Pompano

Trachinotus carolinus and Trachinotus blochii

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United States

Recirculating Aquaculture Systems

Asia and Dominican Republic

Net Pens

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Aaron Welch, Consulting Researcher

Final Seafood Recommendation – Pompano (Recirculating)

Criterion	Score (0-10)	Rank	Critical?
C1 Data	9.38	GREEN	
C2 Effluent	10.00	GREEN	NO
C3 Habitat	9.33	GREEN	NO
C4 Chemicals	10.00	GREEN	NO
C5 Feed	5.09	YELLOW	NO
C6 Escapes	10.00	GREEN	NO
C7 Disease	10.00	GREEN	NO
C8 Source	10.00	GREEN	
3.3X Wildlife mortalities	0.00	GREEN	NO
6.2X Introduced species escape	0.00	GREEN	
Total	**73.80**		
Final score	**9.22**		

OVERALL RANKING

Final Score	9.22
Initial rank	GREEN
Red criteria	0
Interim rank	GREEN
Critical Criteria?	NO
Final Rank	BEST CHOICE

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

Summary

Farmed pompano produced in recirculating tanks receives a high final numerical score of 9.22 and, with no red criteria, receives a final recommendation of green.

Final Seafood Recommendation – Pompano (Net Pens)

Criterion	Score (0-10)	Rank	Critical?
C1 Data	4.00	YELLOW	
C2 Effluent	0.00	RED	YES
C3 Habitat	5.04	YELLOW	NO
C4 Chemicals	5.00	YELLOW	NO
C5 Feed	2.38	RED	NO
C6 Escapes	4.00	YELLOW	NO
C7 Disease	4.00	YELLOW	NO
C8 Source	8.00	GREEN	
3.3X Wildlife mortalities	-2.00	GREEN	NO
6.2X Introduced species escape	-1.80	GREEN	
Total	**28.62**		
Final score	**3.58**		

OVERALL RANKING

Final Score	3.58
Initial rank	YELLOW
Red criteria	2
Interim rank	RED
Critical Criteria?	YES
Final Rank	AVOID

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

Summary

Farmed pompano produced in net pens receives a final numerical score of 3.58, but with two red criteria, one of which is critical, the final recommendation is red.

Executive Summary

Scope*:* This report covers the recirculating and net-pen production of pompano (*Trachinotus spp*.).

Two firms in the U.S., Virginia Cobia Farms, LLC, and AquaGreen, LLC, have begun small-scale production of Florida pompano (*Trachinotus carolinus*) in recirculating aquaculture systems. Production by Virginia Cobia Farms and AquaGreen is still relatively limited and is intended primarily for local markets. Both firms intend to expand production in the coming years.

Most pompano net pen aquaculture is done in Indo-Pacific region countries, especially China, although Vietnam, Malaysia, India, and the Philippines are developing pompano aquaculture as well. In these countries, the leading species being cultured is *Trachinotus blochii*. Total global production of all species of pompano is in excess of 110,000 tons and appears to be growing. A small amount of Asian pompano produced in Indonesia (and perhaps in other countries in the region) is being sold to restaurants and higher end grocery stores in the U.S. Florida pompano is also produced in net-pens in the Dominican Republic for distribution in the Caribbean and U.S.

Recirculating Aquaculture

Data Quality: In most subcategories, the quality of data available on the recirculating aquaculture production of Florida pompano was scored as high, resulting in a final score of 9.38 out of 10.00 and a green rating for this criterion. All recirculating production of pompano is located in the U.S., where aquaculture firms operate in a relatively transparent atmosphere and are subject to a variety of federal, state, and local environmental laws. Moreover, there are currently only two small farms actively involved in U.S. pompano production, making it relatively easy to gather information and assess the industry as a whole. Research institutions within the U.S. involved in pompano work are all very open to inquiry and publish a great deal of peer-reviewed literature on husbandry techniques for the species.

Effluents: The recirculating aquaculture systems currently used to produce Florida pompano in the U.S. are either zero wastewater discharge systems or discharge all waste water into municipal treatment systems according to permit terms. For this reason, the effluent score for recirculating aquaculture production of Florida pompano was given a score of 10 out of 10 and a green rating for this criterion.

Habitat: Recirculating aquaculture production of pompano was judged to have minimal impact on habitat and the provision of ecosystem services. Recirculating facilities do not require the conversion of large amounts of habitat and do not have effluent effects that extend beyond the farm site. Regulatory protections in the U.S. are robust and farms are located in areas considered to be low-value terrestrial habitats according to the SFW scoring criteria. The assessed systems received a score of 9.33 and a green rating for this criterion.
Evidence or Risk of Chemical Use: While there are a small number of drugs approved for use as spawning hormones (such as chorionic gonadotropin), as well as a few low regulatory drugs

(such as sodium chloride) available for use as water quality control agents, the primary drug approved by the Food and Drug Administration (FDA) for use in food-fish pompano aquaculture is formalin. Because formalin is a wide-spectrum antimicrobial agent, it is difficult to use this chemical in recirculating aquaculture systems that rely on biofiltration. Additionally, management at Virginia Cobia Farms and AquaGreen report almost no use of formalin or any other chemicals in their culture systems. The environmental and human health risks associated with excessive or unsafe chemical use in recirculating aquaculture production of pompano were therefore judged to be of very low concern and Criterion 4 received a score of 10 out of 10.

Feed: In recirculating aquaculture in the U.S., pompano production is done using feeds with 4% fish oil (FO) inclusion and 0% fishmeal (FM) inclusion, resulting in a relatively moderate Fish In: Fish Out (FIFO) ratio of 1.60 and an assessed FIFO score of 5.68. Assessed values of 45% crude dietary protein, an eFCR of 2.0, and a whole body protein content of 18%, resulted in an 80.4% net loss of protein at harvest and a feed footprint of 3.19 ha/tFish. These scores resulted in a final score of 5.09 out of 10 and a yellow rating for this criterion.

Escape: The land-based, self-contained nature of recirculating aquaculture systems with no direct connection to marine water bodies results in zero escape risk, resulting in a score of 10 out of 10 and a green rating for this criterion.

Disease, Pathogen, and Parasite Interaction: With no connection to natural water bodies or endemic fish populations, disease, pathogen, and parasite interactions were considered to be of no concern. The assessed systems received a score of 10 out of 10 and a green rating for this criterion.

Source of Stock – Independence from Wild Fisheries: Pompano produced in recirculating systems at Virginia Cobia Farms and AquaGreen are reported to be reared entirely from hatchery-reared broodstock. Larval rearing technologies are well understood and have been under development since the 1970s, indicating that aquaculture production is completely independent of wild populations for broodstock or juveniles. Recirculating aquaculture-based production of pompano thus received a score of 10 out of 10 and a green rating for this criterion.

Net-Pen Aquaculture

Data Quality: In all sub-categories, the quality of data available on net pen production of pompano was scored as moderate or low-moderate leading to a final score of 4 out of 10 for this criterion and a yellow rating. There is reliable peer-reviewed information available on the husbandry practices of the Asian pompano industry, the aquaculture performance of *Trachinotus spp.,* and the environmental impacts of net pen aquaculture generally. This information is available in a variety of scientific journals, trade and professional magazines, and from international monitoring agencies such as the United Nations Food and Agriculture Organization. Specific national and farm-level data, however, is difficult to obtain.

Effluents: With high protein feed and a high feed conversion ratio, the estimated amount of nitrogenous waste produced by pompano in net pen systems is substantial (133.2 kgN/tFish), and the open nature of the net pens means that this waste is discharged directly into surrounding waters. The regulatory control and monitoring capabilities of regional governments with respect to siting and control of effluent impacts appear to be improving, but seem nonetheless weak at the present time. These regulatory limitations, along with the relatively high estimated amount of nitrogen waste generation, led to a final score of 0 out of 10 and a critical rating.

Habitat: While there are encouraging trends in aquaculture regulation and monitoring across the region, there is still a large body of evidence that suggests that aquaculture development in the Indo-Pacific region has the potential to affect natural habitats in a negative way and is poorly regulated and monitored. Additionally, the permitting processes that have arisen in many Indo-Pacific countries lack transparency and make it difficult to assess the regulatory realities for aquaculture in the region. The combination of these factors led to a score of 5.04 out of 10 and a yellow rating for the habitat effects of net pen based pompano aquaculture.

Evidence or Risk of Chemical Use: While there is no specific evidence of chemical use practices in net-pen pompano aquaculture that endanger human health or damage the environment, and while food safety systems in many Asian countries (including China) appear to be improving, the aquaculture industry in the Indo-Pacific region has a history of aggressive, unregulated, and non-transparent use of antibiotics and other therapeutics. Given this history, and given the considerable environmental and human health concerns associated with improper use of chemicals in aquaculture, a precautionary approach should be adopted for this impact category, which leads to the conclusion that there is some risk from chemical use associated with net pen farmed pompano. This criterion received a final score of 5 out of 10 and a yellow rating.

Feed: While inclusion rates for net-pen pompano feeds appear to vary widely, 25% FM and 5% FO were chosen as representative of the net pen industry. These levels resulted in an assessed FIFO value of 2.50 and an assessed FIFO score of 2.25, with estimated crude dietary protein levels of 45%, an eFCR of 2.25 and a whole body protein content of 18%, resulting in an 86% net loss of protein at harvest and a feed footprint of 15.61 ha per ton of fish harvested. The scores resulted in a final score of 2.38 out of 10 and a red rating for this criterion.

Escape: The escape factor received a score of 4 out of 10 and was therefore scored yellow for net-pen pompano aquaculture. There is no evidence that best management practices designed to lessen the risk of escape are utilized on an industry-wide basis. Net pen reared pompano, however, are native to their respective regions (*T. carolinus* in the Dominican Republic and *T. blochii* in the Indo-Pacific region) and there are no reports of negative ecological effects occurring due to farmed pompano escapism, which mitigates the invasiveness factor.

Disease, Pathogen, and Parasite Interaction: Net-pen systems have inherent biosecurity limitations due to their openness to surrounding waters. This, combined with evidence of weak biosecurity practices in the Indo-Pacific region hatcheries, led to a score of 4 out of 10 and a yellow rating for this criterion.

Source of Stock – Independence from Wild Fisheries: There are no reports that Asian pompano production is currently reliant on wild seed. Hatchery technology for pompano has been transferred throughout the Indo-Pacific region. Because the techniques for captive spawning and larval rearing of pompano are relatively new to some countries, it was assessed that 10%–20% of the available Asian pompano seed was not more than one generation from the wild, resulting in a score of 8 out of 10 and a green rating for this criterion.

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Introduction

Scope of the analysis and ensuing recommendation
Species: *Trachinotus spp*—Species specifically covered in this report include 1) the Florida pompano (*Trachinotus carolinus*) (Linnaeus 1766), and 2) the Asian pompano (*Trachinotus blochii*) (Lacepède, 1801). Other species of the genus *Trachinotus*, such as the longfin pompano (*Trachinotus goreensis*) (Cuvier 1832), the palometa (*Trachinotus goodei*) (Jordan & Everman 1896), and others are produced in Asia and are also considered in this report where appropriate.

Geographic coverage: United States, Dominican Republic, and Asia (including China and India).

Production Methods: *Recirculating Aquaculture*—In the U.S., production of Florida pompano is done in recirculating tank aquaculture systems (S. Craig, Low Salinity Inc./Virginia Cobia Farms, personal communication, February – March 2013). In Asia and the Dominican Republic, pompano are produced in floating net pens (Kongeo et al. 2010; LeClerc 2012), although there has been some experimentation with pond systems in the past (e.g. Zhang et al. 2001; CMFRI 2011).

Species Overview
Florida pompano: Florida pompano are a laterally compressed, silver bodied fish of the family Carangidae. They are native to the western Atlantic Ocean and Caribbean Sea, and range as far north as New England and as far south as Brazil (Smith 1997). Florida pompano are a relatively fast growing species. In captivity they are reported to grow to a market size of approximately 500 g in 5 to 7 months (Weirich et al. 2006; LeClerc 2012). In the wild, they have been reported to grow up to 3.6 kg and 63 cm (TL) over a maximum lifespan of 7 years (Murphy et al. 2008). Florida pompano are diurnal predators that feed at low trophic levels, consuming bivalves, crustaceans and other invertebrates (Bellinger and Avault 1971; Patillo et al. 1997; Wheeler et al. 2002). Florida pompano are euryhaline and tolerate a wide variety of environmental conditions, although they are sensitive to cold (Main 2007). These fish are believed to spawn offshore, although spawning in the wild has never been witnessed (Solomon and Tremain 2009).

