Monterey Bay Aquarium
Seafood Watch®

Farmed Tilapia

(Oreochromis niloticus)

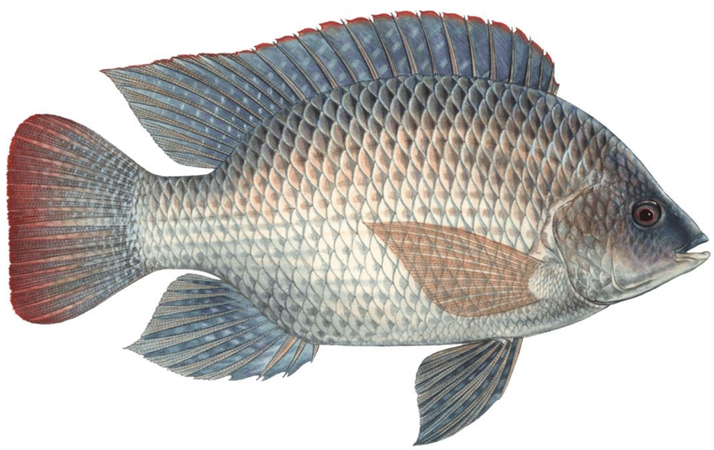

Image courtesy of Monterey Bay Aquarium

Mexico

Net Pens

September 2015

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About Seafood Watch®

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

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

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

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

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

Guiding Principles

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

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

Seafood Watch will:

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

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

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

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

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

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

Final Seafood Recommendation

Criterion	Score (0-10)	Rank	Critical?
C1 Data	3.89	YELLOW	
C2 Effluent	5.00	YELLOW	NO
C3 Habitat	6.67	GREEN	NO
C4 Chemicals	8.00	GREEN	NO
C5 Feed	7.90	GREEN	NO
C6 Escapes	7.00	GREEN	NO
C7 Disease	4.00	YELLOW	NO
C8 Source	10.00	GREEN	
C9X Wildlife mortalities	-2.00	GREEN	NO
C10X Introduced species escape	-4.00	YELLOW	
Total	**46.45**		
Final score	**5.81**		

OVERALL RANKING

Final Score	5.81
Initial rank	YELLOW
Red criteria	0
Interim rank	YELLOW
Critical Criteria?	NO

FINAL RANK
YELLOW

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

Tilapia farmed in open net cages in Mexico present a final YELLOW overall score of 5.81 out of 10, and with no red or critical scores results in a final recommendation of "Good Alternative."

Executive Summary

Tilapia farming occurs all over the world in various forms including closed containment recirculation systems, ponds, raceways, and open net cages. Tilapia are native to Africa but have been introduced widely by governments due primarily to their ability to control mosquito larvae and aquatic weeds in irrigation systems and also to provide a food source for growing populations from fisheries and, more recently, aquaculture. Tilapia production in Mexico began in the 1980s but has been mainly for domestic consumption. Regal Springs, one of the largest tilapia farming companies in the world, expanded their open net pen operations to Mexico in 2008 and operates two farm sites located in artificial (i.e., dammed) reservoirs.

At the time of writing, no significant quantities of pond-produced tilapia are exported to the US market and therefore this evaluation will focus exclusively on net pen operations. As Regal Springs' exports represent 90%–95% of the Mexican tilapia on the US market, this recommendation covers the large majority of Mexico's export production. Both of Regal Springs' sites in Mexico are certified to the Aquaculture Stewardship Council (ASC) standards, and the publically available audit reports were used as a source of information on the farm's operations. A site visit was also made as part of this Seafood Watch assessment.

Data availability and quality scored 3.89 of 10 as, although partially verified data were available through the ASC audit reports required for certification to the ASC Tilapia Standard, the ASC audit reports are limited to one year of verification for the Malpaso farm (2015) and two years for the Lake Peñitas farm (2013 and 2015). As a result, there are limitations to extrapolating data collected by the audits to reflect long-term impacts. In addition, the ASC tilapia standards are not equally applicable to the Seafood Watch assessment criteria and the audit reports are more helpful for some criteria that others (Effluent, Habitat, and Disease).

Although robust data are collected by Regal Springs and evaluated to some degree by an ASC audit, not all monitoring data were available for the purpose of this assessment and thus the risk-based effluent assessment was used rather than the evidence-based assessment. An average feed conversion ratio (FCR) of 1.75 and protein inclusion of 32% result in 60.8 kg of nitrogen waste per ton of tilapia production. With approximately 80% of this being discharged from net pen production, nitrogen discharge is moderate and, when combined, increased monitoring required for ASC certification and resulted in a final Criterion 2 score of 5 out of 10.

Regal Springs' Mexico operations are sited in reservoirs that were artificially created and their farming operations do not significantly impact habitats, which results in a score of 8 (out of 10) in Factor 3.1. For regulatory and management effectiveness, compliance and auditing by the ASC tilapia standards results in a score of 4.0 of 10. When the two scores are combined, the final score is 6.67 of 10 or a "Low Concern."

Chemical use scored 8 (out of a possible 10) due to the lack of any chemical used in farming operations as verified by the ASC audits, with the exception of methyltestosterone for sex reversal during the hatchery phase.

The strong feed performance is due to a low requirement for inclusion of marine ingredients, the use of byproducts, reasonably low FCR value (1.75), and the use of harvested farmed fish carcass and internal organs for other feeds, resulting in low waste from processing. These factors were verified by the ASC audits in 2013 and 2015 to some degree. While there is a net loss of protein edible to humans, the low levels of marine and land animal ingredients result in a high feed score of 7.90 out of 10.

The Escape score was 7 out of 10 as both lakes that Regal Springs operates in were artificially created reservoirs where tilapia were historically introduced and where they now have become established. Regal Springs actively adds tilapia to the lakes from their own hatcheries as a condition of their operating license. It is therefore assumed that any escapes from farm sites will not significantly increase the impact to wild species.

Pathogen and parasite interactions in the Disease criterion scored moderately as there are few reported disease issues with tilapia production in Mexico. In addition, ASC audits demonstrate the implementation of an effective health management plan, zero use of chemicals (there is little disease requiring chemical use), and proper management of mortalities. The open net pen production systems increase the likelihood of the spread of disease or parasites (if any were to occur) and the moderate score (4 of 10) reflects this increased risk.

All tilapia stocked at Regal Springs sites in Mexico is obtained from hatchery-raised broodstock on-farm and tilapia production in Mexico is considered to be fully independent from wild fisheries. The Source of Stock criterion scores 10 out 10.

Regal Springs uses nets to cover their cages while the fish are small, but otherwise uses no other forms of predator control. The ASC audits of Regal Springs farms in 2013 and 2015 confirm no use of lethal predator devices and no mortality of IUCN listed species. The only reported wildlife mortalities from their operations were birds (cormorants) but exact numbers are not available although the mortalities are not considered to occur beyond exceptional cases. A score of -2 of -10 was assigned for this exceptional criterion.

