry is regulated according to the number of farms. Special demarcated fisheries rights are granted by the prefectural government to FCAs in the case of multiple operators wanting to engage in aquaculture in an area that is sheltered, and is therefore pollution-prone (FAO 2004). The farms in these areas are managed together to ensure continuing ecosystem functionality and to regulate their cumulative impact. Aquaculture projects may only proceed under these conditions, and this control on the process means that siting is carried out under the EIA control measures, when applicable.

The Law to Ensure Sustainable Aquaculture Production states that FCAs should put in place the Aquaculture Ground Improvement Program, but this is a voluntary measure. If a cooperative has not enacted the Ground Improvement Program and the environment around the farm sites is found to be degraded, the prefectural governor (Yokoyama 2003) may enforce the use of the Ground Improvement. If the cooperative does not follow the program, the governor may then make their environmental status public (Yokoyama 2003). But the enforcement process is not transparent, and farm sites are only available by number in each prefecture to the public. The EIA reports or other reports of poor environmental performance are only made public as a last measure in a punitive process to control farm adherence to the regulations. In the 2014 fishery white paper released by the Japanese government (MAFF 2014), more than 300 improvement plans by aquaculture area were included. This is an indication that monitoring is being conducted; however, in the literature surveyed, including that which discussed the rules, regulations, and management bodies, no further evidence is available to indicate that the control measures have been achieved (Takeda 2009) (FAO 2004) (Yokoyama 2003).

The prefecture government and FCAs are clearly identifiable, contactable, and appropriate to the size of the industry, resulting in a “Yes” (1) score for factor 3.2b 1. FCAs responsible for aquaculture grounds site and manage farms in a manner that takes into consideration the zone and cumulative impacts within; however, the specific requirements for an EIA are unknown. Factor 3.2b 2 and 3 score “Mostly” (0.75). Factors 3.2b 4 and 5 received scores of “Moderately” (0.5) and “Partly” (0.25), respectively, because of the lack of transparency, except for unresolved poor performances or evidence that control measures are being achieved. Factor 3.2b scores 3.25 of 5.

Factors 3.2a and 3.2b combine to give a score of 3.575 out of 10 for Factor 3.2.

Factors 3.1 and 3.2 combine to give a final Criterion 3 – Habitat numerical score of 5.86 out of 10.

Criterion 4: Evidence or Risk of Chemical Use

Impact, unit of sustainability and principle

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

Criterion 4 Summary

Chemical Use parameters	Score	
C4 Chemical Use Score	**0.00**	
C4 Chemical Use Final Score	**0.00**	**CRITICAL**
Critical?	YES	

Brief Summary

Chemical use in Japanese aquaculture falls within the oversight of two laws and is regulated by the Ministry of Agriculture, Forestry and Fisheries for veterinary use. Antibiotics that are approved or reported as being used widely, such as oxytetracycline, florfenicol, and ampicillin, are considered highly or critically important antimicrobials for human health by the World Health Organization. Data on actual usage are absent. Importantly, peer-reviewed literature provides strong evidence of bacteria resistant to both ampicillin and oxytetracycline around yellowtail aquaculture sites in Japan, and results in an overall Critical score for Criterion 4 – Chemical Use.

Justification of Ranking

The use of chemicals has been steadily decreasing as vaccines have become more prevalent in aquaculture in Japan (Maita 2012). In the 3 years following the start of a vaccination plan in 2005, antibiotic usage in yellowtail farming decreased 90% (Salati 2011). However, the list of chemicals approved for yellowtail aquaculture includes those considered both highly important (oxytetracycline and florfenicol) and critically important for human medicine as determined by the World Health Organization (WHO) (amoxicillin, ampicillin, erythromycin, oxolinic acid, josamycin and spiramycin) (Wilder 2000) (Yoshimizu et al. 2016).

The use of chemicals in Japanese aquaculture is governed by two laws: the Agricultural Chemicals Regulation Law (1948, as amended) and the Pharmaceutical Affairs Law (1960) (FAO 2004). The laws are administered by the Ministry of Health and Welfare, but MAFF overseas the application of the law for veterinary drugs, including regulations on prescribed usage (FAO

2004). The use of malachite green is strictly prohibited (pers. comm., Ichiro Nagano 2014). Since 1995, the Fisheries Agency has issued guidance (as opposed to regulations) on the administration, quantities, and withdrawal times for chemicals used in aquaculture production (FAO 2004). While recommended dosages can be found, total usage and frequency of use is not reported in the available literature (Yoshimizu et al. 2016).

Research demonstrates the presence of specific and multidrug-resistant bacteria on yellowtail farms in Japan (Furushita et al. 2005) (Kim et al. 2004) (Nonaka et al. 2007). *Stenotrophomonas maltophilia* is a multidrug-resistant bacterium found on site at a *S. quinqueradiata* farm with resistance to ampicillin, panipenem, cefotaxime, and ceftazidime (Furushita et al. 2005). Of these, only ampicillin is approved for aquaculture use, but is considered critically important to human medicine by the WHO (WHO 2011). Tetracycline-resistant bacteria have also been found to increase in sediment and sea water around yellowtail farms after oxytetracycline treatment (Nonaka et al. 2007). Oxytetracycline is considered highly important to human health by WHO (WHO 2011).

Conclusion and Final Score

Specific data on chemical use at yellowtail farm sites in Japan are lacking, but a wide range of antibiotics is approved for use. Importantly, peer-reviewed literature provides strong evidence of bacteria resistance to both ampicillin and oxytetracycline around yellowtail aquaculture sites. Given that they are considered critically and highly important to human health, respectively, this is an especially serious concern, and necessitates a score of Critical for Criterion 4 – Chemicals.