Asian pompano: The primary species of pompano produced in Asian aquaculture systems is *Trachinotus blochii*. *T. blochii* are similar in appearance to Florida pompano with a laterally compressed, silver body and yellow-tinted anal and caudal fins (Chan et al. 1974). In the Indian Ocean, *T. blochii* have been reported in the Red Sea and off the coast of East Africa. In the Pacific, they have been reported as far north as Japan and as far south as Australia (e.g. Smith-Vaniz 1984; Randall 1986; Letourneur et al. 2004). The ecology of *T. blochii* is relatively less studied than that of *T. carolinus,* at least within the published literature, but the fish are commonly found in the wild at apx 40 cm (Chan et al. 1974) and are reported to grow to a maximum size of 110 cm (Myers 1991). In captivity, T. blochii reaches a marketable size of 400-600 g in approximately 5-10 months (Chou et al. 1997; Seafood Source 2011). Like *T. carolinus*, *T. blochii* is reported to feed primarily on bivalves and other invertebrates and is found in a variety of marine habitats (Lieske and Myers 1994).

Common Names: The Florida pompano (*T. carolinus*) is also known as the common pompano and the Atlantic pompano. Common names for *T. blochii* include Asian pompano, longfin pompano, pampano, snubnose pompano, snubnose dart, silver pompano, golden pompano, shortfin pompano and the American pomfret.

A Note on Nomenclature: *Trachinotus blochii* (Lacepède, 1801) appears to be the dominant species of pompano produced in Asia. There is, however, some confusion surrounding the scientific names used to identify pompano. In China, the aquaculture community often refers to *Trachinotus ovatus* (Linnaeus 1758) (e.g., Gu and Zhou 2009; Niu et al. 2013). This is also the name used by the UN FAO in their statistical databases of aquaculture production in China and the rest of Asia. *T. ovatus* (Linneaus 1758), however, is a distinct species of pompano that is native to the Mediterranean and eastern Atlantic (Tutman 2004; Smith-Vaniz 1986). There is no record of the introduction of *T. ovatus* (Linneaus 1758) into Indo-Pacific waters in the scientific literature, and every visual record of the species in an Asian aquaculture setting that this author has found appears to be of *T. blochii* (Lacepède, 1801). Additionally, this author has shared pictures of specimens of *T. blochii* with Chinese aquaculture researchers who stated that this was the fish they refer to as *T. ovatus*. Further, in the recent past *Trachinotus ovatus* was a synonym commonly used to describe what is now referred to as *Trachinotus blochii* (Lacepède, 1801) (Wheeler 1962; Chan et al. 1974). Because resolution of the question about the taxonomically correct species names is beyond the scope of this report, and in order to avoid dense explanations of the differences in species, all pompanos produced in Asian aquaculture systems will therefore be described as “Asian pompano,” while “Florida pompano” will be used to refer to the species produced in the U.S and the Dominican Republic.

Production and Market Overview

United States: In the U.S., there has been a great deal of experimental work done on aquaculture techniques for the Florida pompano in recent years (e.g Riche 2009; Weirich et al. 2009; Rossi and Davis 2012), but historically there have been few successful commercial operations. This is changing to a limited degree. Two commercial recirculating aquaculture firms, AquaGreen, LLC, located in Perkinston, MS, and Virginia Cobia Farms, LLC, located in Saltville, VA, have begun to establish the infrastructure needed to produce the species, and each company intends to produce 5,000 lbs/month (apx 27 metric tons/year) by the end of 2013, primarily for sale to restaurants. It should be noted that as of this writing AquaGreen is still completing the physical construction of their system. Additionally, Global Sea Farms in the Dominican Republic produced a small amount of Florida pompano in net-pens in 2012 (approximately 15 metric tons) and intends to expand production in 2013 and beyond (LeClerc 2012). The bulk of the Florida pompano on the market in the U.S. is wild caught and comes largely from the state of Florida.

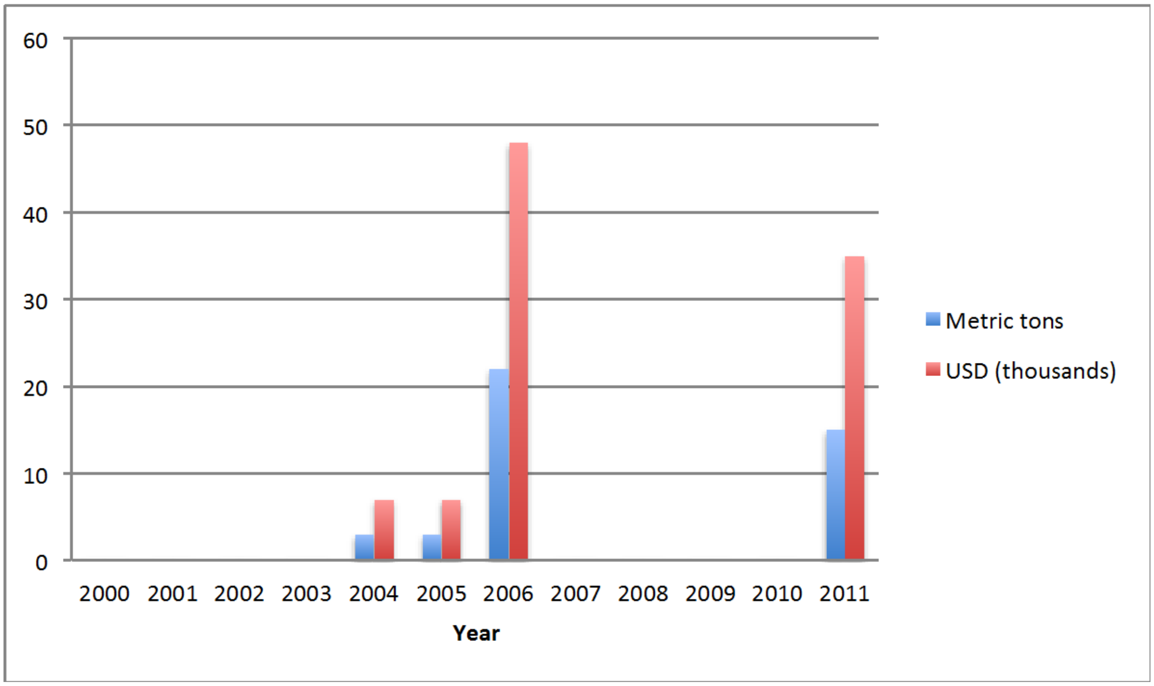

Figure 1: Florida Pompano Production (USA/D.R., Aquaculture). Source: UN FAO (FIGIS DATABASE).

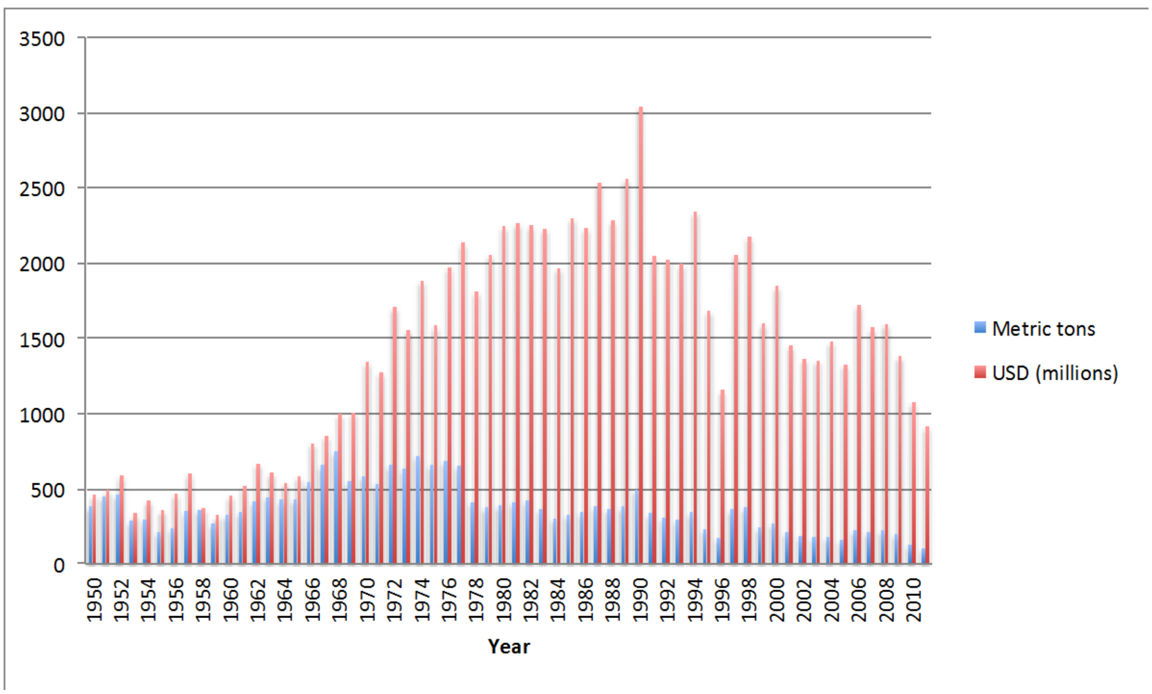

Figure 2:Florida Pompano Production (USA/Wild Caught). Source: NOAA-NMFS (Annual Commercial Landings Statistics).

Asia: Commercial production of Asian pompano (*Trachinotus spp*.) appears to have begun in Asia in the early 1990s in Singapore, with much of the production destined for markets in Hong Kong (Chou 1995; Chou and Lee 1997). By the later part of the 2000s, production had exploded in China (FIGIS 2013), and today is reported to be over 110,000 metric tons annually. In recent years, limited amounts of Asian pompano production has occurred in other Asian countries, including Indonesia (Tsai 2009; B. Olson, Anova Food, personal communication, March 22, 2013), Malaysia (Sim et al. 2004), India (CMFRI 2012), the Phillipines (Fontanilla 2011) and Vietnam (Seafood Source 2011). Production outside of China may be most significant in Vietnam and Indonesia. In Vietnam, approximately 700 tons a year of Asian pompano have been produced by Marine Farms Vietnam (Seafood Source 2011). In Indonesia, approximately 1,000 tons were produced by P.T. Lucky Samudra Pratama in 2012 (B. Olson, Anova Food, personal communication, March 22, 2013). None of the production occurring outside of Singapore, Hong Kong, and China appears to be captured by UN FAO statistics (FIGIS 2013).

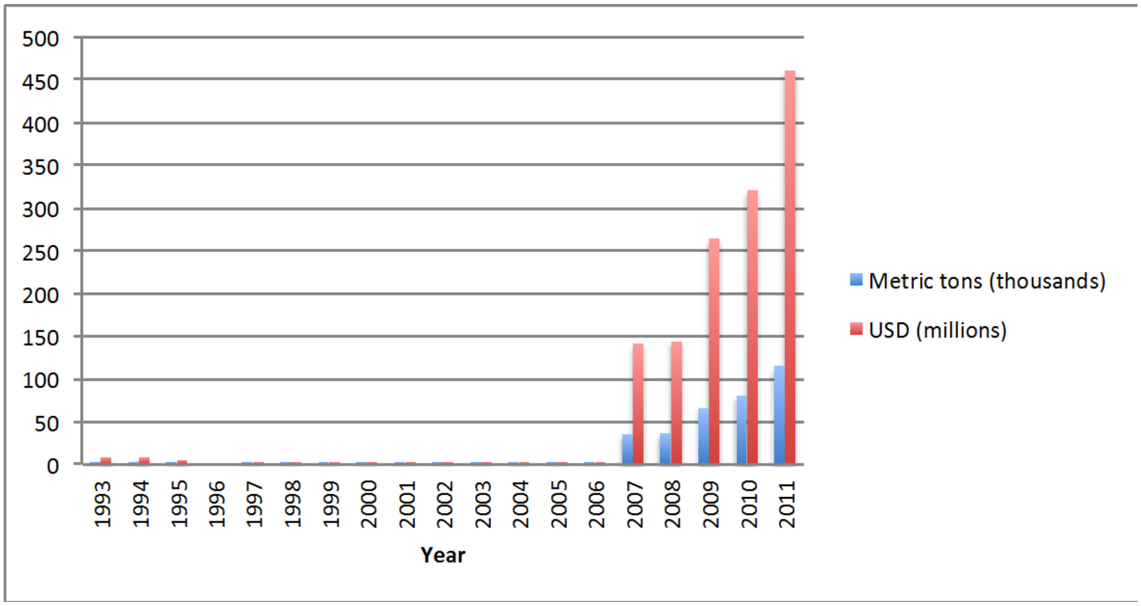

Figure 3: Asian Pompano Production (Aquaculture). Source: UN FAO (FIGIS Database).

Product forms

In the U.S., producers concentrate on the live and whole (fresh) market, primarily for the restaurant trade. Florida pompano can frequently be found on the menu at seafood restaurants throughout the U.S. southeast. Asian pompano is marketed as fillets (frozen), as well as whole and gutted and gilled (fresh). Asian pompano is also sold into the restaurant trade and can be found in a small number of high-end supermarkets in the U.S.