Regal Springs does not use any kind of international live animal movements but does operate live animal movements within Mexico from a biosecure hatchery to open net pen farms. The score for 10X was -4 out of -10.

Overall, Regal Springs' tilapia production in Mexico scored "Yellow" or a "Good Alternative" with a numeric score of 5.81 out of a possible 10 and no "red" criteria.

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Introduction

Scope of the Analysis and Ensuing Recommendation

Species: Nile tilapia *Oreochromis niloticus*
Geographic coverage: Mexico
Production Methods: Regal Springs tilapia exported to the US is farmed in open net cages.

Tilapia are one of the most important aquaculture species globally, and have been cultivated for food for thousands of years. They are a fast-growing tropical species native to Africa and are now farmed on every continent on the planet. Tilapia are omnivores, eating both plants and animals, and can live in either fresh or salt water, but require temperatures above 50 °F (Fitzsimmons and Watanabe 2010). Tilapia is a common name applied to three genera: *Oreochromis* (maternal mouthbrooders), *Sarotherodon* (paternal mouthbrooders), and *tilapia* (substrate spawners).

Tilapia is the second most important group of farmed fish after carp. In 2012, farmed tilapia production exceeded 4.5 million metric tons from 140 nations, surpassing any other farmed fish (FAO 2014). According to the National Fisheries Institute (2013), tilapia is the fourth most consumed fish in the United States after shrimp, tuna and salmon. During 2013, the average consumption of tilapia (1.43 pounds) was down slightly from 2012 (1.48 pounds), but still higher than previous years (1.19 pounds in 2010). Tilapia is also known in the market as Saint Peter fish and Izumidai (Izumidai refers only to processed fillets, primarily for the sushi and sashimi markets).

Production in Mexico

Aquaculture in Mexico was born as a complementary activity of social support to rural communities, as a means to increase consumption of animal protein and thus improve nutritional levels of local populations (Juárez-Palacios 1987, FAO 2013). Today, many species are raised domestically and there is a well-developed aquaculture infrastructure (Fitzsimmons pers. comm. 2014). Mexican aquaculture has been growing rapidly since 2002 and production has nearly doubled over that period. In 2012, tilapia aquaculture contributed 16.5% of national farmed fish production and, including tilapia, four species represent 95% of production (70% shrimp, 5% trout, 3.5% oysters; FAO 2014a).

Tilapia was first introduced into Mexico in the 1960s and many species have been introduced since that time due to both private and state interests (Pullin et al. 1997). Today, tilapia are established in every state. The stocking of tilapia in artificial reservoirs is common and serves as an important food source for communities around the country (Fitzsimmons 2000). *O. aureus* are the most common tilapia in the southern Mexico and in reservoir fisheries, while *O. niloticus* is the most widely cultured species in intensive net cage systems.

In 1987, national production (wild catch and aquaculture) of tilapia was 27,765 metric tons, and by 1994 Mexico produced 81,490 metric tons of tilapia (FAO 2013). At that time, virtually all of the production was consumed domestically (World Bank 1997). Today, annual production is about 70,000 mt with approximately 20,000 mt coming from controlled and cultured situations (FAO 2013, Laurence & Wallhoff pers. comm. 2014). The rest comes from tilapia fisheries in reservoirs where fisherman use gillnets to capture the fish.

In the 1980s and ‘90s, Mexico began using small ponds that were often treated with chemical and organic fertilizers for tilapia aquaculture throughout the country (Morales 1974, Porras Diaz 1990, Aguilera Hernandez, Noriega Curtis 1991a and b, and Fitzsimmons 2000). Government support encouraged subsistence tilapia farming through provision of fry and helped establish hatcheries. Tilapia was also grown in ponds that use irrigation water or were grown in drainage water that comes from irrigated fields (Fitzsimmons 2000). Although extensive culture was still common throughout Mexico as of 2000, other more intensive practices have increased in frequency over the last decade and a half (Fitzsimmons 2000, Morales and Reinaldo Morales 2006, CSPTM 2009).

The other culture systems used can be classified into two groups: stocking in reservoirs (presas) or cage culture (jaulas and corrales). After construction of dams in the ‘60s and ‘70s, the reservoirs were stocked with tilapia juveniles and left to grow to maturity before harvest. Although stocking continues to some extent, tilapia populations quickly reproduced and became established on their own (Fitzsimmons 2000). No external feed or other inputs are provided to populations in the reservoirs, but tilapia catches from these artificial water bodies continue to be included in aquaculture statistics since juveniles are stocked (Fitzsimmons 2000, CSPTM 2009).

Several types of cages and pens are used by Mexican farmers to raise tilapia, including: floating cages (jaulas) and staked pens (corrales) (Fitzsimmons 2000). Cages are often favored because they reduce the ability of tilapia to spawn and they are easier to harvest (Fitzsimmons 2000). Most tilapia fry and fingerlings in Mexico are now produced in private hatcheries. Farmers in Jalisco, Tabasco, Quintana Roo, and Veracruz states produce many of their tilapia in high density recirculating tank systems with mechanical aeration and constructed wetlands to filter wastes (Fitzsimmons 2000, CSPTM 2009).

Regal Springs Mexico

Regal Springs is a tilapia producer that has operated in Indonesia and Honduras for more than 20 years and, in 2008, developed an operation in the reservoir above the Peñitas dam in the state of Chiapas, Mexico (Figure 1). The facilities consist of a hatchery, juvenile fry nursery, floating growout cages and a state of the art processing facility. More recently Regal Springs added a second growout site and now raises tilapia in floating cages on both Lake Peñitas and Malpaso (officially known as the Nezahualcóyotl Dam) (Figure 2).

When fully operational, the production facility alone will employ 850 to 1000 local residents. Regal Springs offers strong commitments to the community including supporting the opening of a new school as well as pledging support for the Ocote Jungle Biosphere. Regal Springs was one of the first farms certified by the newly formed Aquaculture Stewardship Council (Stark 2013) for their operations in Indonesia 2012, Honduras 2010, and (one of two sites) in Mexico 2013.

Figure 1. Google Earth Image of the Regal Springs Farm Location in Mexico–Peñitas