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

Extruded Pellets

Feed parameters	Value	Score	
F5.1a Fish In: Fish Out ratio (FIFO)	5.90	0.00	
F5.1b Source fishery sustainability score		–6.00	
F5.1: Wild Fish Use		0.00	
F5.2a Protein IN	103.30		
F5.2b Protein OUT	17.44		
F5.2: Net Protein Gain or Loss (%)	–83.1	1	
F5.3: Feed Footprint (hectares)	47.56	0	
C5 Feed Final Score		**0.25**	**CRITICAL**
Critical?	YES		

Moist Pellets

Feed parameters	Value	Score	
F5.1a Fish In: Fish Out ratio (FIFO)	9.38	0.00	
F5.1b Source fishery sustainability score		–6.00	
F5.1: Wild Fish Use		0.00	
F5.2a Protein IN	180.9		
F5.2b Protein OUT	12.08		
F5.2: Net Protein Gain or Loss (%)	–93.3	0	
F5.3: Feed Footprint (hectares)	182.05	0	
C5 Feed Final Score		**0**	**CRITICAL**
Critical?	YES		

Weighted average feed scores used in scoring

Feed parameters	Value	Score	
F5.1a Fish In: Fish Out ratio (FIFO)			
F5.1b Source fishery sustainability score			
F5.1: Wild Fish Use		0	
F5.2a Protein IN			
F5.2b Protein OUT			
F5.2: Net Protein Gain or Loss (%)		0.674	
F5.3: Feed Footprint (hectares)		0	
C5 Feed Final Score		**0.08**	**CRITICAL**
Critical?	YES		

Brief Summary

Feed for yellowtail in Japan consists of both a diet of extruded pellets (EP) and moist pellets (MP). In order to determine the scoring for Criterion 5 – Feed, the feed scores were determined for both EP and MP, and weighted averages used in the ratio of 67.4% EP and 32.6% MP.

For EP, the FIFO value is 5.90 using an FCR of 2.84. The Factor 5.1 score is Critical due to a FIFO greater than 4. There is an 88.3% net loss of protein, resulting in a Factor 5.2 score of 1 out of 10. Approximately 47.7 hectares of land and ocean area are appropriated per ton of fish produced, leading to a Factor 5.3 feed footprint score of 0 out of 10. The final Criterion 5 score for extruded pellets is 0.25 out of 10 and Critical.

For MP, the FCR is an average of 8, which results in a FIFO value of 9.38 due to a combination of both fishmeal and raw/frozen fish being used as ingredients. This value is scored as Critical because the FIFO value is above 4. There is a 92.5% net loss of protein, resulting in a Factor 5.2 score of 0 out of 10. Approximately 182.05 hectares of ocean area are appropriated to produce 1 ton of fish, leading to a Factor 5.3 feed footprint score of 0 out of 10. The final Criterion 5 score for moist pellets is 0 out of 10 and Critical.

The weighted average of the extruded pellet and moist pellet scores were used in the final scoring of the feed criterion. Factor 5.1 Wild Fish Use is scored as 0 out of 10, Factor 5.2 Protein Gain/Loss is scored 0.674 out of 10, and Factor 5.3 Feed Footprint is scored as 0 out of 10. These scores lead to a final Criterion 5 score of 0.08 out of 10 and a final ranking of Critical due to the high FIFO value for both types of feed used.

Justification of Ranking

Yellowtail farmed in Japan are fed both extruded pellets (EP) and moist pellets (MP). In order to determine the scoring for Criterion 5 – Feed, the feed scores were determined for both EP and

MP, and weighted averages used in the ratio of 67.4% EP and 32.6% MP (pers. comm., Nagano 2015) (see Table 1 in Criterion 2 for calculations).

Factor 5.1. Wild Fish Use

<u>Extruded Pellets (EP)</u>

<u>Factor 5.1a Wild Fish Use</u>
The fishmeal inclusion rate for EP is reported to be 55% (pers. comm., Ichiro Nagano 2015). The fishmeal comes primarily from imported sources—namely Peru, Chile, and Ecuador (Statistical yearbook of fish oil 2013, via pers. comm., Ichiro Nagano 2015), and the use of byproducts was reported to be 15% (pers. comm., Ichiro Nagano 2015). A fish oil inclusion rate of 9% was reported consistently from 2008–2012, with approximately 90% of this sourced from byproduct (Statistical yearbook of fish oil 2013, via pers. comm., Ichiro Nagano 2015). Without more specific data, the default yields for fishmeal and fish oil, 22.5% and 5%, respectively, were used. The economic Feed Conversion Ratio (eFCR) for extruded pellets was reported as 2.84 as recently as 2012 (pers. comm., Ichiro Nagano 2015).

Parameter	**Data**
Fishmeal inclusion level	55%
Percentage of fishmeal from byproducts	15%
Fishmeal yield (from wild fish)	22.50%[1]
Fish oil inclusion level	9%
Percentage of fish oil from byproducts	90%
Fish oil yield	5.00%[2]
Economic Feed Conversion Ratio (eFCR)	2.84
Calculated Values	
Fish In : Fish Out ratio (fishmeal)	5.90
Fish In : Fish Out ratio (fish oil)	0.51
Seafood Watch FIFO Score (0-10)	**0 (Critical)**

The FIFO value for fishmeal (5.90) is higher than the value for fish oil (0.51); thus, fishmeal drives the FIFO score of 0 out of 10. With a FIFO value greater than 4 and a zero score, Factor 5.1 is automatically considered Critical.