Synthesis

This report covers the recirculating and net-pen production of pompano (*Trachinotus spp*.). Two firms in the U.S., Virginia Cobia Farms, LLC, and AquaGreen, LLC, are beginning to produce small amounts of Florida pompano (*Trachinotus carolinus*) in recirculating aquaculture systems. Production by Virginia Cobia Farms is still relatively limited while AquaGreen is still completing buildout of their system. Both firms intend to produce primarily for local markets and hope to expand production in the coming years. Most net-pen aquaculture of pompano is done in the Indo-Pacific countries, especially China. In these countries, a variety of pompano species are being cultured. Total global production of pompano in net-pens is in excess of 110,000 tons and appears to be growing. The overwhelming majority of pompano production occurs in China, although significant amounts are also produced in Indonesia and Vietnam. Malaysia, the

Philippines, and India are also working with the species. A small amount of Asian pompano is coming to U.S. markets, primarily for restaurants and higher end grocery stores. A small amount of Florida pompano is also produced in net-pens in the Dominican Republic.

Analysis

Scoring Guide

- With the exclusion of the exceptional factors (3.3x and 6.2X), all scores result in a zero to ten final score for the criterion and the overall final rank. A zero score indicates poor performance, while a score of ten indicates high performance. In contrast, the two exceptional factors result in negative scores from zero to minus ten, and in these cases zero indicates no negative impact.
- The full Seafood Watch Aquaculture Criteria that the following scores relate to are available here: http://www.montereybayaquarium.org/cr/cr_seafoodwatch/sfw_aboutsfw.aspx
- The full data values and scoring calculations are available in Annex 1.

Criterion 1: Data Quality and Availability

Impact, unit of sustainability and principle

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

Criterion 1 Summary: Recirculating Aquaculture

Data Category	Relevance (Y/N)	Data Qualit	Score (0-10)
Industry or production stati	Yes	10	10
Effluent	Yes	10	10
Locations/habitats	Yes	10	10
Predators and wildlife	No	Not relevant	n/a
Chemical use	Yes	10	10
Feed	Yes	10	10
Escapes, animal movements	No	Not relevant	n/a
Disease	Yes	7.5	7.5
Source of stock	Yes	10	10
Other – (e.g. GHG emissions	Yes	7.5	7.5
Total			**75**

C1 Data Final Score	9.38	GREEN

In most subcategories, the quality of data available on the recirculating aquaculture production of Florida pompano was scored as high, resulting in a final score of 9.38 out of 10.00 and a green rating for this criterion. All recirculating production of pompano is located in the U.S., where aquaculture firms operate in a relatively transparent atmosphere and are subject to a variety of federal, state, and local environmental laws. Moreover, there are currently only two small farms actively involved in U.S. pompano production, making it relatively easy to gather information and assess the industry as a whole. Research institutions within the U.S. involved in pompano work are all very open to inquiry and publish a great deal of peer-reviewed literature on husbandry techniques for the species.

Justification of Ranking

In most subcategories for this criterion, the quality of data available on the recirculating aquaculture of Florida pompano was scored as “high.” *Production* is located entirely in the U.S. where it is tracked via state and federal reporting systems, such as the USDA’s Census of Agriculture and Census of Aquaculture programs, which are coordinated by both federal and state officials. Additionally, many states (e.g., Florida FWCC 2012) keep detailed and reliable records of wild landings to assist interested parties in understanding overall trends in the market. *Effluent* levels and impacts are also easily ascertained due to relatively rigorous monitoring by local, state, and federal authorities (S. Craig, Low Salinity Inc./Virginia Cobia Farms, personal communication, February – March 2013), and there is a sufficiently large body of published data in the peer-reviewed literature to allow for an effective review of the impacts of *feed* usage and other basic husbandry practices (e.g. Riche and Williams 2009). Finally, data for other subcategories (*chemical use/location/sources of stock*) were considered of high quality because the small and interconnected nature of the pompano aquaculture community in the U.S. allowed for independent verification of claims made by producers. It is also important to note that there is a great deal of peer-reviewed research being done by U.S. institutions, and that the scientific community involved in this research is open to inquiry.

In a few subcategories for this criterion, the quality of data available on the recirculating aquaculture of Florida pompano was less robust and was not scored as “high.” For the *disease* and ‘*other’* categories, data quality was assessed as “high-moderate.” For these categories, the available information is considered reliable, but in the absence of precise farm- level data it was impossible to assess the operation with perfect certainty. Given that Virginia Cobia Farms and AquaGreen are both recirculating, land-based aquaculture facilities located a considerable distance from the ocean, the *predator/wildlife* and the *escape/animal movements* categories were considered not relevant.

Notwithstanding the “high-moderate” scores, the overall combination of data sources and industry attributes resulted in a score of 9.38 out of 10 and a green rating for this section, indicating relatively high data quality and availability.

Criterion 1 Summary: Net Pen Aquaculture

Data Category	Relevance (Y/N)	Data Quali	Score (0-10)
Industry or production stati	Yes	5	5
Effluent	Yes	5	5
Locations/habitats	Yes	2.5	2.5
Predators and wildlife	Yes	2.5	2.5
Chemical use	Yes	2.5	2.5
Feed	Yes	5	5
Escapes, animal movement	Yes	5	5
Disease	Yes	5	5
Source of stock	Yes	5	5
Other – (e.g. GHG emission	Yes	2.5	2.5
Total			**40**

C1 Data Final Score	**4.00**	**YELLOW**

In all sub-categories, the quality of data available on net-pen production of pompano was scored as moderate or low-moderate leading to a final score of 4 out of 10 for this criterion and a yellow rating. There is reliable peer-reviewed information available on the husbandry practices of the Asian pompano industry, the aquaculture performance of *Trachinotus spp.,* and the environmental impacts of net pen aquaculture generally. This information is available in a variety of scientific journals, trade and professional magazines, and from international monitoring agencies such as the United Nations Food and Agriculture Organization. Specific national and farm-level data, however, is difficult to obtain.

Justification of Ranking

Subcategories were scored as "moderate" (5 out of 10) if there was enough useful information available to make reasonable industry-wide estimates, and "low-moderate" (2.5 out of 10) if this was not the case. *Production statistics*, for example, are difficult to locate at the local or national level, and extra-national reporting systems such as the United Nation's Fisheries Global Information System (FIGIS) are reliant entirely on data provided by the national governments. This can be problematic as many suggest that these statistics, especially those provided by the government of China, can be inflated (e.g., Boyd 2008; Pauly 2009). Nonetheless, there are production statistics available for Asian pompano via FIGIS and aquaculture data collection systems operate in many countries in Asia (BFARa 2011; BFARb 2011). Similarly, data on *effluent* and *feed* and their impacts are difficult to come by on a farm-level basis, but there is enough information available in the scientific literature to make reasonable estimates of the effluent impacts and feed usage of a representative net-pen pompano farm (e.g. Islam 2005; Gu and Zhou et al. 2009; Wang et al. 2012; Niu et al. 2013). The combination of "moderate" and "low-moderate" scores for net-pen production of Asian pompano led to a final score of 4.00 out of 10.00 and a yellow rating for this criterion.

Criterion 2: Effluents

Impact, unit of sustainability and principle

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

Criterion 2 Summary: Recirculating Aquaculture

C2 Effluent Final Score	10.00	GREEN

The recirculating aquaculture systems currently used to produce Florida pompano in the U.S. are either zero wastewater discharge systems or discharge all wastewater into municipal treatment systems[1] according to permit terms. For this reason, the effluent score for recirculating aquaculture production of Florida pompano was given a score of 10 out of 10 and a green rating for this criterion.

Criterion 2 Summary: Net-Pen Aquaculture

Effluent parameters	Value	Score	
F2.1a Biological waste (nitrogen) production per of fish (kg N ton-1)	133.2		
F2.1b Waste discharged from farm (%)	80		
F2 .1 Waste discharge score (0-10)		0	
F2.2a Content of regulations (0-5)	1.25		
F2.2b Enforcement of regulations (0-5)	1.25		
F2.2 Regulatory or management effectiveness score (0-10)		0.625	
C2 Effluent Final Score		**0.00**	**RED**
Critical?	YES		

With high protein feed and a high feed conversion ratio, the estimated amount of nitrogenous waste produced by pompano in net-pen systems is substantial (133.2 kgN/tFish), and the open nature of the net-pens means that this waste is discharged directly into surrounding waters. The regulatory control and monitoring capabilities of regional governments with respect to

[1] Virginia Cobia Farms discharges into the Saltville, Virginia, municipal wastewater treatment system. The municipal government in Saltville has recently outsourced operation of its wastewater treatment systems to Veolia Water. Veolia Water is a large multi-national firm that operates wastewater treatment facilities throughout the U.S. Verifying the quality of service provided by Veolia is beyond the scope of this report, especially given that Veolia has only recently assumed responsibility for the operation, however, there are no indications that Veolia is not complying with relevant laws and regulations.

siting and control of effluent impacts appear to be improving, but seem nonetheless weak at present time. These regulatory limitations, along with the relatively high estimated amount of nitrogen waste generation led to a final score of 0 out of 10 and a critical rating.

Justification of Ranking

Factor 2.1a. Biological Waste Production Per Ton of Fish

For Factor 2.1a, biological waste production associated with net-pen aquaculture Net pen production of pompano was estimated to be 133.2 kg nitrogen (N) per ton of fish produced and was calculated as follows:

N input = (Feed protein content (45%)) x (N Content Factor (16%)) x (FCR (2.25)) * (1000) = **162.0 kg N/tFish**

Harvested N = (Whole Body Protein Content (18%)) x (N Content Factor (16%)) x (1000) = **28.8 kg N/tFish**

Waste N (per ton of fish) = (N input (162 kg N)) – (Harvested N (28.8 kg N) = **133.2 kg N/tFish**

The formulas used here are found in the Seafood Watch criteria document on page 8 (Seafood Watch 2013). The values in this calculation were estimated based on published values for feed conversion ratios (FCR), crude protein content of feed, and whole body protein content of the harvested animal (Table 5).

Table 1: References on Feed, FCR, Feed Protein Content, and Whole Body Protein Content

Author/Authority	eFCR	Feed Protein Content	Whole Body Protein Content	Size of Fish in Study
Yan Pers. Comm.	~ 1.5	not reported	not reported	700 to 1000 g (at harvest)
Olson Pers. Comm	~ 2.0 to 2.5	not reported	not reported	800 to 1300 g (at harvest)
Niu et al. 2013	1.28 to 2.07	42.9 to 43.0 %	18.8 to 21.7 %	51 to 82 g
Lin et al. 2013	1.35 to 1.52	46.2 to 47.2 %	16.89 to 17.61 %	53 to 67 g
Wang et al. 2012	1.14 to 1.49	33.5 to 50.0 %	14.8 to 16.9 %	20 to 50 g
CMFRI 2012	~1.8	not reported	not reported	450 to 550 g (at harvest)
Gu and Zhou 2009	1.75 to 1.8	not reported	not reported	450 to 500 g
Lan et al. 2007	2.51 to 2.59	43.0%	not reported	~ 600 g (at harvest)
This Analysis	***2.25***	***45%***	***18%***	***n/a***

The values in table 5 provided the basis for the assumptions made in calculating the effluent production numbers. Because the papers above refer to a wide range of culture systems and locations and to a similarly wide range of sizes (small and large fish) it was not possible to generate an average FCR, feed protein content, or whole body protein content. Instead reasonable estimates from the center of these ranges were chosen. Where there was a question about an appropriate number to choose, the benefit of the doubt was given to the producer, based on the observed tendency of market forces to drive FCRs and other important metrics down over time. Note that this calculation uses economic FCR (eFCR), which is defined as the total amount of feed used in a production cycle divided by the total harvest (wet weight) of fish in a production cycle.

Factor 2.1b. Production System Discharge Score

No literature could be found describing remediation or integrated multi-trophic aquaculture (IMTA) techniques being used in net-pen production systems for pompano that could justify an adjustment to the basic waste N calculated for this analysis. It should be noted that there is at least one pompano farm in the region (P.T. Lucky Samudra Pratama) certified under the AquaGAP program (IMO 2010), which implies they are following best management practices for cage culture (Bio Stiftung Schweiz 2010), including best management practices for effluent mitigation and management. Unfortunately, there is not enough evidence to conclude that these practices are common throughout the industry. In the absence of mitigating factors, the Seafood Watch Aquaculture criteria assume 80% of the waste from open net-pens has the potential to cause impacts beyond the immediate farm site (assessed in Criterion 3 – Habitat below). Given the lack of information or evidence on mitigative or assimilative techniques used in Asian pompano production, the production system discharge score (Factor 2.1b) is 0.8.

The high protein content of the feed, combined with a high FCR leads to high waste production from the fish (Factor 2.1a). When combined with the open nature of the farming system (Factor 2.1b), this results in a score of 0 out of 10 for the waste discharge score (Factor 2.1).