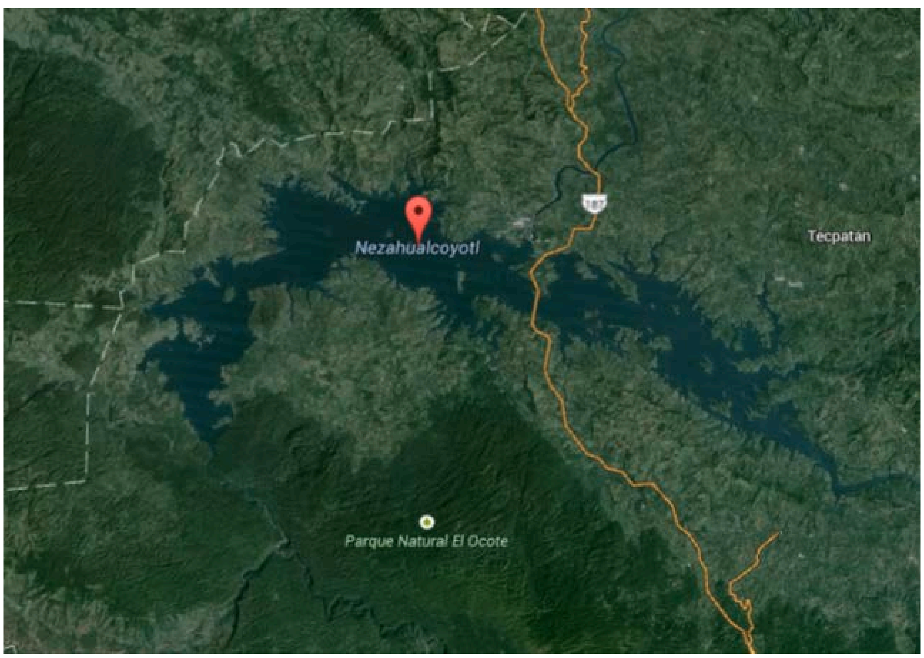

Figure 2. Google Earth Image of the Regal Springs Farm Location in Mexico–Malpaso

Production Statistics

The tilapia market can be divided into two segments: the frozen and the fresh products (Norman-López and Bjørndal 2009). Chinese products dominate the frozen sector of the US market, providing about 60% of whole tilapia and 90% of the tilapia fillets, and Indonesia is the second supplier of frozen tilapia fillets to the US after China. Latin American countries dominate the market of fresh products. In 2013, Honduras, Ecuador, Costa Rica and Columbia supplied 84% of imported fresh fillets to the US market. During 2013, the United States imported more than 3.6 million pounds of tilapia, valued at US$12.5 million from Mexico, from which almost all (more than 99%) were frozen fillets (USDA 2014).

Tilapia aquaculture production has been quite variable over the last 40 years (Figure 3). With the entry of Regal Springs into the country in 2008, there has been a dramatic increase in tilapia exports to the United States (Figure 4).

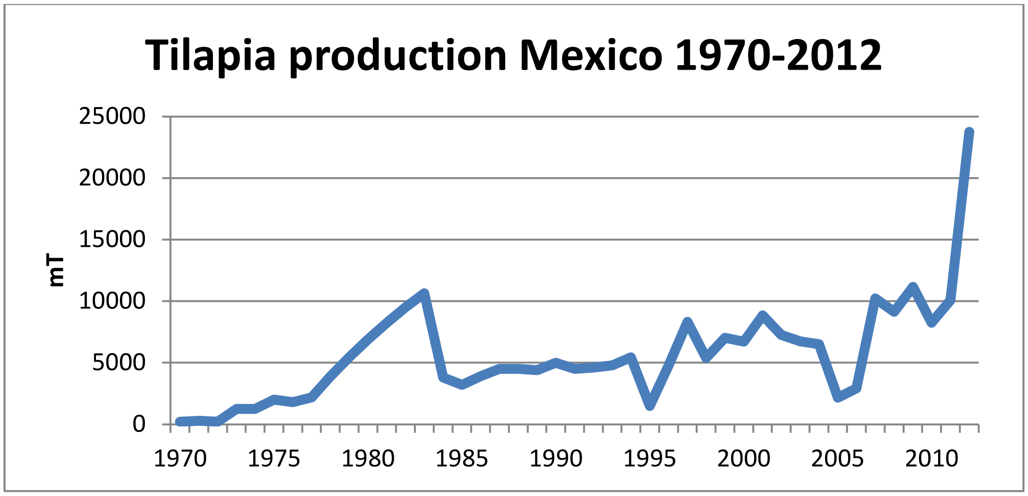

Figure 3. Tilapia production, in metric tons, in Mexico (FAO 2014a)

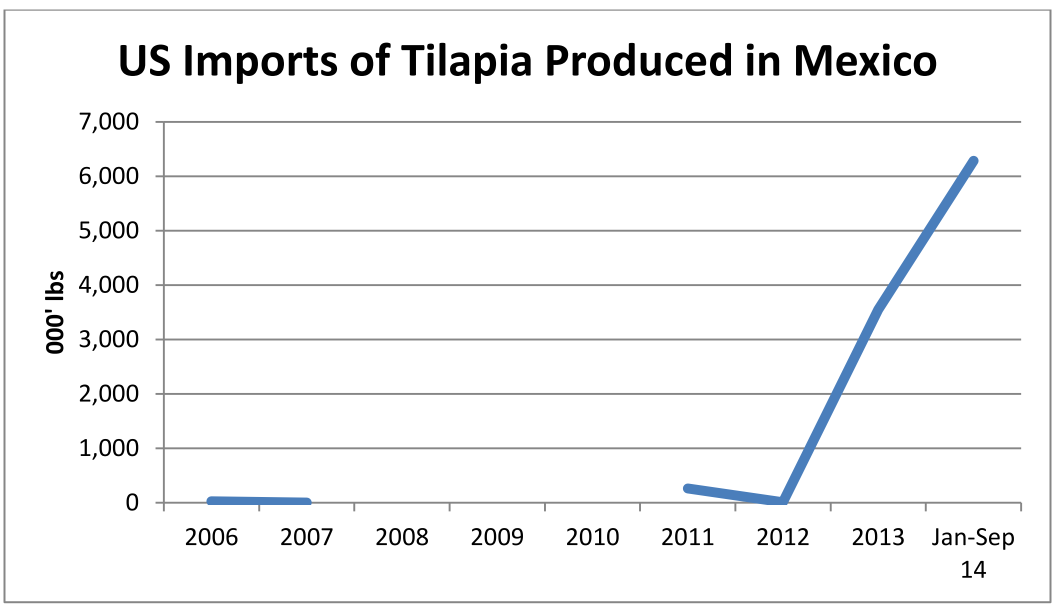

Figure 4. Tilapia imports to the United States from Mexico (USDA 2014)

Common and Market Names
Tilapia is also known in the market as Saint Peter fish and Izumidai (Fitzsimmons 2006).

Analysis

Scoring guide

- With the exception 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.seafoodwatch.org/cr/cr_seafoodwatch/content/media/mba_seafoodwatch_aquaculturecriteramethodology.pdf
- The full data values and scoring calculations are available in Annex 1.

Criterion 1: Data Quality and Availability

Impact, unit of sustainability and principle

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

Criterion 1 Summary

Data Category	Relevance (Y/N)	Data Quality	Score (0-10)
Industry or production statistics	Yes	7.5	7.5
Effluent	Yes	2.5	2.5
Locations/habitats	Yes	2.5	2.5
Chemical use	Yes	2.5	2.5
Feed	Yes	2.5	2.5
Escapes, animal movements	Yes	7.5	7.5
Disease	Yes	2.5	2.5
Source of stock	Yes	5	5
Predators and wildlife	Yes	2.5	2.5
Other – (e.g., GHG emissions)	No	Not relevant	n/a
Total			**35**

C1 Data Final Score	**3.89**	**YELLOW**

Summary

Data provided for this assessment comes mainly from the ASC audit reports which cover initial audits for the Lake Peñitas (2013) and Malpaso farms (2015) as well as one surveillance audit for the Lake Peñitas farm (2015). In addition, there was no water quality, habitat impact, or disease monitoring data shared for this assessment by the farm. As are result of the limitations in data availability, the final score for the data criterion is 3.89 out of 10.