<u>Factor 5.1b Sustainability of the Source of Wild Fish</u>
For the domestically captured species, TAC and acceptable biological catch are set and reported by the Fisheries Research Agency, Ministry of Agriculture, Forestry and Fisheries (pers. comm.,

[1] 22.5% is a fixed value from the Seafood Watch Aquaculture Standard based on global values of the yield of fishmeal from typical forage fisheries. Yield estimated by Tacon and Metian (2008).
[2] 5% is a fixed value from the Seafood Watch Aquaculture Standard based on global values of the yield of fish oil from typical forage fisheries. Yield estimated by Tacon and Metian (2008).

Ichiro Nagano 2015). But the majority of fishmeal comes from imported sources (Peru, Chile, and Ecuador) (Statistical yearbook of fish oil 2013, via pers. comm., Ichiro Nagano 2015). Without further detail concerning species and stock sustainability, the sources of fishmeal and fish oil are considered of unknown sustainability, and a deduction of –6 out of –10 is applied for the Sustainability of Source of Wild Fish.

Moist Pellets (MP)

Factor 5.1a Wild Fish Use

MP feed contains 12.5% fishmeal, 5% fish oil, and 70% raw/frozen whole fish (pers. comm., Nagano 2015). The same byproduct inclusion rates for EP were applied for MP calculations. The default yield rates for fishmeal and fish oil were used (22.5% and 5%, respectively), while raw/frozen fish are considered entirely used and have a 100% yield rate. The eFCR of MP was reported as 6–10 (pers. comm., Ichiro Nagano 2015), so an average of 8 was used.

Parameter	Fish meal/oil	Whole fish	Added Total
Fishmeal inclusion level	12.5%	70%	
Percentage of fishmeal from byproducts	15%	0%	
Fishmeal yield (from wild fish)	22.50%[3]	100%	
Fish oil inclusion level	5%	0%	
Percentage of fish oil from byproducts	90%	0%	
Fish oil yield	5.00%[4]	N/A	
Economic Feed Conversion Ratio (eFCR)	8	8	
Calculated Values			
Fish In : Fish Out ratio (fishmeal)	3.78	5.6	9.38
Fish In : Fish Out ratio (fish oil)	0.80	N/A	
Seafood Watch FIFO Score (0-10)	**0.55**	**0 (Critical)**	**0 (Critical)**

To calculate the final FIFO score for MP, the FIFO value of fishmeal (higher than fish oil) was added to that of the raw/frozen fish. This results in a FIFO value of 9.93, and a FIFO score of 0. As a FIFO value greater than 4 and a zero score, Factor 5.1 for MP is automatically considered Critical.

Factor 5.1b Sustainability of the Source of Wild Fish

The raw/frozen fish utilized in MP are sourced from domestic fisheries in Japan (pers. comm., Ichiro Nagano 2014).

But the fishmeal and fish oil sources are unknown; therefore, a deduction of –6 out of –10 is applied for the Sustainability of Source of Wild Fish.

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[3] 22.5% is a fixed value from the Seafood Watch Aquaculture Standard based on global values of the yield of fishmeal from typical forage fisheries. Yield estimated by Tacon and Metian (2008).

[4] 5% is a fixed value from the Seafood Watch Aquaculture Standard based on global values of the yield of fish oil from typical forage fisheries. Yield estimated by Tacon and Metian (2008).

Factor 5.1 Weighted Score

Because FIFO values for both EP and MP are greater than 4, and therefore each result in 0 FIFO scores, Factor 5.1 Wild Fish Use is automatically considered to be Critical.

Factor 5.2. Net Protein Gain or Loss

Extruded Pellets (EP)

The EP contains, on average, 44% protein, based on the values from the Skretting Japan Sustain formulation (Miura et al. 2014). Because of a lack of data describing ingredients in EP used for yellowtail, it is assumed that all protein from non-marine ingredients comes from edible crop ingredients. With a 55% inclusion level of fishmeal (15% from byproducts) (pers. comm., Ichiro Nagano 2014), and a fishmeal protein content of 66.5%, it is calculated that the percentage of protein in EP coming from ingredients non-edible to humans is 12.47%. The percentage of protein in EP coming from crop ingredients edible to humans is 17%. The remaining protein in EP comes from fishmeal from edible wild caught fish.

The protein content of whole harvested yellowtail was reported as 22.8% in an older publication (Torry Research Station 1989), but no further information was available in the literature, so this value was retained. The edible yield was reported as 53% edible flesh (Torry Research Station 1989). No information is available describing the percent of non-edible byproducts from harvested, processed farmed yellowtail used for further food production; therefore, it is assumed that 50% are used.

These values lead to a net protein loss of 83.1% and a final Factor 5.2 score of 1 out of 10 for EP.

Parameter	Data
Protein content of feed	44%
Percentage of total protein from non-edible sources (byproducts, etc.)	12.47%
Percentage of protein from edible crop sources	17%
Feed Conversion Ratio	2.84
Protein INPUT per ton of farmed yellowtail	103.3 kg
Protein content of whole harvested yellowtail	22.8%
Edible yield of harvested yellowtail	53%
Percentage of farmed yellowtail byproducts utilized	50%
Utilized **protein OUTPUT** per ton of farmed yellowtail	17.44 kg
Net protein gain	–83.1%
Seafood Watch Score (0–10)	**1**

Moist Pellets (MP)

The MP used in Japan's yellowtail aquaculture are a combination of fishmeal (12.5%), fish oil (5%), and raw/frozen fish (70%).

The raw/frozen fish utilized are sourced from domestic fisheries in Japan (pers. comm., Ichiro Nagano 2014). The likely species used and their respective protein contents are listed in the table below.