Factor 2.2. Management of Farm-level and Cumulative Impacts and Appropriateness to the Scale of the Industry.

Regulatory control of effluent from net-pen aquaculture production appears to be relatively weak in Asia, which led to uniformly low scores for all the relevant questions in Factor 2.2. There have undoubtedly been some improvements in water quality management in Asia in recent years (Gečeck and Legović 2010; Hosono et al. 2010; 2011), but many problems remain and governments in the region struggle to deal effectively with the environmental problems associated with economic development (e.g., Zhang and Wen 2008). China has been observed to suffer from a variety of water quality problems, especially eutrophication (Gao and Zhang 2010). Net-pen aquaculture, because it is conducted largely in nearshore waters, (e.g., Travaglia et al. 2004; Cao et al. 2007) can exacerbate the problems, contributing additional nutrients to the water column and sediment. These nutrients have been associated with acute environmental problems such as harmful algae blooms and fish kills (White 2009), and with more chronic conditions such as declining seagrass beds (e.g. Delgado et al. 1999; Ruiz et al. 2001; 2010).

Water quality standards in existing law in most countries in the region lack specific aquaculture provisions. In China, Indonesia, and Malaysia, for example, there is no mention of aquaculture in any of the relevant water quality laws (FAO 2013a; 2013b; 2013c). Nor is there a great deal of evidence that governments develop site-specific limits for individual aquaculture operations. Cao et al. (2007:460) mentioned that they were (at the time of their writing) unaware of any studies that "characterized waters receiving aquafarm effluent and waters used by the farms, or have related water quality to farming activity."

Enforcement of effluent limits and the associated monitoring is also challenging in Asia (Phillips et al. 2009). The practice of "cluster farming," where a number of small farmers operate together in a small area due to proximity to a feed mill, access to processing plants, or ready availability of trash fish makes effective regional management of farm-level wastes exceedingly difficult (Boyd 2008). Moreover, most governments in the area are focused on using their limited resources on economic development rather than enforcing environmental standards (Hishamunda et al. 2009; G. Muldoon, WWF Coral Triangle Program, personal communication, March 13, 2013). Due to the generally ineffective management of farm-level and cumulative impacts, this criteria received a score of 0.625 out of 10 and a red rating.

Factor 2.1a, 2.1b, and 2.2. Final Combined Score

This analysis demonstrates that net-pen based aquaculture of pompano produces a relatively high amount of waste and that the industry is not well managed at the farm or cumulative level. The combination of all the scores for all three factors (2.1a, 2.1b, and 2.2) leads to a final score of 0 out 10 and a critical rating.

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: Recirculating Aquaculture

Habitat parameters	Value	Score	
F3.1 Habitat conversion and function		9.00	
F3.2a Content of habitat regulations	5.00		
F3.2b Enforcement of habitat regulations	5.00		
F3.2 Regulatory or management effectiveness score		10.00	
C3 Habitat Final Score		9.33	GREEN
Critical?	NO		

Recirculating aquaculture production of pompano was judged to have "minimal impact" on habitat and the provision of ecosystem services. Recirculating facilities do not require the conversion of large amounts of habitat and do not have effluent effects that extend beyond the farm site. Regulatory protections in the U.S. are robust and farms are located in areas considered to be low-value terrestrial habitats according to the SFW scoring criteria. The assessed systems received a score of 9.33 and a green rating for this criterion.

Justification of Ranking

Factor 3.1. Habitat Conversion and Function

The two farms involved in the recirculating aquaculture production of pompano (Virginia Cobia Farms and AquaGreen) are both located in terrestrial habitat that is considered relatively low value per Seafood Watch criteria (SE U.S. – coniferous forest) (Seafood Watch 2013) and have a minimal physical footprint due to their high-density tank production. Additionally, the pollution impacts of these operations on the surrounding ecosystems are low. Virginia Cobia Farms discharges less than 10% of their culture water per day into the local municipal wastewater system, which is made possible in part by the fact that Saltville, Virginia already has highly saline groundwater. Discharge to the municipal waste water system avoids the deposit of waste directly into natural water bodies and allows Virginia Cobia Farms to operate without a Clean Water Act National Pollutant Discharge Elimination System (NPDES) permit (EPA 2006). AquaGreen's system, which is under construction as of this writing, is being built to be zero discharge and will presumably not require a NPDES permit (S. Craig, Low Salinity Inc./Virginia

Cobia Farms, personal communication, February – March 2013). There are no reports that either Virginia Cobia Farms or AquaGreen have violated the terms of any wastewater permits. These factors led to a final score of 9 out of 10 for Factor 3.1.

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

The regulatory and licensing processes associated with recirculating aquaculture in the U.S. are relatively robust, which led to answers of "yes" on all the management effectiveness and enforcement questions included as part of the Factor 3.2 assessment. Neither Virginia Cobia Farms nor AquaGreen were required to perform an Environmental Impact Assessment (EIA) under the National Environmental Policy Act (NEPA) as part of the approval process for farm siting and licensing, but both were required to meet state and local regulatory conditions, including zoning laws and, in the case of Virginia Cobia Farms, municipal wastewater codes. While the content of some local or state regulations may not always be as rigorous as possible, both farms are highly transparent with their locations, discharge levels, and permitting reports, which means that both farms are relatively easy for any concerned party to monitor. Both operations have their addresses prominently displayed on their websites, including maps. Expansion of the industry is possible, but given the technology intensive nature of these systems and their relatively small physical footprint, it seems highly unlikely that industry expansion would threaten valuable natural habitats. These factors resulted in a final score of 10 out of 10 for this factor.

Factor 3.1 and 3.2. Final Combined Score

The combined scores from Factors 3.1 (9 out of 10) and 3.2 (10 out of 10) led to an overall score of 9.33 out of 10 for this criterion, and a green rating.

Criterion 3 Summary: Net-Pen Aquaculture

Habitat parameters	Value	Score	
F3.1 Habitat conversion and function		7.00	
F3.2a Content of habitat regulations	2.25		
F3.2b Enforcement of habitat regulations	1.25		
F3.2 Regulatory or management effectiveness score		1.13	
C3 Habitat Final Score		5.04	YELLOW
Critical?	NO		

Justification of Ranking

While there are encouraging trends in aquaculture regulation and monitoring across the region, there is still a large body of evidence that suggests that aquaculture development in the Indo-Pacific region has the potential to negatively affect natural habitats and is poorly regulated and monitored. Additionally, the permitting processes that have arisen in many Indo-Pacific countries lack transparency and make it difficult to assess the regulatory realities for aquaculture in the region. The combination of these factors led to a score of 5.04 out of 10 and a yellow rating for the habit effects of net-pen based pompano aquaculture.

Factor 3.1. Habitat Conversion and Function

Most of the net-pen aquaculture in Asia is conducted in coastal inshore regions (e.g. Travaglia et al. 2004; Cao et al. 2007; White 2009). When aquaculture is present in these regions, key ecosystem services continue to be provided to some degree, but they are often degraded within the cages and in the surrounding environment (White 2009). These impacts are due to effluent and nutrient discharges. The nutrient footprints associated with the operation of marine net-pens have been observed in other parts of the world to extend several hundred meters from the cages and can cause negative impacts on natural communities such as seagrass beds (e.g. Delgado et al. 1999; Ruiz et al. 2001; 2010). Additionally, the added nutrient load associated with intensive coastal aquaculture development (including cage aquaculture) has also been linked with increases in local occurrences of eutrophication, fish kills, and harmful blooms throughout Asia (White 2009).

This is not intended to suggest that all net-pen operations in Asia are poorly or carelessly sited. In fact, the Chinese industry has experimented with offshore pompano production in the recent past (Lan et al. 2007) and individual operations throughout the region appear to be sophisticated and thoughtful in their selection of cage locations (e.g. Tsai 2009). Nonetheless, the preponderance of the evidence suggests that regionally, net-pen production of pompano has a moderate impact on habitat conversion and functionality, resulting in a score of 7 out of 10 for Factor 3.1.

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

Habitat and farm siting management effectiveness received scores of moderately to partly effective. This relatively low score is largely due to the history of poor siting decisions and the often uncontrolled expansion of aquaculture that has occurred in parts of the Indo-Pacific region. Governments in the region have been anxious to promote aquaculture as a means of increasing employment, protein supply, income and export volumes (Hishamunda et al. 2009), but plans for managing the environmental results of the industry's expansion have lagged.

As with factor 3.1, the resulting score does not suggest that there is no management of aquaculture development in Asia. In fact, in many ways, management efforts by regional governments appear to be improving, and for this reason many of the specific questions about regulatory or management effectiveness were answered with "moderately," a mid-range score. China, for example, has developed an EIA system that requires new and altered aquaculture facilities to submit detailed environmental reports prior to being permitted, and other nations have similar requirements (although small-scale aquaculture projects are often exempt) (White 2009; FAO 2013a; 2013b; 2013c; 2013d). MPA establishment and other programmatic habitat management efforts (e.g. zoning) are also being undertaken by governments in the region (Balgos 2005; Jakobsen et al. 2007; Lowry et al. 2009; Qiu et al. 2009; White 2009). These efforts have the potential to ensure that the most vulnerable wild populations and places are protected from the uncontrolled expansion of the industry.

Aquaculture development in Asia does not appear to be guided by any long-term vision of habitat protection or ecosystem function (e.g. Qiu et al. 2009) and the industry has experienced a litany of problems associated with over-enthusiastic aquaculture development, including eutrophication, mass fish kills, and harmful algal blooms (Wang et al. 2008; Cruz-Trinidad et al. 2009; Gao and Zhang 2010:387-388). Many of the questions relating to regulatory and management effectiveness were therefore scored as only partly effective. Most obviously, a lack of institutional capacity means that there is often a difference between environmental policy and regulatory practice in many of the nations where net-pen production of pompano occurs (e.g. Weeks et al. 2009; Fabiniyi and Dalabajan 2009). The lack of capacity also manifests itself in poor enforcement of existing regulation (G. Muldoon, WWF Coral Triangle Program, personal communication, March 13, 2013). Moreover, aquaculture siting is a decentralized affair in most Asian nations. In China, Malaysia, Indonesia, and the Philippines, decisions about permitting individual operations are pushed to the provincial, or even village level (Satria and Matsuda 2004; Siry 2006; 2009; 2011; White and San Diego-McGlone 2009). This horizontally structured regulatory system is perhaps more amenable to local input and collaborative management, but it does make the system less transparent with regard to farm locations, sizes, EIA reports, and enforcement measures. The lack of transparency and demonstrated flaws in management and habitat protection led to a score of 1.125 out of 10 for Factor 3.2.

Factor 3.1 and 3.2. Final Combined Score

The relatively good score for Factor 3.1 (7 out of 10) indicates that net-pen aquaculture of pompano is not necessarily highly destructive of habitat, especially if well managed. However, the lower score of 1.125 out of 10 for Factor 3.2 indicates that regulatory authorities in the relevant countries have not managed these industries as well as could be hoped, at least from the standpoint of habitat protection. The combined scores from Factors 3.1 (7 out of 10) and 3.2 (1.125 out of 10) led to an overall score of 5.04 out of 10 for this criterion, and a yellow rating.

Factor 3.3X: Wildlife and Predator Mortalities

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

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

Factor 3.3X Summary: Recirculating Aquaculture

Wildlife and predator mortality parameters	Score	
F3.3X Wildlife and predator mortality Final Score	0.00	GREEN
Critical?	NO	

Justification of Ranking

Land-based recirculating aquaculture production imposes zero deliberate or accidental mortality on wildlife or predators.

Factor 3.3X Summary: Net-Pen Aquaculture

Wildlife and predator mortality parameters	Score	
F3.3X Wildlife and predator mortality Final Score	-2.00	GREEN
Critical?	NO	

Justification of Ranking

While peer-reviewed literature on the subject is sparse, sharks and other predatory organisms often interact with net-pen aquaculture facilities in the tropics. Additionally, there is literature describing entanglement events between marine wildlife (dolphins) and aquaculture equipment (López and Shirai, 2007) as well as literature that suggests that dolphins avoid aquaculture facilities in the wild, thus depriving them of habitat that might otherwise be available for foraging (Markowitz et al. 2004). This literature suggests that some impacts are occurring and that a score of "no concern" is not warranted.

Alternatively, properly managed farms can usually reduce or avoid lethal interactions with predators via good management techniques (e.g., use of predator nets, daily fish mortality removal, etc...). The ability to manage predator interactions, and the lack of any material in the scientific literature indicating that wildlife and predator mortalities are occurring beyond exceptional cases, results in a score of 2 out of 10 and a "low" concern for this factor.