Justification of the Ranking

As Regal Springs is the major open net cage producer of tilapia in Mexico (90%–95% of exports to the US), this assessment was conducted as a farm-level assessment rather than a country-level assessment. The authors were able to establish contact with Regal Springs and participated in a site visit in Chiapas, Mexico in early November 2013. Regal Springs has a technical team that manages the collection of data on disease, effluent, escapes, habitat, etc., however, only limited amounts of data were made available for purposes of this report. The bulk of data used in this assessment comes from publicly available ASC audit reports. Both of Regal Springs' farms are now certified to the Aquaculture Stewardship Council's tilapia standard as of April 2015 (Peñitas certified in 2013) and some of the data points could be independently verified through the third-party audit reports available on the ASC website (Stark 2013, Spence 2015). A surveillance audit of Lake Peñitas was performed early 2015 and an initial audit was conducted for Lake Malpaso. For the 2015 audit, 0 major non-compliances, 3 minor non-compliances (2 closed prior to report publication of Spence 2015), and 5 recommendations were raised for Lake Peñitas. For Maplaso, there were 0 major non-compliances, 3 minor non-compliances (2 closed prior to report publication of Spence 2015), and 6 recommendations.

All criteria that contain data points that can be partially verified are based on one initial audit plus one surveillance audit for Lake Peñitas and one initial audit for Malpaso. This results in a data quality score of 2.5 for Effluent, Locations/Habitat, Chemicals, Feed, Disease, and Predators/Wildlife. The Escapes scored a 7.5 as no data were provided on the numbers of escapees, but Regal Springs can demonstrate that they actively stock the lakes they farm with tilapia from their own hatcheries as a condition of their operating license. Source of Stock scored 5 due to Regal Springs operating their own hatcheries. The data scores combine for an overall Data Quality score of 3.90 out of 10.

Criterion 2: Effluents

Impact, unit of sustainability and principle

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

Criterion 2 Summary

Effluent Risk-Based Assessment

Effluent parameters	Value	Score	
F2.1a Biological waste (nitrogen) production per of fish (kg N ton-1)	60.8		
F2.1b Waste discharged from farm (%)	80		
F2 .1 Waste discharge score (0-10)		5	
F2.2a Content of regulations (0-5)	2.75		
F2.2b Enforcement of regulations (0-5)	4.75		
F2.2 Regulatory or management effectiveness score (0-10)		5.23	
C2 Effluent Final Score		**5.00**	**YELLOW**
Critical?	NO		

Summary

Although robust data are collected by Regal Springs and evaluated to some degree by an ASC audit, not all monitoring data were available for the purpose of this assessment and thus the risk-based effluent assessment was used rather than the evidence-based assessment. The risk-based assessment calculates the biological waste produced per ton of fish (using nitrogen as a proxy) combined with the amount of waste that is discharged from the production system. These factors are then combined with management measures present, and effectiveness of implementation at minimizing cumulative effluent impacts. An average FCR of 1.75 and protein inclusion of 32% result in 60.8 kg of nitrogen waste per ton of tilapia production. With approximately 80% of this being discharged from net pen production, nitrogen discharge is moderate at 48.6 kg nitrogen per ton of production, which results in waste discharge score of 5 out of 10. Farm-level effluent management along with the increased monitoring required for ASC certification result in a regulation and management score of 5.2 of 10. The final Criterion 2 Effluent score is 5 of 10 recognizing moderate impacts beyond the farm boundaries.

Justification of Ranking

Intensive aquaculture of tilapia can lead to eutrophication if effluents are not properly managed, which can lead to increased growth of algae and other aquatic plants (Armantrout

1998). Historically, reservoir waters used to farm tilapia in Mexico have not had issues with eutrophication, but cage farming is still not on a large scale across Mexico (Fitzsimmons 2000). While this reference is no longer current, these farm sites each remain the only sites in their respective lakes in which they operate and any further expansion will need to be closely monitored.

Regal Springs' tilapia production is certified by the Aquaculture Stewardship Council and, as such, is required to meet all of the criteria of that standard as well as all regulations set by the regional or national government(s) of Mexico for maintaining water quality (ASC 2012a, ASC 2012b). ASC certification is valid for 3 years and this report is based on the farms compliance with the ASC standard. If the farms choose to not renew their certification then the ranking is no longer applicable. The ASC audit released in 2013 indicates minor non-compliance with water quality monitoring data due to poor procedures, contamination and incorrect results (Stark 2013). However, Regal Springs is in compliance with dissolved oxygen levels, and Secchi disk measurements surpassed the lower <5m limit (meaning phosphorus and chlorophyll a measurements were not required) (ASC 2012b, Stark 2013, Spence 2015). Dissolved oxygen levels are measured and limited to ensure that the additions of nutrients to a body of water are not above a threshold likely to result in eutrophication. Secchi disk measurements (and phosphorus/chlorophyll a) are taken to make sure that nutrient additions are set and maintained below a level that will affect a body of water, depending on how nutrient rich/poor it is. Compliance with the standards and criterion evaluated are outlined in the audit reports and surveillance audits (Stark 2013, Spence 2015) for Regal Springs, Mexico and is available on the ASC website (http://www.asc-aqua.org/). Regal Springs reportedly conducts extensive daily, weekly, and monthly monitoring for factors including: turbidity, temperature, nitrite, nitrate, ammonia, oxygen, pH, Secchi disk, conductivity, chlorophyll, cumulative oxygen deficit, and total phosphorus. However, monitoring data were not made available for the purpose of these assessments, but were made available to the auditors for the ASC audits.

Factor 2.1

Factor 2.1a Biological waste produced per ton of production

Nitrogen (N) production is used as a proxy measure representing the amount of waste being produced per ton of fish. Depending on the size of fish and season, the FCR ranges from 1.5 to 1.8. A weighted average FCR of 1.75 was used in calculations (Malpaso harvests smaller fish with an FCR of 1.65 and Peñitas harvests larger fish with an FCR of 1.85; Yupangco pers. comm. 2015). The protein content of feed used is 32%. Protein is considered to be 16% nitrogen, therefore, when combined with the FCR the amount of nitrogen waste produced is calculated to be 60.2 kg per ton of tilapia (Laurence & Wallhoff pers. comm. 2014).

Factor 2.1b Production System Discharge

Regal Springs uses net pen production systems, which according to the Seafood Watch Criteria are estimated to release of 80% of fish wastes to the surrounding waterbody as soluble effluent. The remaining 20% are assumed to be solid wastes that settle on the benthic environment below the net pen (and are therefore assessed in the Habitat criterion).