Species	Protein content (%)
Sardine	20.2
Horse mackerel	20.0
Chub mackerel	20.0
Blue mackerel	20.0
Pacific saury	21.8
Alaskan saury	21.8
Snow crab	22.4
Japanese common squid	17.9
Average	20.5

Source: Torry Research Station 1989

But protein content of the raw/frozen fish used in MP varies, and 20.5% is a marginally higher average than would be calculated when using alternative protein contents of each of the aforementioned species. For example, protein contents are 17.2% in sardine and sand lance (Satoh 2003, via pers. comm., Nagano) (Satoh 2005, via pers. comm., Nagano), 18.6% in chub and blue mackerel (Satoh 1999, via pers. comm., Nagano) and 18.5% in mackerel and jack mackerel (Verakunpiriya et al. 1996, via pers. comm., Nagano) have all been reported. The average of all protein contents is calculated as 18.7%, and as 70% of the MP, contributes 13.09% of the total protein.

The 12.5% fishmeal content contributes a further 8.25% of the protein to the MP. It is assumed that the fishmeal is sourced from the same fisheries as the EP (15% byproduct) (pers. comm., Nagano), which means that 5.8% of total protein is from byproduct. Since no information is available regarding the ingredients of the remaining 12.5% of the MP, they are assumed to be edible crop.

The protein content of whole harvested yellowtail was reported as 22.8% in a dated publication (Torry Research Station 1989), but no further information was available in the literature and is not believed to vary markedly, so this value was retained. Similarly, the edible yield was reported as 53% edible flesh (Torry Research Station 1989).

These values result in a net protein loss of 93.3% and a final Factor 5.2 score of 0 of 10.

Parameter	Fishmeal	Whole fish	Combined Total
Inclusion rate	12.5%	70%	82.5%
Protein content	66.5%	18.7%	%
Contribution to total protein	8.25%	13.09%	24.95% (includes 3.55% from the 12.5% crop)

Percentage of total protein from non-edible sources (byproducts, etc.)	5.8%		5.8%
Percentage of protein from edible crop sources			12.5%
Feed conversion ratio			8
Protein INPUT per ton of farmed yellowtail			180.9
Protein content of whole harvested yellowtail			22.8%
Edible yield of harvested yellowtail			53%
Percentage of farmed yellowtail byproducts utilized			50%
Utilized protein OUTPUT per ton of farmed yellowtail			17.4
Net protein gain			**–90.4%**
Seafood Watch Score (0–10)	**0**		

Factor 5.2 Weighted Score
The final Factor 5.2 scores are 1 of 10 for extruded pellets and 0 of 10 for moist pellets, resulting in an overall score of 0.67.

Factor 5.3. Feed Footprint

Extruded Pellets
The inclusion level of aquatic feed ingredients (fishmeal and fish oil), including byproducts, is 64%, leading to a value of 47.27 hectares of ocean area appropriated for the production of 1 ton of farmed yellowtail. The inclusion level of crop ingredients is 27%, leading to a value of 0.29 hectares of land appropriated for the production of 1 ton of farmed yellowtail. Combined, the ocean and land area appropriated to produce 1 ton of farmed yellowtail is 47.56 hectares, resulting in a final Factor 5.3 score of 0 out of 10 for EP.

Moist Pellets
The inclusion level of aquatic feed ingredients is 87.5%, leading to 182.05 hectares of ocean appropriated to produce 1 ton of farmed yellowtail. Because there is no further information about the moist pellet feed ingredients, the remaining 12.5% are assumed to be crop ingredients, adding 0.38 hectares of land for a total of 181.43 hectares of primary productivity per ton of fish production. This value for F5.3 leads to a final Factor 5.3 score of 0 of 10.

Factor 5.3 Weighted Score
The final Factor 5.3 scores are 0 of 10 for extruded pellets and 0 of 10 for whole fish feed. The weighted average final Factor 5.3 score is 0 of 10.

Criterion 5 – Feed Final Score

The final score for Criterion 5 – Feed, based on the weighted average scores for Factors 5.1, 5.2, and 5.3, is 0.08 of 10. In addition to being numerically Red, the high FIFO values (> 4) for both feed types used (EP and MP) automatically result in a Critical conservation concern.

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		0.00	
F6.1a Recapture and mortality (%)	0		
F6.1b Invasiveness		10	
C6 Escape Final Score		**10.00**	**GREEN**
Critical?	NO		

Brief Summary

The net pen farming systems used to grow yellowtail have an inherently high risk of escape, and with anecdotal evidence suggesting small- and large-scale escape events occur, the score for Factor 6.1a is 0 out of 10. However, because 95%–99% of growout stock are captured from the wild, their escape from farms would not result in any additional competitive or genetic impact than had they remained in the wild. Thus, the final Criterion 6 – Escapes score is 10 out of 10.

Justification of Ranking

Factor 6.1a. Escape risk

Yellowtail culture in Japan takes place in open net pen structures. The farms are designed with best management practices for design and construction (FAO 2004) and some utilize new materials and technologies (such as chain link mesh) to reduce escapes (Ecosea 2009). But no current details about escape-prevention mechanisms could be found specific to Japanese yellowtail farming, and no public escape reports were available. Escape events regularly occur (pers. comm., Ichiro Nagano 2014), and in the case of extreme weather events such as typhoons, these include large, catastrophic escape events (pers. comm., Ichiro Nagano 2014).

Without further data available regarding escape prevention strategies or actual escape numbers, and with the high likelihood of large-scale escape events, the score for Factor 6.1a is 0 of 10.

Factor 6.1b. Invasiveness

Yellowtail are native to Japan, and the use of wild-caught fish for growout stock (FAO 2005) (Nagano 2008) is still practiced; current estimates put the percentage of farmed yellowtail captured from the wild between 95% and 99% (pers. comm., Ichiro Nagano 2014). The score for Factor 2.2 Part A is 5 out of 5.