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: Recirculating Aquaculture

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

While there are a small number of drugs approved for use as spawning hormones (such as chorionic gonadotropin), as well as a few low regulatory drugs (such as sodium chloride) available for use as water quality control agents, the primary drug approved by the FDA for use in food-fish pompano aquaculture is formalin. Because formalin is a wide-spectrum antimicrobial agent, it is difficult to use this chemical in recirculating aquaculture systems that rely on biofiltration. Additionally, management at Virginia Cobia Farms and AquaGreen report use very little if any formalin or any other chemicals in their culture systems. The environmental and human health risks associated with excessive or unsafe chemical use in recirculating aquaculture production of pompano were therefore judged to be of very low concern and Criterion 4 received a score of 10 out of 10.

Justification of Ranking

There are only a small number of drugs approved by the FDA for use in pompano aquaculture. Currently, hormone injections are required to induce spawns in broodstock pompano and the FDA has approved chorionic gonadotropin for this purpose (USFWS 2011). Only formalin is approved for use on pompano when produced as food fish (USFWS 2011), although, due to its wide-spectrum antimicrobial properties, it is difficult to use in recirculating aquaculture systems that rely on biofiltration because the formalin kills the bacteria that conduct the biofiltration (Keck and Blanc 2002). Several antibiotics are available for limited use through the "Investigative New Animal Drug" (INAD) program, although it is important to understand that drugs exempted through the INAD program have not been granted "use permits" and their administration is heavily regulated (Johnson and Bosworth 2012). Further, Virginia Cobia Farms and AquaGreen report that they have never used any antibiotics or applied for any INAD exemptions to use them (S. Craig, Low Salinity Inc./Virginia Cobia Farms, personal communication, August 2013). Low regulatory drugs, including sodium chloride and calcium chloride, are used by Virginia Cobia Farms and AquaGreen to make seawater for their culture systems. This is a common use of these drugs and is not regulated by the FDA (FDA 2011). Additionally, the systems currently in use in the U.S. industry either do not allow active chemicals or byproducts to be discharged to a marine environment, or do not discharge any treated water at all. Virginia Cobia Farms discharges effluent (less than 10% a day) to a municipal wastewater facility located over 300 miles from a marine environment. AquaGreen, the other pompano producer in the U.S., is designing their production system to be zero discharge (S. Craig, Low Salinity Inc./Virginia Cobia Farms, personal communication, February-March 2013). The closed nature of these systems does not allow active chemicals to be discharged to the environment and therefore received a final score of 10.00 for this criterion.

Criterion 4 Summary: Net-Pen Aquaculture

Chemical Use parameters	Score	
C4 Chemical Use Score	**5.00**	
C4 Chemical Use Final Score	**5.00**	**YELLOW**
Critical?	NO	

While there is no specific evidence of chemical use practices in net-pen pompano aquaculture that endanger human health or damage the environment, and while food safety systems in many Asian countries (including China) appear to be improving, the aquaculture industry in the Indo-Pacific region has a history of aggressive, unregulated, and non-transparent use of antibiotics and other therapeutics. Given this history, and given the considerable environmental and human health concerns associated with improper use of chemicals in aquaculture, a precautionary approach should be adopted for this impact category, which leads to the conclusion that there is some risk from chemical use associated with net-pen farmed pompano. This criterion received a final score of 5 out of 10 and a yellow rating.

Justification of Ranking

There is no evidence to suggest that the risk of unsafe chemical use for net-pen aquaculture production of pompano is higher than it is for any other aquaculture system or species produced in Asia. There do not appear to be any specific reports of unusual or excessive use of chemicals by net-pen based producers of pompano, nor are there any specific reports detailing tainted pompano products reaching U.S. ports. Further, there is at least one pompano producer in Indonesia (P.T. Lucky Samudra Pratama) that has achieved AquaGAP certification (IMO 2010), a program that requires evidence of farm compliance with the chemical and drug regulations of the countries that import their product, as well as a veterinarian prescription for medical treatments (Bio Stiftung Schweiz 2010). Lastly, it appears that, in general, food safety practices in the Indo-Pacific region are slowly improving (Broughton and Walker 2010; Jia and Jukes 2013).

Nonetheless, the aquaculture industry in the Indo-Pacific region has a history of using antibiotics and other chemical therapeutics in ways that impose significant human health risks for consumers of a wide range of aquacultured products (e.g., Le and Munekage 2004: Love et al. 2011). Antibiotic resistant salmonella, for example, has been found in farmed fish produced in Guangdong, China (Broughton and Walker 2009), and a recent ABC news study recently found that 10% of the imported shrimp they tested were positive for residues of enrofloxican, chloramphenicol, and nitrofurazone, all of which are banned in the U.S. (Avila 2012). Moreover, there is some evidence that researchers in the region continue to do research on pompano with antibiotics banned in the U.S., especially nitrofurans (Vass et al. 2008; Lee et al. 2010). These risks are exacerbated by the relatively weak inspection capability of the U.S. Food and Drug Administration (GAO 2011; Love et al. 2011; Avila 2012). Lastly, because net-pens are open to environment with no control over the flow of water, chemicals used to manage the health of cultured organisms will be released to the environment. This is especially problematic in the case of antibiotics, where there is a risk of developing antibiotic-resistant populations of bacteria (Cabello 2006). Given the lack of available data, and until there is compelling evidence to the contrary, the use of chemicals in the Asian aquaculture industry, and the pompano industry specifically, result in moderate environmental risks and a subsequent score of 5 out of 10 for this criterion.

Criterion 5: Feed

Impact, unit of sustainability and principle

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

Criterion 5 Summary: Recirculating Aquaculture

Feed parameters	Value	Score	
F5.1a Fish In: Fish Out ratio (FIFO)	1.60	6.00	
F5.1b Source fishery sustainability score		-2.00	
F5.1: Wild Fish Use		5.68	
F5.2a Protein IN	64.26		
F5.2b Protein OUT	12.60		
F5.2: Net Protein Gain or Loss (%)	-80.39	**1**	
F5.3: Feed Footprint (hectares)	3.19	8	
C5 Feed Final Score		**5.09**	**YELLOW**
Critical?	NO		

In recirculating aquaculture in the U.S., pompano production is done using feeds with 4% fish oil (FO) inclusion and 0% fishmeal (FM) inclusion, resulting in a relatively moderate Fish In: Fish Out (FIFO) ratio of 1.60 and an assessed FIFO score of 5.68. Estimated values of 45% crude dietary protein in feeds, an eFCR of 2.0, and a whole body protein content of 18%, resulted in a 80.4% net loss of protein at harvest and a feed footprint of 3.19 ha/tFish. These scores resulted in a final score of 5.09 out of 10 and a yellow rating for this criterion.

Justification of Ranking: Recirculating Aquaculture

Factor 5.1a. Wild Fish Use: Fish In: Fish Out (FIFO)

Management at Virginia Cobia Farms report that they achieve an economic feed conversion ratio (eFCR) of 1.8 to 2.0 with Florida pompano harvested at 450 g (S. Craig, Low Salinity Inc./Virginia Cobia Farms, personal communication, February – March 2013). This value is consistent with published FCRs for pompano available in the peer-reviewed scientific literature and reports of other practitioners. Juvenile Florida pompano have been shown to convert feed at eFCRs of well under 1.0 in a research setting (Riche 2009; Rossi and Davis 2012). In a commercial setting the FCR begins to increase when the animal reaches about 350 grams, due in part to the onset of sexual maturity (J. Suarez, personal communication, March 28, 2013). This growth pattern is demonstrated in Weirich et al. (2009), who reported steadily rising FCRs throughout the life of Florida pompano reared in tanks and harvested at between 570 and 630 g. In that study, the final FCR for 570 to 630 g Florida pompano was ~4 (Weirich et al. 2009).

Virginia Cobia Farms manufactures private label feed based on a proprietary formula. This feed will also be manufactured for AquaGreen LLC as part of a collaborative agreement between the two companies. This feed uses no fishmeal (FM) and has a fish oil (FO) inclusion rate of 4%. Given a reported eFCR of 2.0 for the fish produced by Virginia Cobia Farms and AquaGreen, this implies a fish in: fish out (FIFO) value of 1.60 (see calculations below). This means that from first principles, 1.6 pounds of wild fish would need to be caught to supply the fish oil to grow one pound of pompano, and translates to a FIFO score of 6 out of 10 in the Seafood Watch criteria. The formulas used for calculating this score are found in the Seafood Watch criteria document on page 22 (Seafood Watch 2013). It should be noted that the commercial use of zero fishmeal feed is an innovation that has not been reported in any professional literature describing pompano culture techniques, and that this author has not been able to independently verify the composition of the Virginia Cobia Farms private label feed.

Factor 5.1b. Wild Fish Use: Sustainability of the Source of Wild Fish (SSWF).

Factor 5.1b assesses the sustainability of the source fisheries for fishmeal and fish oil. The source for the FO used in this feed is Daybrook Fisheries in Louisiana, USA. Daybrook Fisheries harvests primarily Gulf of Mexico menhaden *(Brevoortia patronus*) as the raw material for their FO manufacturing process. The Gulf of Mexico menhaden fishery has relatively good individual Fishsource scores of ≥ 6 and 10 for all factors (Fishsource 2013) leading to a sustainability score of -2 (as per the SFW criteria).

The sustainability score is used to adjust the FIFO score leading to a final Factor 5.1 score of 5.68, indicating that wild fish use is of a moderate concern for pompano produced in recirculation systems. The formulas used here are found in the Seafood Watch criteria document on page 22-24 (Seafood Watch 2013). The score was calculated as follows:

$$\textbf{FIFO Value}_{\textbf{FO}} = \text{Inclusion}_{FO} \times (\text{eFCR} \div \text{Yield}_{FO}) = 0.04 \times (2.0 \div 0.05) = \textbf{1.60}$$

$$\textbf{FIFO Score} = 10 - (2.5 \times \text{FIFO Value}) = 10 - (2.5 \times 1.60) = \textbf{6.00}$$

$$\textbf{SSWF Adjustment} = (\text{SSWF} \times \text{FIFO}) \div 10 = (-2 \times 1.60) \div 10 = \textbf{-0.32}$$

$$\textbf{Factor 5.1 Score} = \text{FIFO Score} - \text{SSWF Adjustment} = 6.00 - 0.32 = \textbf{5.68}$$

Factor 5.2. Net Protein Gain or Loss

Florida pompano in the U.S. are produced with feeds that have a crude protein content of approximately 45% (Lazo et al. 1998; Riche 2009; Weirich et al. 2009; Rossi and Davis 2012) and do not include any non-edible crop sources (e.g. byproducts from fish, animals, or crops) (Steve Craig, Low Salinity Inc./Virginia Cobia Farms). Given an assessed eFCR of 2.0, a standard whole body protein content of 18% for harvested fish (see Criterion 2), an estimated edible yield (EY) of 40% (Weirich et al. 2009; S. Craig, Low Salinity Inc./Virginia Cobia Farms, personal communication, February – March 2013), and an assumed 50% yield of non-edible byproducts from harvested fish used for other food production, the score was calculated as follows:

a = Protein Content of Feed = 45%
b = eFCR = 2.0
c = Percentage of feed protein from NON-EDIBLE sources = 0
d = Percentage of feed EDIBLE CROP sources = unk = 100
e = Protein content of whole harvested farmed fish = 18%
f = Edible yield of harvested farmed fish = 40%
g = Percentage of non-edible byproducts from harvested fish used in other food = 50%

Protein IN = [a – (a × (c + (0.286 x d)) ÷ 100)] x FCR = [45 – (45 × (28.6) ÷ 100)] × 2 = **64.26**

Protein OUT = (e/100) × [(f + (g × (100-f)) ÷ 100] = (0.18) × [(40 + (50 × (60)) ÷ 100] = **12.6**

Net Protein Loss = (Protein IN – Protein OUT) ÷ Protein IN = (100 – 12.6) ÷ 100 = 80.4%

The net protein loss was estimated to be 80.4%. This resulted in a final score of 1.0 out of 10, indicating a high net loss of protein. The formulas used to calculate these scores are found in the Seafood Watch criteria document on pages 24 and 25 (Seafood Watch 2013).