The combined values for Factors 2.1a and 2.1b result in 48.6 kg of nitrogen waste discharged per ton of tilapia and results in a Factor 2.1 waste discharge score of 5 out of 10.

Factor 2.2

Factor 2.2a Regulatory or management effectiveness
Under the ASC Tilapia Standard, the ASC requires ongoing monitoring, testing and reporting of water quality and receiving waterbody quality. The standards are considered scientifically robust, however water quality limits are not specific to individual waterbodies (as the standard must apply to all geographic regions). The cumulative impact of multiple farms cannot entirely be covered by farm-level certification requirements, although the ASC Tilapia Standard includes requirements for measuring the percent change in diurnal dissolved oxygen based on the water's salinity and temperature (ASC 2012b). This standard partially addresses cumulative impacts of multiple farms in the same waterbody, but uses a standard value that is not specific to the waterbody under assessment. The score for Factor 2.2a is therefore 2.75 out of 5.

Factor 2.2b Enforcement level of effluent regulations or management
The requirements for audit and full compliance for all ASC standards mean that questions 1, 2, 4 and 5 of Factor 2.2b are all scored 1 because enforcement is considered to be effective, while question 3 is scored 0.75 as monthly monitoring may miss the peak discharge events such as harvest or peak biomass. This results in a total score of 4.75 out of 5.

The effluent regulatory and management score that results from compliance with the ASC Tilapia standards is 5.2 out of 10.

The discharge of nitrogen waste from Regal Springs farm and the current moderately effective regulation and management result in a final Effluent criterion score of 5 out of 10.

Criterion 3: Habitat

Impact, unit of sustainability and principle

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

Criterion 3 Summary

Habitat parameters	Value	Score	
F3.1 Habitat conversion and function		8.00	
F3.2a Content of habitat regulations	2.50		
F3.2b Enforcement of habitat regulations	4.00		
F3.2 Regulatory or management effectiveness score		4.00	
C3 Habitat Final Score		**6.67**	**GREEN**
Critical?	NO		

Summary

Regal Springs Mexico operations are sited in a manner to not significantly impact habitats or the ecosystem services they provide, scoring an 8 (out 10) in Factor 3.1. For regulatory and management effectiveness, compliance and auditing by the ASC tilapia standards results in a score of 4.0. When the two scores are combined the result is a final score of 6.67 or a 'Low Concern.'

Justification of Ranking

Factor 3.1. Habitat conversion and function

Habitat impacts associated with net pen farming can result under net pens when concentrations of uneaten food and feces reach levels that can result in organic enrichment and negative effects on the abundance and diversity of benthic communities. These impacts are well studied in the salmon farming industry and in some cases the impacts can be significant (Brooks and Mahnken 2003, Black et al. 2008). Floating net pens do not cause direct harm to ecosystems (especially the limited services provided by artificial reservoirs) and the impact of tilapia production in these habitats is mostly related to the enrichment of the bottom sediments and the water column.

Regal Springs operates two farms in Mexico, both in artificial reservoirs above hydroelectric dams. They operate a smallholder development project on each production site, but no other intensive aquaculture operations currently exist in either lake. Regal Springs' production is relatively large scale and intensive but each farm is located on a lake with no other commercial aquaculture operations. Water quality parameters are monitored by the company and some of the data are checked as part of the ASC certification process. However, no benthic monitoring takes place and therefore benthic impacts, while likely limited, are unknown.

Regal Springs' Lake Peñitas farm has been operating since 2012 in a freshwater reservoir that was created by an artificial dam built 25–30 years ago for hydropower. The ASC audit demonstrates that no high-value wetland habitat conversion is reported within a 5 km radius of the farm due to its construction, however, no information is available from prior to development of the dam (Stark 2013; Spence 2015). Under its standards, the ASC Tilapia Standard considers only wetland habitat impacts and does not include other types of high-value habitats as defined by Seafood Watch. Some habitat loss is expected to have occurred for the dam to be built, but the Regal Springs' farms are not the driver behind the loss. The local community surveyed in the ASC audit report for the operation reported that no change in the wetlands or habitat of the dam have occurred nor been influenced by the operations of the company. Although this information describes only one of the two production sites, the Malpaso site is also an artificial dam and that habitat was not directly converted for the purpose of farming. A score of 8.0 of 10 for minor-moderate impacts is assigned.

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

The Habitat criterion determines the impact of aquaculture on habitat function both in terms of habitat conversion and through the assessment of the existence and enforcement of regulations that control and/or limit aquaculture industry size and concentration. The regulations and management governing Regal Springs' tilapia operations in Mexico are a combination of government oversight and the added control measures to meet Aquaculture Stewardship Council (ASC) tilapia standards.

3.2a – Regulatory or management effectiveness

Regal Springs' production in Mexico is based in artificial reservoirs and completely avoids high-value habitats. The ASC standards contain limited measures to reduce habitat impact (e.g., avoidance of wetland habitat, site selection based on ecological principles and monitoring of farm expansion activities), resulting in a score of 0.75 for Factor 3.2a Question 1. The total size and concentration of the industry as well as designation of suitable areas and aquaculture development are the responsibility of Ministry of Agriculture, Livestock, Rural Development, Fisheries and Food (Secretaría de Agricultura, Ganadaría, Desarrollo Rural, Pesca y Alimentación, SAGARPA) (FAO 2013). However, even though the current commercial tilapia industry in Mexico is relatively limited in scale and is unlikely to develop rapidly (with Regal Springs as the only exporter to international markets), given the capital costs, logistics, and technical expertise required for these production systems, neither the ASC Tilapia Standard nor the government oversight offer promise of managing any expansion based on ecological principles. The future expansion of the industry does not fall under the more restrictive standards set by the ASC, as those limitations are relevant only to farms that apply for certification. In addition, the ASC standards do not robustly manage cumulative impacts. This results in a score of 0 for question 2 and 0.25 for question 3. There is some evidence that high-value habitats are being avoided for siting so the score for question 4 is 1. Question 5 scores a

0.5 because the ASC standards do not address important freshwater habitats beyond wetlands. The final score for regulatory or management effectiveness is 2.50 out of 5.

3.2b – Siting regulatory or management enforcement

Regal Springs' Mexican operations are subject to both government regulations and ASC standards and are required to be fully compliant to maintain certification. The enforcement organizations are identifiable, contactable and appropriate to the scale of the industry under the ASC certification and all of the audit reports are made public. While there is a difference between the regulations required for government and ASC certification, operating under the guidance of both reduces the potential risk for habitat impact from Regal Springs production. As a result, the scores for questions 1, 2, 4, and 5 under 3.2 b are 1. However, neither the ASC nor the Mexican government actively manage potential cumulative impacts and, as such, score 0 on Question 3 under 3.2b. The final score for siting regulatory or management effectiveness is 4.00 out of 5.

The overall Habitat regulation score is 4 of 10 and when combined with the Habitat conversion and function score results in a final Habitat score of 6.67 out of 10.