Because (nearly) all farmed yellowtail are of wild origin, they would not, upon escape from farm sites, impact their wild conspecfic or heterospecific counterparts by acting as additional competition for food resources, available habitat, or breeding partners, or otherwise impact the ecosystem in ways they would not have had they remained in the wild from the *Mojako* stage. The score for Factor 2.2 Part C is 5 out of 5.

The final score for Factor 6.1b is 10 of 10.

Conclusions and Final Score

Net pen farming systems have an inherently high risk of escape, and with anecdotal evidence suggesting small- and large-scale escape events, the score for Factor 6.1a is 0 out of 10. However, because 95%–99% of growout stock are captured from the wild, their escape from farms would not result in any additional competitive or genetic impact. Thus, the final Criterion 6 – Escapes score is 10 out of 10.

Criterion 7. Disease; pathogen and parasite interactions

Impact, unit of sustainability and principle

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

Criterion 7 Summary

Pathogen and parasite parameters	Score	
C7 Biosecurity	2.00	
C7 Disease; pathogen and parasite Final Score	**2.00**	**RED**
Critical?	**NO**	

Brief Summary

The increasing use of vaccines has helped decrease the occurrence of disease in yellowtail culture, but parasitic and bacterial pathogens still cause frequent diseases that remain serious concerns. The production systems have some biosecurity regulations or protocols in place, yet are still open to introductions and discharge of local pathogens and parasites. Combined with a lack of monitoring or reporting information available, this results in a score of 2 out of 10 for Criterion 7 – Disease.

Justification of Ranking

It is reported that, since 2000, the resources spent on vaccines have increased and those for antibiotics have decreased for yellowtail culture in Japan (Maita 2012), and this has greatly helped reduce the occurrence of diseases (UJNR Japan Panel 2015). Antibiotic use decreased 90% from the start of the vaccination plan in 2005 to 2008 (Salati 2011). The health status of the fish is monitored through visual inspections that assess swimming speed and activity, the shoaling behavior of all of the fish in the pen, as well as fish color (Nakada 2008). Stocking densities are limited and water temperatures closely monitored to anticipate potential times of disease outbreak. This allows for preventative actions such as curtailing feeding, further reducing stocking densities, and removing potentially infected or dead fish (FAO 2005) (Nakada 2008).

Despite on-farm biosecurity measures, yellowtail is susceptible to a number of viral, bacterial, fungal, and parasitic infections. Diseases cause the most mortality at the *Hamachi* and *Buri* stages of development (50–7,000 g) (Nakada 2008). The two primary families of pathogens impacting the yellowtail industry are skin flukes/parasitic worms, such as *Benedenia seriolae*, and bacterial diseases, such as *Nocardia seriolae* (Ozaki et al. 2013) (Imajoh et al. 2015) (pers.

comm., Ichiro Nagano 2014). Despite the development and employment of vaccines, some pathogens continue to be a main cause of morbidity and mortality; *Enterococcus seriolicida* is one example (Nakada 2008) (Salati 2011). Mass mortalities on yellowtail farms have been observed due to skin fluke infections (especially during the warmer season), which are often followed by secondary bacterial infections (Ozaki et al. 2013), as well as encephalomyelitis (associated with *Myxobolus spirosulcatus*) (Shirakashi et al. 2013) (Yokoyama et al. 2010). Other reported diseases are iridovirus (Viral Splenic Virus), pancreatic-hepatic necrosis of amberjack (Yellowtail Ascites Virus), vibriosis, pseudotuberculosis, streptococcus, and fungal infection (FAO 2005).

The Sustainable Aquaculture Production Assurance Act requires that operators must report disease occurrences to the local government. The diseases included in this report are identified as “specified diseases” and refer to “an infectious disease of farm-raised aquatic animals and plants, those are not confirmed to have occurred in Japan or has occurred in only one part of Japan and which is specified by ordinance of the Ministry of Agriculture, Forestry and Fisheries as a disease likely to seriously injure the farm-raised aquatic animals and plants if the disease spreads.” Further, Japan is obliged to report disease occurrence to the OIE (those listed as reportable diseases). However, evidence of disease monitoring and/or reporting was not apparent in the academic literature or government publications reviewed. Similarly, the occurrence and impact of disease transmission between farm fish and their wild counterparts is not widely researched or reported.

Farmed yellowtail is known to experience disease-related mortality. And while farms may have some biosecurity regulations or protocols in place, and there are some requirements for disease reporting, there is no evidence that these strategies and their enforcement are effective. Ultimately, net pen-farmed yellowtail is open to introductions of local pathogens and parasites, and the system is also open to discharge of pathogens.

The final numerical score for Criterion 7 – Disease is 2 out of 10.

Criterion 8. Source of Stock – independence from wild fisheries

Impact, unit of sustainability and principle

- *Impact: the removal of fish from wild populations for on-growing to harvest size in farms*
- *Sustainability unit: wild fish populations*
- *Principle: aquaculture operations use eggs, larvae, or juvenile fish produced from farm-raised broodstocks, use minimal numbers, or source them from demonstrably sustainable fisheries.*

Criterion 8 Summary

Source of stock parameters	Score	
C8 % of production from hatchery-raised broodstock or natural (passive) settlement	0	
C8 Source of stock Final Score	**0.00**	**RED**

Brief Summary

Although the life cycle for yellowtail has been closed in commercial hatcheries, the majority of production is still based on the wild capture of juveniles. Anecdotal evidence suggests that 95%–99% of farm stock are wild caught. The final score for Criterion 8 – Source of Stock is 0 of 10.