Table 3: Net Protein Loss Score (Recirculating Aquaculture)

	Protein Gain or Loss (%)	Score
Net Gain	> 0	10
Net Loss	0 - 10	9
	10-20	8
	20-30	7
	30-40	6
	40-50	5
	50-60	4
	60-70	3
	70-80	2
	80-90	**1**
	>90	0

Net Protein Loss = 80.4 % = 80% – 90% Protein Loss Category = Factor 5.2 Score of 1

Factor 5.3. Feed Footprint

Management at Virginia Cobia Farms reports inclusion levels of 4% for marine ingredients, 60% for crop feed ingredients, and 30% for land animal products in their feed (Steve Craig, Low Salinity Inc./Virginia Cobia Farms, personal communication, February – March 2013). Based on an estimate of 2.68 ha/ton average ocean productivity, a conversion ratio for crop ingredients to animal products of 2.88, and an estimated crop yield of 2.64 t/ha (values from the Seafood Watch criteria), the total amount of ocean and land area required to generate these feed components was calculated to be 3.19 ha/ton_{fish}. This score translated into a final score of 8 out of 10 for Factor 5.3. The formulas used to calculate the feed footprint are found in the Seafood Watch criteria document on pages 25 and 26 (Seafood Watch 2013). The score was calculated as follows:

Ocean Area

a = Inclusion level of aquatic feed ingredients (FM and FO) = 4 %
b = eFCR = 2.0
c = Average primary productivity (carbon) required for aquatic feed ingredients = 69.7 tC/tFeed
d = Average ocean productivity for continental shelf areas = 2.68 tC/ha

Ocean Area Appropriated = [(a ÷ 100) × b × c] ÷ d = (0.04 × 2.0 × 69.7) ÷ 2.68 = **2.08 ha/tFish**

Land Area

a = Inclusion level of crop feed ingredients = 60%
b = Inclusion level of land animal products = 30%
c = Conversion ratio of crop ingredients to land animal products = 2.88
d = eFCR = 2.0
e = Average yield of major feed ingredient crops = 2.64 t/ha

Land Area Appropriated = [(a + (b × c)) × 0.01 × d] ÷ e = [40 x 0.01 x 2] ÷ 2.64 = **1.11 ha/tFish**

Total Area Appropriated = Ocean Area + Land Area = 2.08 + 1.11 = **3.19 ha/tFish**

Table 4: Area Appropriated Score (Recirculating Aquaculture)

Total area	ha/tFish	Score
Zero	0	10
Low	0-3	9
	3-6	**8**
Low-moderate	6-9	7
	9-12	6
Moderate	12-15	5
	15-18	4
Moderate-high	18-21	3
	21-24	2
High	24-27	1
Very High	> 27	0

Total Area Appropriated = 3.19 ha/tFish = Low (3-6) Category = Factor 5.3 Score of 8.
Factor 5.1a, 5.1b, 5.2, and 5.3 Final Combined Score

The relatively low level of wild fish use (Factor 5.1a) and reasonably sustainable source of the wild fish (Factor 5.1b) lead to a final score of 5.68 for Factor 5.1 (Wild Fish Use). Net loss of protein is relatively high (80.4%) and leads to a score of 1 for Factor 5.2. The feed footprint of 3.19 ha/tFish, leads to a score of 8 for Factor 5.3. The combination of these scores leads to a final score of 5.09 out 10 and a yellow rating for this criterion.

Criterion 5 Summary: Net-Pen Aquaculture

Feed parameters	Value	Score	
F5.1a Fish In: Fish Out ratio (FIFO)	2.50	3.75	
F5.1b Source fishery sustainability score		-6.00	
F5.1: Wild Fish Use		2.25	
F5.2a Protein IN	101.25		
F5.2b Protein OUT	12.60		
F5.2: Net Protein Gain or Loss (%)	-87.56	**1**	
F5.3: Feed Footprint (hectares)	17.56	4	
C5 Feed Final Score		**2.38**	**RED**
Critical?	NO		

While inclusion rates for net-pen pompano feeds appear to vary widely, 25% FM and 5% FO were chosen as representative of the net-pen industry. These levels resulted in an assessed FIFO value of 2.50 and an assessed FIFO score of 2.25 Estimated crude dietary protein levels of 45%, an eFCR of 2.25 and a whole body protein content of 18%, resulted in a 86% net loss of protein at harvest and a feed footprint of 15.61 ha per ton of fish harvested. The scores resulted in a final score of 2.38 out of 10 and a red rating for this criterion.

Justification of Ranking (Net-Pen Aquaculture Production)

Factor 5.1. Wild Fish Use

A variety of sources report FCRs of approximately 1.14 to 2.59 for Asian pompano, although many of the reports of FCRs below 2 are from research conducted on juvenile fish under 100 g. (Lan et al. 2007; Gu and Zhou 2009; CMRFI 2012; Wang et al. 2012; Lin et al. 2013; Niu et al. 2013; B. Olson, Anova Food, personal communication, March 22, 2013). The Asian pompano is often harvested at sizes as large 1,000 to 1,300 grams, and commercial operators report a pattern of rising FCRs later in the growout cycle as the animal approaches 800 grams (B. Olson, Anova Food, personal communication, March 22, 2013). This is consistent with growth patterns of the Florida pompano, although the rise in FCRs begins at a smaller size for the Florida species. For this reason, an FCR of 2.25 was chosen as representative of conversion efficiencies achieved by commercial Asian pompano producers (see Table 5 – Criterion 2 for further FCR information).

<u>**NOTE**</u>: Because there was very little information in the scientific or trade literature about the use of trash fish[2] for the production of Asian pompano, this report does not consider the use of trash fish. However, this practice is widespread across Asia, especially on artisanal farms that lack access to a steady supply of extruded (ie., formulated and pelletized) feeds (e.g., Nhu, 2011; Hasan 2012) and has been used in the pompano industry in the past (Chou et al. 1995). Had robust data been available and the use of trash fish been considered, the scores for Criterion 5 would be expected to be lower than those reported here.

Feeds for Asian pompano in a research setting have been reported to contain between 13 and 60% FM and 0.2 to 8.6% FO (Lan et al. 2007; Wang et al. 2012; Niu et al. 2013; Lin et al. 2013). Commercial growers report using feeds with 20% to 40% FM and 5% to 8% FO (Lan et al. 2007; B. Olson, Anova Food, personal communication, March 22, 2013). 25% FM and 5% FO were chosen as representative of standard inclusion rates for Asian pompano feeds in the region. These values are toward the lower end of the reported range, but this was considered reasonable given the global trend toward reduced FM and FO inclusion rates for marine aquafeeds and steadily increasing commodity prices globally (Tacon and Metian 2008). Given the reported FCRs and assumed FM and FO inclusion rates, the FIFO values for Asian pompano are calculated to be 2.50 (FM) and 2.25 (FO). This means that from first principles, 2.5 pounds of wild fish would need to be caught to make the fishmeal to grow one pound of pompano.

The source of the fish used to manufacture the FM and FO used in these feeds is unknown, leading to a sustainability score of -6. The FIFO score, a metric that converts the FIFO value into a score between 1 and 10, is 3.75. Once the SSWF conversion is factored in to the equation, the

[2] For further information on trash fish, see the following Sustainable Fisheries Partnership (SFP) briefing. http://cmsdevelopment.sustainablefish.org.s3.amazonaws.com/2011/03/15/Trash%20Fish%20and%20Aquaculture%20Feeds%20-%20Retailer%20Briefing%20Final-c488522f.pdf.

final score is 2.25 out of 10. The formulas used for calculating this score are found in the Seafood Watch criteria document on page 22 (Seafood Watch 2013).
The score was calculated as follows:

$$\textbf{FIFO Value}_{\textbf{FM}} = \text{Inclusion}_{FM} \times (\text{eFCR} \div \text{Yield}_{FM}) = 0.25 \times (2.25 \div 0.225) = \textbf{2.50}$$

$$\textbf{FIFO Value}_{\textbf{FO}} = \text{Inclusion}_{FO} \times (\text{eFCR} \div \text{Yield}_{FO}) = 0.05 \times (2.25 \div 0.05) = \textbf{2.25}$$

$$\textbf{FIFO Score} = 10 - (2.5 \times \text{FIFO Value}_{FM}) = 10 - (2.5 \times 2.5) = \textbf{3.75}$$

$$\textbf{SSWF Adjustment} = (\text{SSWF} \times \text{FIFO Value}) \div 10 = (-6 \times 2.50) \div 10 = \textbf{- 1.50}$$

$$\textbf{Factor 5.1 Score} = \text{FIFO Score} - \text{SSWF Adjustment} = 3.75 - 1.50 = \textbf{2.25}$$

Factor 5.2. Net Protein Gain or Loss

Asian pompano are produced using feeds that have crude protein contents ranging from 33% to 50% (Lan et al. 2007; Wang et al. 2012; Niu et al. 2013; Lin et al. 2013; B. Olson, Anova Food, personal communication, March 22, 2013). For this study 45% crude protein content was chosen as representative of the standard feed used by pompano culturists in the region. Given an eFCR of 2.25, an assumed whole body protein content of 18% (Wang et al. 2012; Lin et al. 2013; Niu et al. 2013), an estimated edible yield of 40% (B. Olson, Anova Food, personal communication, March 22, 2013) and an assumed 50% of non-edible byproducts from harvested fish used for other food production, the net protein loss was estimated to be 87.6%. This represents a high net loss of protein and a final score of 1.0 out of 10 for Factor 5.2. This score was calculated as follows:

a = Protein Content of Feed = 45%
b = eFCR = 2.25
c = Percentage of feed protein from NON-EDIBLE sources = unknown = 0
d = Percentage of feed EDIBLE CROP sources = unknown = 0
e = Protein content of whole harvested farmed fish = 18%
f = Edible yield of harvested farmed fish = 40%
g = Percentage of non-edible byproducts from harvested fish used in other food = 50%

$$\textbf{Protein IN} = [a - (a \times (c + (0.286 \times d)) \div 100)] \times \text{FCR} = 45 \times 2.25 = \textbf{101.25}$$

$$\textbf{Protein OUT} = (e/100) \times [(f + (g \times (100-f)) \div 100] = (0.18) \times [70] = \textbf{12.60}$$

$$\textbf{Net Protein Loss = (Protein IN – Protein OUT) ÷ Protein IN = (101.25 – 12.60) ÷ 101.25 = 87.6\%}$$

The net protein loss was estimated to be 87.6%. This resulted in a final score of 1.0 out of 10, indicating a high net loss of protein. The formulas used to calculate these scores are found in the Seafood Watch criteria document on pages 24 and 25 (Seafood Watch 2013).

	Protein Gain or Loss (%)	Score
Net Gain	> 0	10
Net Loss	0 - 10	9
	10-20	8
	20-30	7
	30-40	6
	40-50	5
	50-60	4
	60-70	3
	70-80	2
	80-90	**1**
	>90	0

Net Protein Loss = 87.6% = 80% – 90% Protein Loss Category = Factor 5.2 Score of 1

Factor 5.3. Feed Footprint

Feeds for Asian pompano were assumed to have inclusion levels of 30% for marine ingredients, 60% for crop ingredients, and 0% for land animal ingredients. These estimates were based on available information about commercial diets used in the region (Lan et al. 2007; Wang et al. 2012; Niu et al. 2013; Lin et al. 2013). Based on estimates of 69.7 tC of PPR for the production of marine ingredients, 2.68 tC productivity per hectare of ocean, a conversion ratio of 2.88 for crop ingredients to animal products, and an estimated yield of 2.64 t per hectare for major feed ingredient crops (all values from the Seafood Watch criteria), the total amount of ocean and land area required to generate these feed components was calculated to be 17.56 ha/ton$_{fish}$. This area is substantially higher than that for the feed used in recirculation systems above due to the higher use of marine feed ingredients in Asia. This score translated into a final score of 4 out of 10, or "moderate," for Factor 5.3. The formulas used to calculate the feed footprint are found in the Seafood Watch criteria document on pages 25 and 26 (Seafood Watch 2013). The score was calculated as follows:

Ocean Area

a = Inclusion level of aquatic feed ingredients (FM and FO) = 30 %
b = eFCR = 2.25
c = Average primary productivity (carbon) required for aquatic feed ingredients = 69.7 tC/tFeed
d = Average ocean productivity for continental shelf areas = 2.68 tC/ha

Ocean Area Appropriated = [(a ÷ 100) × b × c] ÷ d = (0.04 × 2.0 × 69.7) ÷ 2.68 = **17.56 ha/tFish**

Land Area

a = Inclusion level of crop feed ingredients = 60%
b = Inclusion level of land animal products = 0%
c = Conversion ratio of crop ingredients to land animal products = 2.88
d = eFCR = 2.25
e = Average yield of major feed ingredient crops = 2.64 t/ha

Land Area Appropriated = [(a + (b × c)) × 0.01 × d] ÷ e = [0.0135] ÷ 2.64 = **0.0051 ha/tFish**

Total Area Appropriated = Ocean Area + Land Area = 17.56 + 0.0051 = **17.56 ha/tFish**

Total area	ha/tFish	Score
Zero	0	10
Low	0-3	9
	3-6	8
Low-moderate	6-9	7
	9-12	6
Moderate	12-15	5
	15-18	**4**
Moderate-high	18-21	3
	21-24	2
High	24-27	1
Very High	> 27	0

Total Area Appropriated = 17.57 ha/tFish = Moderate (15-18) Category = Factor 5.3 Score of 4

Factor 5.1a, 5.1b, 5.2, and 5.3 Final Combined Score

The relatively high level of wild fish use (Factor 5.1a) and unknown source of the wild fish (Factor 5.1b) lead to a final score of 2.25 for Factor 5.1 (Wild Fish Use). Net loss of protein is relatively high (87.6%) and leads to a score of 1 for Factor 5.2. The feed footprint for net-pen production of pompano is 17.56 ha/tFish, leads to a score of 4 for Factor 5.3. These individual scores are all relatively poor and combine to lead to a final score of 2.38 out 10 and a red rating for this criterion.