Criterion 4: Evidence or Risk of Chemical Use

Impact, unit of sustainability and principle

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

Criterion 4 Summary

Chemical Use parameters	Score	
C4 Chemical Use Score	**8.00**	
C4 Chemical Use Final Score	**8.00**	**GREEN**
Critical?	NO	

Summary

The ASC audit reports and declarations provided by Regal Springs indicate no use of chemicals during production for both production sites, which results in a high score for the chemical use criterion score (8 out of 10).

Justification of Ranking

For Regal Springs in Mexico, tilapia is grown in open net cages and chemicals would be directly released to the environment if applied. However, discussions with the farm manager and review of the current ASC audit reports indicate that no therapeutants or antibiotics are used during production (Stark 2013, Spence 2015). While the ASC verifications can provide the evidence to demonstrate limited or no chemical use, they are limited. The Lake Peñitas farm was originally audited in 2013, and there was no surveillance audit in 2014 (as there was short supply of auditors). Additionally, the surveillance audit for Lake Peñitas, along with the first audit for Malpaso, was only just conducted in 2015. This means that there have been only 2 audits of the Lake Peñitas farm and 1 of the Malpaso, which does not provide substantial evidence to support the 'no chemical use' conclusion. In hatcheries, tilapia fingerlings are fed with the male hormone for the purpose of obtaining 100% tilapia male populations; sex reversal of newly hatched tilapia aims to avoid overcrowding due to the early maturation of tilapia, and males are preferred owing to their higher growth rates compared to females (Phelps 2006). Regal Springs uses only methyltestosterone (MT) in the feed for the fingerlings at 0.002 mg per fish and iodine on divers prior to cage inspections (Laurence pers. comm. 2014). MT use is considered low risk to human health and the environment if the recommended best practices are being observed (Macintosh 2008).

Information from farm managers and the ASC audit indicates that chemicals are used only in the hatchery stage and results in a chemical criterion score of 8 out of 10.

Criterion 5: Feed

Impact, unit of sustainability and principle

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

Criterion 5 Summary

Feed parameters	Value	Score	
F5.1a Fish In: Fish Out ratio (FIFO)	0.26	9.34	
F5.1b Source fishery sustainability score		-2.00	
F5.1: Wild Fish Use		9.29	
F5.2a Protein IN	31.72		
F5.2b Protein OUT	14.00		
F5.2: Net Protein Gain or Loss (%)	-55.86	4	
F5.3: Feed Footprint (hectares)	2.81	9	
C5 Feed Final Score		**7.90**	**GREEN**
Critical?	NO		

Summary

The overall Wild Fish Use score was 9.34 (out of 10) due to a low Fish In: Fish Out (FIFO) ratio of 0.26 made possible by low inclusion rates of fishmeal and fish oil and the use of fisheries byproducts. Regal Springs' Mexico production results in a net loss of protein (-55.9%) and a score of 4 out of 10 for Factor 5.2. The feed footprint was found to score 9 out of 10 due to a high use of crop ingredients. Overall for this criterion, Regal Spring tilapia scores 7.90 (out 10).

Justification of Ranking

C5.1. Wild Fish Use

The Wild Fish Use factor calculates the FIFO ratio to get a score that is adjusted by the sustainability of the source of marine ingredients. Tilapia feeds in Mexico consist of 4%–6% marine ingredients, where fishmeal is included at 2%–4% (average 3%), and fish oil at 1%–2% (average 1.5%)(Laurence & Wallhoff 2014 pers. comm.). In addition, Regal uses byproducts for 90% of their fishmeal and 50% of their fish oil (Spence 2015, Yupangco pers. comm. 2015). Feed conversion ratios (FCRs) in tilapia aquaculture vary depending on several factors, including fish size, water temperature, and the amount of fishmeal in feed (Boyd 2005). Global farmed tilapia FCR was predicted to be around 1.6 by 2010 (Tacon 2004) and the average reported by Regal

Springs is 1.75 (Malpaso harvests smaller tilapia with an FCR of 1.65 and Peñitas harvests larger with an FCR of 1.85; Yupangco pers. comm. 2015).

The FIFO is calculated separately for fishmeal and fish oil through their inclusion level (minus any byproducts used of which there are none in feeds used by Regal Springs), their yields (i.e., the proportion of fishmeal and fish oil obtained from processing the fish; 22.5% and 5% respectively), and the feed conversion ratio. The FIFO value for fish oil is the higher of the two (0.26), therefore it is used to drive the FIFO calculations. The fish oil generally drives the FIFO value due to its lower yield when compared to the fishmeal (Naylor et al. 2009). The relatively low FIFO value determines a high FIFO score (9.34 of 10). This score is corrected by the Source Fishery Sustainability factor calculated on the sole use of South American pilchard (*Sardinop sagax*) from the Gulf of California (Yupangco pers. comm. 2015). No FishSource scores are currently available for this stock, but the fishery is MSC certified with minor conditions, resulting in a sustainability of the source of wild fish (SSWF) score of -2. The low inclusion level and a low penalization for sourcing results in a high overall Wild Fish Use score (9.29 out of 10).

Factor 5.2. Net Protein Gain or Loss

The majority of tilapia aquaculture in Mexico uses formulated feeds, including Regal Springs (Fitzsimmons 2000, Laurence pers. comm. 2014). Regal Springs' tilapia feed in Mexico contains 32% crude protein (Laurence pers. comm. 2014).

Protein comes from a number of sources, all of which are edible by humans (marine ingredients, crop ingredients) with the exception of that from land animal byproduct (Yupangco pers. comm. 2015). Land animal byproduct comprises 14% of feed, or 24% of the overall protein (assuming all land animal ingredients are protein contributing ingredients and assuming a protein yield of 55.6%). Of the total protein in the feed, 67.7% is from edible crop sources with the remaining 8.3% of protein coming from marine sources. The average protein content of whole harvested fish is 14% (Boyd 2007). The edible yield of tilapia is 37% (DeLong et al. 2009). Finally, the percentage of nonedible byproducts from harvested farmed tilapia by Regal Springs used for other food production was 100% as the fish are generally sold as whole fish in local markets (30%) and as fillets on the US market (70%, but with 100% use of byproducts in further feed production) (Laurence & Wallhoff pers. comm. 2014).

The protein gain or loss from tilapia production is calculated using the amount of edible protein going into the system versus the amount of edible protein regained at harvest. Regal Springs Mexican tilapia production has a protein loss of -55.9%, which results in a score for this factor of 4 out of 10.

Factor 5.3. Feed Footprint

The feed footprint is estimated through the sum of the ocean and land areas required to produce the crop, terrestrial animal and marine ingredients in feeds. Although byproducts offset the use of resources in the first two feed categories, all feed sources are included in the feed footprint calculation since they represent the appropriation of primary productivity that would otherwise remain in the respective ecosystems.

The greater the amount of feed from crop ingredients the lower the overall feed footprint. Listed in descending order of primary productivity requirements: marine ingredients, land animal ingredients, crop based ingredients. Crop ingredient inclusion amounted to 75%, and marine and terrestrial animal ingredients (6% and 14% respectively) result in a low feed footprint of 2.81 hectares. This results in a high feed footprint score of 9 out of 10.