Justification of Ranking

Although the life cycle of yellowtail has been closed in commercial hatcheries, the overwhelming majority of production is still based on the capture of wild juveniles (FAO 2005) (Nakada 2008) (Maita 2012) (Stuart and Drawbridge 2012) (pers. comm., Ichiro Nagano 2014), called *Mojako*. Farmers have been noted to prefer to use wild stock, because they have reported that hatchery-sourced stock are more expensive and are too small for successful rearing (Nakada 2008). Taking into account annual fluctuations of hatchery production and wild capture, between 95% and 99% of farm-stocked yellowtail are wild-caught (pers. comm., Ichiro Nagano 2014). The Japanese government caps the capture of wild *Mojako* at 25 million specimens annually, and the number of wild-caught juveniles has decreased in recent years (Nakada 2008). But overall, high production quantities have been maintained and are likely to continue due to import of juveniles from the Republic of Korea, Vietnam, and China (Nakada 2008) (Sicuro and Luzzana 2016).

The near total reliance on wild sources for farm stocked results in a final numerical score for Criterion 8 – Source of Stock of 0 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.

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

Criterion 9X Summary

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

Brief Summary

Personal communication with an industry expert suggested that interactions between wildlife species and yellowtail aquaculture operations do not result in mortality. But no reporting data are available for verification, and predator control strategies cannot be found in academic or other published literature. Therefore, it is considered that wildlife mortalities may result from interactions with yellowtail farms in Japan. The final score for Criterion 9X – Wildlife Mortalities is –6 out of –10.

Justification of Ranking

Personal communication with an industry expert suggested that the only wildlife interactions in yellowtail aquaculture are non-lethal encounters with other fish (pers. comm., Ichiro Nagano 2015); no mammal or turtle interactions are reported, and the siting of farms in inlets reduces the likelihood of interactions with mammals (pers. comm., Ichiro Nagano 2014). But no reporting data are available for verification, and further detail regarding predator control strategies cannot be found in academic or other published literature. Because net pen systems in other regions are known to have wildlife interactions that result in direct and/or incidental mortality (Kemper et al. 2005) (Quick et al. 2004) (Würsig and Gailey 2000), and without evidence to the contrary, it is considered that wildlife mortalities may result from interactions with yellowtail farms in Japan. Thus, the score for Criterion 9X – Wildlife Mortalities is –6 out of –10.

Criterion 10X: Escape of unintentionally introduced species

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

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

Criterion 10X Summary

Escape of unintentionally introduced species parameters	Score	
F10Xa International or trans-waterbody live animal shipments (%)	2.00	
F10Xb Biosecurity of source/destination	0.00	
C10X Escape of unintentionally introduced species Final Score	**-8.00**	**RED**

Brief Summary

Juvenile yellowtail are collected from the wild for rearing in the waters around Japan, but are also imported from other countries including South Korea, Vietnam, and China. The exact percentage is unknown, but indications suggest a high reliance, perhaps as much as 75% in a given year. The biosecurity of the source is 0 out of 10 (wild-sourced), and the destinations (i.e., open net pens) are open to exchange with the surrounding ecosystem. This results in a score of –8 out of –10 for Criterion 10X – Escape of unintentionally introduced species.

Justification of Ranking

Factor 10Xa International or trans-waterbody live animal shipments

Yellowtail culture in Japan is of native species in locations very near their native habitat (FAO 2005). Between 95% and 99% of the farmed yellowtail are wild-caught (pers. comm., Ichiro Nagano 2014). With an annual limit on the number of juveniles that are permitted for capture (25 million), the deficit is made up through imports from the Republic of Korea, Vietnam, and China (Nakada 2008). There have been several occurrences of diseases entering Japan via yellowtail seed importation, including the nematode worm *Anisakis* spp. (from China) and iridovirus (from tropical areas) (Nakada 2008). Although more recent data are not available indicating quantities coming from each country, it is assumed that trans-waterbody shipments of live animals are still occurring at a high rate, because seed stock used in yellowtail aquaculture has ranged from a low of 25 million to as much as 100 million (Nakada 2008). To assign a score for Factor 10Xa, it can be considered that if as many as 100 million fish are stocked for growout, but national Japanese regulations limit capture (in Japanese waters) to 25 million, as much as 75% of growout stock may be imported in any given year. Thus, the score for Factor 10Xa is 2 out of 10.

Factor 10Xb Biosecurity of the source and destination

Because the seed are wild-caught, the source biosecurity score is 0. The biosecurity of the destination (i.e., net pen growout systems) is assigned the same score as for the Escapes criterion, 0 out of 10.

Conclusions and Final Score

Ultimately, there is a high risk of an unintentionally introduced species due to trans-waterbody shipments. The final numerical score for Criterion 10X – Escape of Unintentionally Introduced Species is a negative deduction of –8 out of –10.

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 scores 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 score.

Criterion	Score (0-10)	Rank	Critical?
C1 Data	5.00	YELLOW	
C2 Effluent	0.00	CRITICAL	YES
C3 Habitat	5.86	YELLOW	NO
C4 Chemicals	0.00	CRITICAL	YES
C5 Feed	0.08	CRITICAL	YES
C6 Escapes	10.00	GREEN	NO
C7 Disease	2.00	RED	NO
C8 Source	0.00	RED	
C9X Wildlife mortalities	–6.00	YELLOW	NO
C10X Introduced species escape	–8.00	RED	
Total	**8.94**		
Final score	**1.12**		

OVERALL RANKING

Final Score	1.12
Initial rank	RED
Red criteria	6
Interim rank	RED
Critical Criteria?	YES

FINAL RANK

RED

Acknowledgements

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

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About Seafood Watch®

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

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

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

Disclaimer

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

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Guiding Principles

Seafood Watch defines sustainable seafood as originating from sources, whether fished[5] 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

[5] "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.