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: Recirculating Aquaculture

Escape parameters	Value	Score	
F6.1 Escape Risk		10.00	
F6.1a Recapture and mortality (%)	n/a		
F6.1b Invasiveness		n/a	
C6 Escape Final Score		**10.00**	**GREEN**
Critical?	NO		

The land-based, self-contained nature of recirculating aquaculture systems with no direct connection to marine water bodies results in zero escape risk and a score of 10 out of 10 and a green rating for this criterion.

Justification of Ranking

Factor 6.1a. Escape

Both Virginia Cobia Farms and AquaGreen are recirculating aquaculture systems with no connection with natural water bodies. There is no realistic risk of escape and therefore the score for this factor is 10 out of 10.

Factor 6.1b. Invasiveness

As there is no risk of escape, this factor is not applicable, but for information purposes, Florida pompano are native to the Atlantic and Gulf coasts of the U.S., and the fish are reported to range as far north as Massachusetts. Fish cultured at both Virginia Cobia Farms and AquaGreen are reported to be two generations hatchery reared (S. Craig, Low Salinity Inc./Virginia Cobia Farms, personal communication, February – March 2013). Due to the fact that these fish are reared in recirculating tank systems with no connection to any natural water body, there are no ongoing escapes that put local ecosystems at risk.

Factor 6.1a and 6.1b: Final Combined Score

With no connection to natural water bodies, the combined score for the Escape criterion for recirculating aquaculture production of Florida pompano is 10 out of 10.

Criterion 6 Summary: Net-Pen Aquaculture

Escape parameters	Value	Score	
F6.1 Escape Risk		0.00	
F6.1a Recapture and mortality (%)	0		
F6.1b Invasiveness		8	
C6 Escape Final Score		**4.00**	**YELLOW**
Critical?	NO		

The escape factor received a score of 4 out of 10 and was therefore scored yellow for net-pen based pompano aquaculture. There is no evidence that best management practices designed to lessen the risk of escape are utilized on an industry-wide basis. Net-pen reared pompano, however, are native to their respective regions (*T. carolinus* in the D.R., and *T. blochii* in the Indo-Pacific region) and there are no reports of negative ecological effects occurring due to farmed pompano escapism, which mitigates the invasiveness factor.

Justification of Ranking

Factor 6.1a. Escape risk

Due their inherent vulnerability, net-pens are considered a “high” risk system according to the Seafood Watch scoring system, unless there is evidence that effective best management practices are in place. There is at least one pompano farm in the region (P.T. Lucky Samudra Pratama) certified under the AquaGAP program (IMO 2010), which implies they are following best management practices for cage culture (Bio Stiftung Schweiz 2010). Unfortunately, there is no evidence that suggests that these practices are common throughout the industry. Therefore, a score of 0 out of 10 is assigned, indicating a high risk of escape.

While it is likely that there will be some direct mortality of escapees at the farm site and potentially some recaptures, there is no evidence with which to establish a score for the Recapture and Mortality score, and the escape risk score remains zero.

Factor 6.1b. Invasiveness

Asian pompano is native to the Indo-Pacific region (Smith-Vaniz 1984; Randall 1986; Letourneur et al. 2004) and is produced in hatcheries throughout the region, including in the Philippines, Taiwan, China, India, Indonesia, Malaysia (Lan 2007; Juniyanto et al. 2008; Pakingking et al. 2011; Gopakumar 2012; B. Olson, Anova Food, personal communication, March 22, 2013). While it is unclear from the available literature the degree to which selective breeding is occurring, and given the wide interest in developing the species for aquaculture, and the number of hatcheries currently capable of producing pompano, it seems likely that the industry has begun at least some genetic improvement work. Because of this, it was assumed that the

Asian pompano being cultured in aquaculture systems across the region were two generations hatchery reared.

In terms of direct ecological impacts, pompano escapism was judged to have no significant negative ecosystem effect. There is no evidence of significant ecological effects from escaping pompano, but this is unlikely to have been robustly studied. Pompano is not an aggressive predator or a competitor for resources, and is unlikely to significantly modify habitat or otherwise impact wild species; therefore, it is not considered likely to have a significant negative ecological impact beyond the escape site. Additionally, the relatively small size of the industry implies an also relatively low total number of escapes, which is likely to limit the aggregate genetic impact of the escapism that is occurring. The fact that Asian pompano is native to the region in which it is produced and is not likely creating significant ecosystem effects via escapism led to a final score of 8 out of 10 for this factor.

Factor 6.1a and 6.1b: Final Combined Score

The combination of high escape risk due to the inherent limitations of net-pen farming and the relatively low invasiveness of native Asian pompano resulted in a final score for this criterion of 4 out of 10.

Factor 6.2X: Escape of Unintentionally Introduced Species

A measure of the escape risk (introduction to the wild) of alien species <u>other than the principle farmed species</u> 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.

<u>Factor 6.2X Summary: Recirculating Aquaculture</u>

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

Justification of Ranking

Factor 6.2Xa International or Trans-waterbody Live Animal Shipments

Both Virginia Cobia Farms and AquaGreen report using in-house hatchery facilities for seed stock production (S. Craig, Low Salinity Inc./Virginia Cobia Farms, personal communication, February – March 2013) and using well established larviculture technologies and techniques (e.g. Cavalin and Weirich 2009). The reliance on international or trans-waterbody live animal shipments was therefore estimated to be zero, resulting in a score of 10 for this factor.

Factor 6.2X Summary: Net-Pen Aquaculture

Escape of unintentionally introduced species parameters	Score	
F6.2Xa International or trans-waterbody live animal shipments (%)	7.00	
F6.2Xb Biosecurity of source/destination	4.00	
C6 Escape of unintentionally introduced species Final Score	**-1.80**	**GREEN**

Justification of Ranking

Factor 6.2Xa International or Trans-waterbody Live Animal Shipments

While seed production capabilities are improving throughout the Indo-Pacific region (e.g., Juniyanto et al. 2008; Pakingking et al. 2011; Gopakumar 2012; Nazar et al. 2012), hatcheries in Taiwan are still reported to supply a significant amount of the seed stock to farms in Malaysia, Vietnam, and Indonesia (Ransangan et al. 2011; Seafood Source 2011; B. Olson, Anova Food, personal communication, March 22, 2013). In 2011, for example, seed stock from Taiwan was used to stock cages at Marine Farms Vietnam and at P.T. Lucky Samudra Pratama in Indonesia, resulting in production of approximately 1,200 tons of fish (Seafood Source 2011; B. Olson, Anova Food, personal communication, March 22, 2013). Based on the continued reliance of at least a portion of the industry on shipments of seed stock from Taiwan, it was estimated that 20% to 30% of Asian pompano production relies on international or trans-waterbody live animal shipments, resulting in a score of 7 out of 10 for Factor 6.2Xa.

Factor 6.2Xb Biosecurity of Source/Destination

As with many other species of marine finfish, protocols for Asian pompano larviculture call for relatively robust amounts of water exchange (more than 100% per day after 3 weeks) (Nazar et al. 2012). The requirement for high water exchange usually means that marine fish hatcheries are flow-through tank-based operations. Hatcheries, however, often have some level of biosecurity built in because the need for high water quality requires the use of physical filtration, ozone, and ultraviolet filtration in water systems. Nonetheless, disease outbreaks can occur and pathogens can be introduced into even relatively biosecure flow-through systems. Given these realities, concern over the biosecurity of the sources of Asian pompano seed was judged to be “moderate” and thus received a score of 4 out of 10.

The destination for hatchery reared Asian pompano seed stock appears overwhelmingly to be open cage systems. Any pathogens that have been inadvertently introduced at the hatchery stage may be transported with the seed stock and may therefore be introduced into the natural water bodies where the cages are located. Transport of seed stock has been a vector for unintended introductions of non-native species and pathogens all over the world, and in many different segments of the aquaculture industry (Minchin 2007). Thus, while Asian pompano are native throughout the region, the risk that their transport could result in the introduction of pathogens to previously naïve wild populations cannot be disregarded. This concern about biosecurity at the destination was judged to be of “high” concern and received a score of 0 out of 10.

Per the Seafood Watch criteria, the score for Factor 6.2Xb is the highest (i.e., the most biosecure) of either the source or the destination. Given a score of “moderate” concern (4 out of 10) for the source and “high” concern for the destination of the seed (0 out of 10), Factor 6.2Xb received a score of 4 out of 10 reflecting a level of “moderate” overall concern..

Factor 6.2Xa and 6.2Xb: Final Combined Score.

Per the Seafood Watch criteria, the combination of a score of 7 out of 10 for Factor 6.2Xa and a final score of 4 out of 10 for Factor 6.2Xb led to a final combined score of -1.8. This is an “exceptional factor” that is subtracted from the overall score of the other criteria.

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: Recirculating Aquaculture

Pathogen and parasite parameters	Score	
C7 Biosecurity	10.00	
C7 Disease; pathogen and parasite Final Score	**10.00**	**GREEN**
Critical?	**NO**	

With no connection to natural water bodies or endemic fish populations, disease, pathogen, and parasite interactions were considered to be of no concern. The assessed systems received a score of 10 and a green rating for this criterion

Justification of Ranking

The recirculating aquaculture systems analyzed here have no connection with wild populations, and therefore disease, pathogen, and parasite interactions were considered to be no concern.

Criterion 7 Summary: Net-Pen Aquaculture

Pathogen and parasite parameters	Score	
C7 Biosecurity	4.00	
C7 Disease; pathogen and parasite Final Score	**4.00**	**YELLOW**
Critical?	**NO**	

Net-pen systems have inherent biosecurity limitations due to their openness to surrounding waters. This, combined with evidence of weak biosecurity practices in hatcheries in the Indo-Pacific region, led to a score of 4 out of 10 and a yellow rating for this criterion.

Justification of Ranking

Net-pen systems are open to the introduction of pathogens and parasites, and while some of the farms may be utilizing advanced health maintenance systems for their fish, it is unclear the degree to which best management practices are followed throughout the region. Further, there is evidence that biosecurity practices in the region are lacking. Philippine hatcheries have reported outbreaks of viral nervous necrosis (Pakingking et al. 2011) and seed stock produced in Taiwan and shipped around the region are not properly screened for viral pathogens (Ransangan and Manin 2010). This improper screening may have been responsible for major disease outbreaks in Asian pompano reared in net-pens in Malaysia in recent years (Ransangan et al. 2011). Based on these concerns (especially the fact that net-pen systems are open to the introduction and discharge of pathogens), the Seafood Watch criteria dictate a finding of “moderate” concern for the “Disease, Pathogen and Parasite Interaction” criterion and a score of 4 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 thereby avoiding the need for wild capture.*

Criterion 8 Summary: Recirculating Aquaculture

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

Justification of Ranking (Recirculating Aquaculture Production)

Pompano produced in recirculating systems at Virginia Cobia Farms and AquaGreen are reported to be reared entirely from hatchery reared broodstock. Larval rearing technologies are well understood and have been under development since the 1970s (Main et al. 2007). Therefore, the final score is 10 out of 10, indicating a complete independence from wild stocks.

Criterion 8 Summary: Net-Pen Aquaculture

Source of stock parameters	Score	
C8 % of production from hatchery-raised broodstock or natural (passive) settlement	80	
C8 Source of stock Final Score	**8.00**	**GREEN**

There are no reports that Asian pompano production is currently reliant on wild seed. Hatchery technology for pompano has been transferred throughout the Indo-Pacific region (e.g. Juniyanto et al. 2008; Nazar et al. 2012). Because the techniques for captive spawning and larval rearing of pompano are relatively new to some countries, it is possible that not all hatchery-reared fish are more than one generation from the wild. It was assessed that 10%-20% of the available Asian pompano seed was not more than one generation from the wild, resulting in a score of 8 out of 10 and a green rating for this criterion.

Overall Recommendation

Final Seafood Recommendation – Pompano (Recirculating)

Final Score	9.22
Initial rank	GREEN
Red criteria	0
Interim rank	GREEN
Critical Criteria?	NO

FINAL RANK
GREEN

Final Seafood Recommendation – Pompano (Net-Pens)

Final Score	3.58
Initial rank	YELLOW
Red criteria	2
Interim rank	RED
Critical Criteria?	YES

FINAL RANK
RED

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.