The three feed factors combine to give a high final score of 7.54 out of 10.

Criterion 6: Escapes

Impact, unit of sustainability and principle

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

Criterion 6 Summary

Escape parameters	Value	Score	
C6 Escape Final Score		**7.00**	**GREEN**
Critical?	NO		

Summary

As Regal Spring's Mexico operates in artificial lakes that they actively stock with tilapia from their own hatchery as a condition of their license to operate, the Seafood Watch 'Risk of Escape' assessment criteria are not robustly applicable. Given that there is no way to definitively determine that escaped tilapia are or are not having an impact the score for this criteria is a "low conservation concern" which translates to a 7 out of 10.

Justification of Ranking

Factor 6.1a. Escape risk

Tilapia was introduced to Mexican water bodies for non-aquaculture purposes, therefore it is difficult to measure to what extent tilapia catches are controlling escapees or just reducing the level of tilapia populations already established in the wild. The Mexican government continues to deliberately release tilapia into lakes for food security purposes (Laurence & Wallhoff pers. comm. 2014). Both lakes Regal Springs where operates were artificially created and were stocked with tilapia prior to when production began. Regal Springs also has developed a system to recapture tilapia by using gillnets after an escape is detected with traps placed between cages to sample the escapes. Even though Regal Springs operates "high risk" systems for its production, the reality of the continual introductions of tilapia by Regal Springs into the lakes it operates from its own hatcheries as a condition of its operating license means that the Seafood Watch Criteria are not robustly applicable (Stark 2013, Spence 2015).

Factor 6.1b. Invasiveness

Tilapia is only native to Africa and the Middle East but is now one of the most widely distributed exotic fish species in the world (De Silva et al. 2004). Tilapia were intentionally introduced and widely distributed in many countries in the mid-1900s for aquatic weed and mosquito control agents as superior options over herbicides and pesticides. However, they were able to establish breeding populations in new habitats because they reproduce quickly and have a high affinity for disturbed ecosystems (Canonico et al. 2005). The introduction of tilapia, especially into altered habitats, has been linked to the decline of native species in varied freshwater habitats across the globe (Boyd et al. 2005, Senanan & Bart 2009).

Tilapia were introduced to Mexico in the 1960s and 1970s and are now found in every state and are established in the wild throughout much of the country (Fitzsimmons 2000). Regal Springs raises only *Oreochromis niloticus* (nile tilapia). As noted above, both Lake Malpaso and Lake Peñitas had been stocked with tilapia prior to Regal Springs initiating production. While it is not environmentally benign for the government to stock lakes with a non-native species, there appears to be a relatively low added risk from escaped fish from Regal Springs' operations. Although the Escapes scoring matrix using the production system risk and invasiveness score results in a final score of 5 out of 10, this seems to unduly punish Regal Springs for a system already stocked with the same species. There is still ongoing potential for some level of impact from escapees and thus does not warrant a perfect score, but an exception is made in this case and results in a higher final Escape score of 7 out of 10.

Criterion 7: Disease; Pathogen and Parasite Interactions

Impact, unit of sustainability and principle

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

Criterion 7 Summary

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

Summary

Regal Springs operates an open net system that is open to the discharge of pathogens as well as the introductions of pathogens and parasites. It has biosecurity measures in place as well as a monitoring program but no data were shared to demonstrate performance. The ASC audit offers some confirmation of a low occurrence of disease through a demonstrably low use of chemicals. Regal Springs' Mexican tilapia scores a 4 of 10, or a moderate conservation concern on the disease criterion.

Justification of Ranking

Tilapia disease problems are caused by parasites, fungi, viruses and bacterial pathogens (CSPTM 2009). Bacterial pathogens *Aeromonas dhakensis*, *Pseudomonas Mosselii,* and *Microbacterium paraoxydans* have been isolated from diseased farmed tilapia in Sinaloa, Mexico (Soto-Rodriguez et al. 2013). Although these bacteria do not appear to be a widespread problem in Mexican tilapia aquaculture yet, they are virulent, known to occur predominantly throughout warm countries and precautions should be taken to prevent their introduction and spread (Soto-Rodriguez et al. 2013). Boyd (2005) further reports that tilapia are more resistant to disease than most cultured species and there is generally a low incidence of disease in tilapia farms. The most common health problem encountered in Mexican tilapia (primarily on juveniles) is infestation with parasites (CSPTM 2009).

In Mexico, Regal Springs reports low occurrence of parasites/disease (*Aeromonas, Pseudomonas* and *Streptococcus*), but data on mortality were shared for confirmation (Laurence pers. comm. 2014, Yupanco pers. comm. 2015). The ASC audit report provides some confirmation in that there is verification and proper disposal of mortalities as well as the presence and implementation of a site-specific health plan that includes effective measures to protect the farm from the introduction of pathogens, preventing the spread of pathogens within the farms and to receiving waters, and reducing the potential for development of disease resistance by mandating responsible therapeutant use. In addition, the ASC audits demonstrate that is no chemical use, which further suggests the low occurrence of disease (Stark 2013, Spence 2015).

Despite the low reported occurrence of disease in Regal Springs' operations, the production systems are open to the surrounding ecosystem and cannot prevent the spread of any pathogens or parasites that may occur to established tilapia populations. The final disease criterion score is cautious and combines the low concern for disease with the high risk for spread if an outbreak should occur. The overall score is a moderate 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 ongrowing to harvest size in farms*
- *Sustainability unit: wild fish populations*
- *Principle: aquaculture operations use eggs, larvae, or juvenile fish produced from farm-raised broodstocks thereby avoiding the need for wild capture*

Criterion 8 Summary

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

Summary and Justification of Ranking

Regal Springs Mexico is a vertically integrated company and operates its own hatchery. All of the tilapia stock is obtained from hatchery-raised broodstock on-farm (Laurence & Wallhoff pers. comm. 2014). As tilapia production in Mexico is considered to be fully independent from wild fisheries, the overall score for the source of stock criterion is 10 of 10.

Criterion 9X: Predator and wildlife 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" criteria that may not apply in many circumstances. It generates a negative score that is deducted from the overall final score. A score of zero means there is no impact.

Criterion 9X Summary

Wildlife and predator mortality parameters	Score	
F9X Wildlife and predator mortality Final Score	**-2.0**	**GREEN**
Critical?	NO	

Summary and Justification of Ranking

Aquaculture operations can directly or indirectly cause the death of predators or other wildlife that are attracted by the concentration of cultured aquatic animals. Regal Springs uses nets to cover their cages while the fish are small, but otherwise uses no other forms of predator control (author personal observation 2013, Stark 2013, Spence 2015). The ASC audits of Regal Springs' farms in 2013 and 2015 confirm no use of lethal predator devices and no mortality of IUCN listed species. The only reported wildlife mortalities from their operations were birds (cormorants) but exact numbers are not available although the mortalities are not considered to occur beyond exceptional cases (Stark 2013, Lawrence pers. comm. 2014, Spence 2015). A score of -2.0 of -10 was assigned for this exceptional criterion.