Appendix 1 - Data points and all scoring calculations

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

Criterion 1: Data quality and availability

Data Category	Relevance (Y/N)	Data Quality	Score (0-10)
Industry or production statistics	*Yes*	10	10
Effluent	Yes	5	5
Locations/habitats	Yes	5	5
Chemical use	Yes	2.5	2.5
Feed	Yes	7.5	7.5
Escapes, animal movements	Yes	2.5	2.5
Disease	Yes	2.5	2.5
Source of stock	Yes	7.5	7.5
Predators and wildlife	Yes	2.5	2.5
Other – (e.g. GHG emissions)	No	Not relevant	n/a
Total			**45**

C1 Data Final Score	5	YELLOW

Criterion 2: Effluents

Factor 2.1a - Biological waste production score

Protein content of feed (%)	28.95
eFCR	8
Fertilizer N input (kg N/ton fish)	0
Protein content of harvested fish (%)	22.8
N content factor (fixed)	*0.16*
N input per ton of fish produced (kg)	226.98
N in each ton of fish harvested (kg)	36.48
Waste N produced per ton of fish (kg)	**190.50**

Factor 2.1b - Production System discharge score

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

Adjustment 2 (if applicable)	0
Adjustment 3 (if applicable)	0
Discharge (Factor 2.1b) score	**0.8**

8
0 % of the waste produced by the fish is discharged from the farm

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

Factor 2.2a - Regulatory or management effectiveness

Question	Scoring	Score
1 - Are effluent regulations or control measures present that are designed for, or are applicable to aquaculture?	Yes	1
2 - Are the control measures applied according to site-specific conditions and/or do they lead to site-specific effluent, biomass or other discharge limits?	Partly	0.25
3 - Do the control measures address or relate to the cumulative impacts of multiple farms?	Mostly	0.75
4 - Are the limits considered scientifically robust and set according to the ecological status of the receiving water body?	Partly	0.25
5 - Do the control measures cover or prescribe including peak biomass, harvest, sludge disposal, cleaning etc?	Moderately	0.5
		2.75

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?	No	0
3 - Does enforcement cover the entire production cycle (i.e. are peak discharges such as peak biomass, harvest, sludge disposal, cleaning included)?	Moderately	0.5
4 - Does enforcement demonstrably result in compliance with set limits?	No	0
5 - Is there evidence of robust penalties for infringements?	No	0
		1.5

F2.2 Score (2.2a*2.2b/2.5)	**1.65**

C2 Effluent Final Score	0.00	RED
	Critical?	YES

Criterion 3: Habitat

3.1. Habitat conversion and function

F3.1 Score	7

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

Factor 3.2a - Regulatory or management effectiveness

Question	Scoring	Score
1 - Is the farm location, siting and/or licensing process based on ecological principles, including an EIAs requirement for new sites?	Mostly	0.75
2 - Is the industry's total size and concentration based on its cumulative impacts and the maintenance of ecosystem function?	Mostly	0.75
3 – Is the industry's ongoing and future expansion appropriate locations, and thereby preventing the future loss of ecosystem services?	Mostly	0.75
4 - Are high-value habitats being avoided for aquaculture siting? (i.e. avoidance of areas critical to vulnerable wild populations; effective zoning, or compliance with international agreements such as the Ramsar treaty)	Partly	0.25
5 - Do control measures include requirements for the restoration of important or critical habitats or ecosystem services?	Partly	0.25
		2.75

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?	Yes	1
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?	Partly	0.25
		3.75

F3.2 Score (2.2a*2.2b/2.5)	**4.13**

C3 Habitat Final Score	**6.04**	**YELLOW**
	Critical?	NO

Criterion 4: Evidence or Risk of Chemical Use

Chemical Use parameters	**Score**	
C4 Chemical Use Score	**CRITICAL**	
C4 Chemical Use Final Score	**CRITICAL**	**RED**
Critical?	YES	

Criterion 5: Feed – Extruded Pellets (EP)

5.1. Wild Fish Use

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

Fishmeal inclusion level (%)	55
Fishmeal from by-products (%)	15
% FM	46.75
Fish oil inclusion level (%)	9
Fish oil from by-products (%)	90
% FO	0.9
Fishmeal yield (%)	22.5
Fish oil yield (%)	5
eFCR	2.84
FIFO fishmeal	5.90
FIFO fish oil	0.51
Greater of the 2 FIFO scores	5.90
FIFO Score	**0.00**

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

SSWF	-6
SSWF Factor	-3.54

F5.1 Wild Fish Use Score	**0.00**

5.2. Net protein Gain or Loss

Protein INPUTS	
Protein content of feed	44
eFCR	2.84
Feed protein from NON-EDIBLE sources (%)	12.47
Feed protein from EDIBLE CROP soruces (%)	17
Protein OUTPUTS	
Protein content of whole harvested fish (%)	22.8
Edible yield of harvested fish (%)	53
Non-edible by-products from harvested fish used for other food production	0
Protein IN	103.30
Protein OUT	17.44
Net protein gain or loss (%)	-83.1

	Critical?	NO
F5.2 Net protein Score	**1.00**	

5.3. Feed Footprint

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

Inclusion level of aquatic feed ingredients (%)	64
eFCR	2.84
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)	47.27

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

Inclusion level of crop feed ingredients (%)	27
Inclusion level of land animal products (%)	0
Conversion ratio of crop ingredients to land animal products	*2.88*
eFCR	2.84
Average yield of major feed ingredient crops (t/ha)	*2.64*
Land area appropriated (ha per ton of fish)	0.29