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

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About Seafood Watch®

Monterey Bay Aquarium's Seafood Watch® program evaluates the ecological sustainability of wild-caught (hyphen here but not in other places) 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[3] 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

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

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

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

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

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

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

Data Points and All Scoring Calculations: Recirculating Aquaculture

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 Qualit	Score (0-10)
Industry or production stati	*Yes*	10	10
Effluent	Yes	10	10
Locations/habitats	Yes	10	10
Predators and wildlife	No	Not relevant	n/a
Chemical use	Yes	10	10
Feed	Yes	10	10
Escapes, animal movements	No	Not relevant	n/a
Disease	Yes	7.5	7.5
Source of stock	Yes	10	10
Other – (e.g. GHG emissions	Yes	7.5	7.5
Total			**75**

C1 Data Final Score	9.375	GREEN

Criterion 2: Effluents

Factor 2.1a - Biological Waste Production Score

Protein content of feed (%)	45
eFCR	2
Fertilizer N input (kg N/ton fish	0
Protein content of harvested f	18
N content factor (fixed)	*0.16*
N input per ton of fish produce	144
N in each ton of fish harvested	28.8
Waste N produced per ton of	**115.2**

Factor 2.1b - Production System Discharge Score

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

Factor 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 aq	Moderately	0.5
2 - Are the control measures applied according to site-specific conditions and/or do they lead to site-s	Moderately	0.5
3 - Do the control measures address or relate to the cumulative impacts of multiple farms?	Moderately	0.5
4 - Are the limits considered scientifically robust and set according to the ecological status of the rece	Moderately	0.5
5 - Do the control measures cover or prescribe including peak biomass, harvest, sludge disposal, clear	Moderately	0.5
		2.5

Factor 2.2b - Enforcement Level of Effluent Regulations or Management

Question	Scoring	Score
1 - Are the enforcement organizations and/or resources identifiable and contactable, and appropriate	Moderately	0.5
2 - Does monitoring data or other available information demonstrate active enforcement of the cont	Moderately	0.5
3 - Does enforcement cover the entire production cycle (i.e. are peak discharges such as peak bioma	Moderately	0.5
4 - Does enforcement demonstrably result in compliance with set limits?	Moderately	0.5
5 - Is there evidence of robust penalties for infringements?	Moderately	0.5
		2.5

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

C2 Effluent Final Score	10.00	GREEN
	Critical?	NO

Criterion 3: Habitat

3.1. Habitat Conversion and Function

F3.1 Score	9

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 EIA	Yes	1
2 - Is the industry's total size and concentration based on its cumulative impacts and the maintenanc	Yes	1
3 – Is the industry's ongoing and future expansion appropriate locations, and thereby preventing the f	Yes	1
4 - Are high-value habitats being avoided for aquaculture siting? (i.e. avoidance of areas critical to vul	Yes	1
5 - Do control measures include requirements for the restoration of important or critical habitats or e	Yes	1
		5

Factor 3.2b - Siting Regulatory or Management Enforcement

Question	Scoring	Score
1 - Are enforcement organizations or individuals identifiable and contactable, and are they appropria	Yes	1
2 - Does the farm siting or permitting process function according to the zoning or other ecosystem-ba	Yes	1
3 - Does the farm siting or permitting process take account of other farms and their cumulative impa	Yes	1
4 - Is the enforcement process transparent - e.g. public availability of farm locations and sizes, EIA rep	Yes	1
5 - Is there evidence that the restrictions or limits defined in the control measures are being achieved	Yes	1
		5

F3.2 Score (2.2a*2.2b/2.5)	10.00

C3 Habitat Final Score	9.33	GREEN
	Critical?	NO

Exceptional Factor 3.3X: Wildlife and Predator Mortalities

Wildlife and predator mortality parameters	Score	
F3.3X Wildlife and Predator Final Score	0.00	GREEN
Critical?	NO	

Criterion 4: Evidence or Risk of Chemical Use

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

Criterion 5: Feed

5.1. Wild Fish Use

Factor 5.1a - Fish in: Fish Out

Fishmeal inclusion level (%)	0
Fishmeal from by-products (%)	0
% FM	0
Fish oil inclusion level (%)	4
Fish oil from by-products (%)	0
% FO	4
Fishmeal yield (%)	22.5
Fish oil yield (%)	5
eFCR	2
FIFO fishmeal	0.00
FIFO fish oil	1.60
Greater of the 2 FIFO scores	1.60
FIFO Score	**6.00**

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

SSWF	-2
SSWF Factor	-0.32

F5.1 Wild Fish Use Score	**5.68**

5.2. Net Protein Gain or Loss

Protein INPUTS	
Protein content of feed	45
eFCR	2
Feed protein from NON-EDIBLE sources (%)	0
Feed protein from EDIBLE CROP soruces (%)	100
Protein OUTPUTS	
Protein content of whole harvested fish (%)	18
Edible yield of harvested fish (%)	40
Non-edible by-products from harvested fish used for other food production	50
Protein IN	64.26
Protein OUT	12.6
Net protein gain or loss (%)	-80.3922
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 (%)	4
eFCR	2
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)	2.08

5.3b Land Area Appropriated By Feed Ingredients Per Ton Of Production

Inclusion level of crop feed ingredients (%)	60
Inclusion level of land animal products (%)	30
Conversion ratio of crop ingedients to land animal products	*2.88*
eFCR	2
Average yield of major feed ingredient crops (t/ha)	*2.64*
Land area appropriated (ha per ton of fish)	1.11

Value (Ocean + Land Area)	**3.19**

F5.3 Feed Footprint Score	**8.00**

C5 Feed Final Score	**5.09**	**YELLOW**
	Critical?	**NO**

Criterion 6: Escapes

6.1a. Escape Risk

Escape Risk	**10**

Recapture & Mortality Score (RMS)	
Estimated % recapture rate or direct mortality at the escape site	100
Recapture & Mortality Score	1
Factor 6.1a Escape Risk Score	**10**

6.1b. Invasiveness

Part A – Native Species

Score	3

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 behavio	No
Do escapees modify habitats to the detriment of other species (e.g. by feeding, foraging, settlement c	No
Do escapees have some other impact on other native species or habitats?	No
	5

F 6.1b Score	8

Final C6 Score	10.00	GREEN
	Critical?	NO

Exceptional Factor 6.2X: Escape of Unintentionally Introduced Species

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

Criterion 7: Diseases

Pathogen and parasite parameters	Score	
C7 Biosecurity	10.00	
C7 Disease; pathogen and parasite Final Score	**10.00**	**GREEN**
Critical?	NO	

Criterion 8: Source of Stock

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

Data Points And All Scoring Calculations: Net pen Aquaculture

Criterion 1: Data Quality and Availability

Data Category	Relevance (Y/N)	Data Qualit	Score (0-10)
Industry or production stati	*Yes*	5	5
Effluent	Yes	5	5
Locations/habitats	Yes	2.5	2.5
Predators and wildlife	Yes	2.5	2.5
Chemical use	Yes	2.5	2.5
Feed	Yes	5	5
Escapes, animal movements	Yes	5	5
Disease	Yes	5	5
Source of stock	Yes	5	5
Other – (e.g. GHG emissions	Yes	2.5	2.5
Total			**40**

C1 Data Final Score	4	YELLOW

Criterion 2: Effluents

Factor 2.1a - Biological Waste Production Score

Protein content of feed (%)	45
eFCR	2.25
Fertilizer N input (kg N/ton fish	0
Protein content of harvested f	18
N content factor (fixed)	*0.16*
N input per ton of fish produce	162
N in each ton of fish harvested	28.8
Waste N produced per ton of	**133.2**

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**

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 aqu	Partly	0.25
2 - Are the control measures applied according to site-specific conditions and/or do they lead to site-s	Partly	0.25
3 - Do the control measures address or relate to the cumulative impacts of multiple farms?	Partly	0.25
4 - Are the limits considered scientifically robust and set according to the ecological status of the rece	Partly	0.25
5 - Do the control measures cover or prescribe including peak biomass, harvest, sludge disposal, clear	Partly	0.25
		1.25

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	Partly	0.25
2 - Does monitoring data or other available information demonstrate active enforcement of the cont	Partly	0.25
3 - Does enforcement cover the entire production cycle (i.e. are peak discharges such as peak bioma	Partly	0.25
4 - Does enforcement demonstrably result in compliance with set limits?	Partly	0.25
5 - Is there evidence of robust penalties for infringements?	Partly	0.25
		1.25

F2.2 Score (2.2a*2.2b/2.5)	0.625	
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 EIA	Moderately	0.5
2 - Is the industry's total size and concentration based on its cumulative impacts and the maintenanc	Partly	0.25
3 – Is the industry's ongoing and future expansion appropriate locations, and thereby preventing the f	Moderately	0.5
4 - Are high-value habitats being avoided for aquaculture siting? (i.e. avoidance of areas critical to vul	Moderately	0.5
5 - Do control measures include requirements for the restoration of important or critical habitats or e	Moderately	0.5
		2.25

Factor 3.2b - Siting Regulatory or Management Enforcement

Question	Scoring	Score
1 - Are enforcement organizations or individuals identifiable and contactable, and are they appropria	Partly	0.25
2 - Does the farm siting or permitting process function according to the zoning or other ecosystem-ba	Partly	0.25
3 - Does the farm siting or permitting process take account of other farms and their cumulative impa	Partly	0.25
4 - Is the enforcement process transparent - e.g. public availability of farm locations and sizes, EIA rep	Partly	0.25
5 - Is there evidence that the restrictions or limits defined in the control measures are being achievec	Partly	0.25
		1.25

F3.2 Score (2.2a*2.2b/2.5)	**1.13**

C3 Habitat Final Score	**5.04**	**YELLOW**
	Critical?	NO

Exceptional Factor 3.3X: Wildlife and Predator Mortalities

Wildlife and predator mortality parameters	Score	
F3.3X Wildlife and Predator Final Score	**-2.00**	**GREEN**
Critical?	NO	

Criterion 4: Evidence or Risk of Chemical Use

Chemical Use parameters	Score	
C4 Chemical Use Score	**5.00**	
C4 Chemical Use Final Score	**5.00**	**YELLOW**
Critical?	NO	

Criterion 5: Feed

5.1. Wild Fish Use

Factor 5.1a - Fish in: Fish Out

Fishmeal inclusion level (%)	25
Fishmeal from by-products (%)	0
% FM	25
Fish oil inclusion level (%)	5
Fish oil from by-products (%)	0
% FO	5
Fishmeal yield (%)	22.5
Fish oil yield (%)	5
eFCR	2.25
FIFO fishmeal	2.50
FIFO fish oil	2.25
Greater of the 2 FIFO scores	2.50
FIFO Score	**3.75**

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

SSWF	-6
SSWF Factor	-1.5

F5.1 Wild Fish Use Score	**2.25**

5.2. Net Protein Gain Or Loss

Protein INPUTS		
Protein content of feed		45
eFCR		2.25
Feed protein from NON-EDIBLE sources (%)		0
Feed protein from EDIBLE CROP soruces (%)		0
Protein OUTPUTS		
Protein content of whole harvested fish (%)		18
Edible yield of harvested fish (%)		40
Non-edible by-products from harvested fish used for other food production		50
Protein IN		101.25
Protein OUT		12.6
Net protein gain or loss (%)		-87.5556
	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 (%)	30
eFCR	2.25
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)	17.56

5.3b Land Area Appropriated By Feed Ingredients Per Ton Of Production

Inclusion level of crop feed ingredients (%)	0.6
Inclusion level of land animal products (%)	0
Conversion ratio of crop ingedients to land animal products	*2.88*
eFCR	2.25
Average yield of major feed ingredient crops (t/ha)	*2.64*
Land area appropriated (ha per ton of fish)	0.01

Value (Ocean + Land Area)	**17.56**

F5.3 Feed Footprint Score	**4.00**

C5 Feed Final Score	**2.38**	**RED**
	Critical?	**NO**

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	3

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 behavio	No
Do escapees modify habitats to the detriment of other species (e.g. by feeding, foraging, settlement o	No
Do escapees have some other impact on other native species or habitats?	No
	5

F 6.1b Score	**8**

Final C6 Score	**4.00**	**YELLOW**
	Critical?	**NO**

Exceptional Factor 6.2X: Escape of Unintentionally Introduced Species

Escape of unintentionally introduced species parameters	Score	
F6.2Xa International or trans-waterbody live animal shipments (%)	7.00	
F6.2Xb Biosecurity of source/destination	4.00	
F6.2X Escape of unintentionally introduced species Final Score	**-1.80**	**GREEN**

Criterion 7: Diseases

Pathogen and parasite parameters	Score	
C7 Biosecurity	4.00	
C7 Disease; pathogen and parasite Final Score	**4.00**	**YELLOW**
Critical?	NO	

Criterion 8: Source of Stock

Source of stock parameters	Score	
C8 % of production from hatchery-raised broodstock or natural (passive) settlement	80	
C8 Source of stock Final Score	**8**	**GREEN**