Value (Ocean + Land Area)	**47.56**

F5.3 Feed Footprint Score	**0.00**

Criterion 5: Feed – Moist Pellets (MP)

Factor 5.1. Wild Fish Use

Parameter	Fish meal/oil	Whole fish	Added Total
Fishmeal inclusion level	12.5%	70%	
Percentage of fishmeal from byproducts	15%	0%	
Fishmeal yield (from wild fish)	22.50%	100%	
Fish oil inclusion level	5%	0%	
Percentage of fish oil from byproducts	90%	0%	
Fish oil yield	5.00%	N/A	
Economic Feed Conversion Ratio (eFCR)	8	8	
Calculated Values			
Fish In : Fish Out ratio (fishmeal)	3.78	5.6	9.38
Fish In : Fish Out ratio (fish oil)	0.80	N/A	
Seafood Watch FIFO Score (0-10)	**0.55**	**-4.0 (Critical)**	**-13.45 (Critical)**

5.2. Net protein Gain or Loss

Parameter	Fishmeal	Whole fish	Combined Total
Inclusion rate	12.5%	70%	82.5%
Protein content	66.5%	18.7%	%
Contribution to total protein	8.25%	13.09%	24.95% (includes 3.55% from the 12.5% crop)
Percentage of total protein from non-edible sources (byproducts, etc.)	5.8%		5.8%
Percentage of protein from edible crop sources			12.5%
Feed Conversion Ratio			8
Protein INPUT per ton of farmed yellowtail			180.9
Protein content of whole harvested yellowtail			22.8%
Edible yield of harvested yellowtail			53%
Percentage of farmed yellowtail byproducts utilized			50%
Utilized **protein OUTPUT** per ton of farmed yellowtail			17.4
Net protein gain			-90.4%
Seafood Watch Score (0-10)			**0**

5.3. Feed Footprint

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

Inclusion level of aquatic feed ingredients (%)	87.5
eFCR	8
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)	182.05

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

Inclusion level of crop feed ingredients (%)	12.5
Inclusion level of land animal products (%)	0
Conversion ratio of crop ingredients to land animal products	*2.88*
eFCR	8
Average yield of major feed ingredient crops (t/ha)	*2.64*
Land area appropriated (ha per ton of fish)	0.38

Value (Ocean + Land Area)	**181.43**

F5.3 Feed Footprint Score	**0.00**

C5 Feed Final Score	**0.00**	**RED**
	Critical?	**YES**

Criterion 6: Escapes

6.1a. Escape Risk

Escape Risk	**0**

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

6.1b. Invasiveness

Part A – Native species

Score	5

Part B – Non-Native species

Score	0

Part C – Native and Non-native species

Question	Score
Do escapees compete with wild native populations for food or habitat?	No
Do escapees act as additional predation pressure on wild native populations?	No
Do escapees compete with wild native populations for breeding partners or disturb breeding behavior of the same or other species?	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
	5

F 6.1b Score	10

Final C6 Score	10.00	GREEN
	Critical?	NO

Criterion 7: Diseases

Pathogen and parasite parameters	Score	
C7 Biosecurity	2.00	
C7 Disease; pathogen and parasite Final Score	2.00	RED
Critical?	NO	

Criterion 8: Source of Stock

Source of stock parameters	Score	
C8 % of production from hatchery-raised broodstock or natural (passive) settlement	0	
C8 Source of stock Final Score	0	RED

Exceptional Criterion 9X: Wildlife and predator mortalities

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

Exceptional Criterion 10X: Escape of unintentionally introduced species

Escape of unintentionally introduced species parameters	Score	
F10Xa International or trans-waterbody live animal shipments (%)	2.00	
F10Xb Biosecurity of source/destination	0.00	
C10X Escape of unintentionally introduced species Final Score	**-8.00**	**RED**

Appendix 2 – Interim Update

An Interim Update of this assessment was conducted in February 2021. Interim Updates focus on an assessment's limiting (i.e. Critical or Red) criteria (inclusive of a review of the availability and quality of data relevant to those criteria), so this review evaluates Criterion 2 Effluent, Criterion 4 Chemical Use and Criterion 5 Feed. No information was found or received that would suggest the final rating is no longer accurate. No edits were made to the text of the report (except an update note in the Executive Summary). The following text summarizes the findings of the review.

Summary

The key driving factors influencing the red Avoid rating in the 2016 assessment of Japanese *Seriola* production from net pens were Effluent, Chemical Use. and Feed. Each of these criteria received a 'Critical' rating. After reviewing peer reviewed literature published since the 2016 assessment and reaching out to external experts, no significant new information was obtained. Limited peer review literature was readily available to assess the ecological impacts of Japanese *Seriola* production from net pens since 2015.

The previous assessment relied heavily on personal communication with Dr. Ichiro Nagano, an expert of Japanese aquaculture. However, attempts to reach out to him during the review process were unsuccessful. A separate personal communication with an expert in Japanese aquaculture noted the following, but was unable to provide documentation:

- Criterion 2 – Effluent: Impacts from effluent may be reduced over time since Revision of the Fishery Law was completed in December of 2020, though it is not likely improvements have been realized yet.
- Criterion 4 – Chemical Use: the current evaluation is likely still accurate, as this is the biggest barrier to obtaining eco certification in Japanese *Seriola* production.
- Criterion 5 – Feed: the ratio of extruded pellets to moist pellets (2/3 : 1/3) has likely shifted with reduced application of moist pellets across the industry. However, moist pellets are still typically applied at the end of the grow out phase.

As a result, there are insufficient data available to conclusively determine if all of these criteria remain Critical. Therefore, the assessment will be prioritized for a full update and the red Avoid rating from the 2016 assessment remains active in the interim.