Criterion 10X: Escape of unintentionally introduced species

A measure of the escape risk (introduction to the wild) of alien species other than the principle farmed species unintentionally transported during live animal shipments. This is an "exceptional criteria that may not apply in many circumstances. It generates a negative score that is deducted from the overall final score.

Criterion 10X Summary

Escape of unintentionally introduced species parameters	Score	
10Xa International or trans-waterbody live animal shipments (%)	0.00	
10Xb Biosecurity of source/destination	6.00	
C10X Escape of unintentionally introduced species Final Score	**-4.00**	**GREEN**

Summary and Justification of Ranking

There is zero reliance on international shipping of broodstock, however, 100% of production at Regal Springs' farm sites relies on trans-waterbody movement of live animals within the country. The ASC tilapia standards required evidence of the use of fish transport containers that eliminate the option of an escape of the culture species and the ASC audits demonstrate Regal Springs' compliance with this requirement (Stark 2013, Spence 2015). However, this demonstrates that trans-waterbody movements of live tilapia occurs. As a result the biosecurity of both the source and the destination of the live animals must be assessed. Regal Springs owns and operates its own hatchery in above-ground cement tanks (Yupanco pers. comm. 2015). The company reports the facility is biosecure, including being guarded by a perimeter fence, quarantine areas, individual water flow to each tank, and disinfection areas for people and vehicles entering and leaving the hatchery (Yupanco pers. comm. 2015). This results in a score of 6 out of 10 for the source. The destination is open net pens that operate with best management practices, which results in a score 2 of 10. These factors result in a moderate risk of unintentionally introducing non-native species as a result of Regal Springs' activities and result in a final score for Criterion 10X of -4 out of -10.

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

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Data Points And All Scoring Calculations

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

Criterion 1: Data quality and availability

Data Category	Relevance (Y/N)	Data Quality	Score (0-10)
Industry or production statistics	*Yes*	7.5	7.5
Effluent	Yes	2.5	2.5
Locations/habitats	Yes	2.5	2.5
Chemical use	Yes	2.5	2.5
Feed	Yes	2.5	2.5
Escapes, animal movements	Yes	7.5	7.5
Disease	Yes	2.5	2.5
Source of stock	Yes	5	5
Predators and wildlife	Yes	2.5	2.5
Other – (e.g., GHG emissions)	No	Not relevant	n/a
Total			**35**

C1 Data Final Score	3.89	**YELLOW**

Criterion 2: Effluents

Factor 2.1a - Biological waste production score

Protein content of feed (%)	32
eFCR	1.75
Fertilizer N input (kg N/ton fish)	0
Protein content of harvested fish (%)	18
N content factor (fixed)	*0.16*
N input per ton of fish produced (kg)	89.6
N in each ton of fish harvested (kg)	28.8
Waste N produced per ton of fish (kg)	**60.8**

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 aquaculture?	Yes	1
2–Are the control measures applied according to site-specific conditions and/or do they lead to site-specific effluent, biomass or other discharge limits?	Mostly	0.75
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 receiving waterbody?	Partly	0.25
5–Do the control measures cover or prescribe including peak biomass, harvest, sludge disposal, cleaning etc?	Moderately	0.5
		2.75

Factor 2.2b–Enforcement level of effluent regulations or management

Question	Scoring	Score
1–Are the enforcement organizations and/or resources identifiable and contactable, and appropriate to the scale of the industry?	Yes	1
2–Does monitoring data or other available information demonstrate active enforcement of the control measures?	Yes	1
3–Does enforcement cover the entire production cycle (i.e., are peak discharges such as peak biomass, harvest, sludge disposal, cleaning included)?	Mostly	0.75
4–Does enforcement demonstrably result in compliance with set limits?	Yes	1
5–Is there evidence of robust penalties for infringements?	Yes	1
		4.75

F2.2 Score (2.2a*2.2b/2.5)	**5.23**

C2 Effluent Final Score	**5.00**	**YELLOW**
	Critical?	NO

Criterion 3: Habitat

3.1. Habitat conversion and function

F3.1 Score	**8**

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

Factor 3.2a–Regulatory or management effectiveness

Question	Scoring	Score
1–Is the farm location, siting and/or licensing process based on ecological principles, including an EIAs requirement for new sites?	Mostly	0.75
2–Is the industry's total size and concentration based on its cumulative impacts and the maintenance of ecosystem function?	No	0
3 – Is the industry's ongoing and future expansion appropriate locations, and thereby preventing the future loss of ecosystem services?	Partly	0.25
4–Are high-value habitats being avoided for aquaculture siting? (i.e., avoidance of areas critical to vulnerable wild populations; effective zoning, or compliance with international agreements such as the Ramsar treaty)	Yes	1
5–Do control measures include requirements for the restoration of important or critical habitats or ecosystem services?	Moderatel y	0.5
		2.5

Factor 3.2b–Siting regulatory or management enforcement

Question	Scoring	Score
1–Are enforcement organizations or individuals identifiable and contactable, and are they appropriate to the scale of the industry?	Yes	1
2–Does the farm siting or permitting process function according to the zoning or other ecosystem-based management plans articulated in the control measures?	Yes	1
3–Does the farm siting or permitting process take account of other farms and their cumulative impacts?	No	0
4–Is the enforcement process transparent–e.g., public availability of farm locations and sizes, EIA reports, zoning plans, etc.?	Yes	1
5–Is there evidence that the restrictions or limits defined in the control measures are being achieved?	Yes	1
		4

F3.2 Score (2.2a*2.2b/2.5)	**4.00**

C3 Habitat Final Score	**6.67**	**GREEN**
	Critical?	NO

Criterion 4: Evidence or Risk of Chemical Use

Chemical Use parameters	Score	
C4 Chemical Use Score	**8.00**	
C4 Chemical Use Final Score	**8.00**	**GREEN**
Critical?	NO	

Criterion 5: Feed

5.1. Wild Fish Use

Factor 5.1a–Fish In: Fish Out (FIFO)

Fishmeal inclusion level (%)	3
Fishmeal from byproducts (%)	90
% FM	0.3
Fish oil inclusion level (%)	1.5
Fish oil from byproducts (%)	50
% FO	0.75
Fishmeal yield (%)	22.5
Fish oil yield (%)	5
eFCR	1.75
FIFO fishmeal	0.02
FIFO fish oil	0.26
Greater of the 2 FIFO scores	0.26
FIFO Score	**9.34**

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

SSWF	-2
SSWF Factor	-0.0525

F5.1 Wild Fish Use Score	**9.29**

5.2. Net Protein Gain Or Loss

Protein INPUTS		
Protein content of feed		32
eFCR		1.75
Feed protein from NON-EDIBLE sources (%)		24
Feed protein from EDIBLE CROP sources (%)		67.7
Protein OUTPUTS		
Protein content of whole harvested fish (%)		14
Edible yield of harvested fish (%)		37
Non-edible byproducts from harvested fish used for other food production		100
Protein IN		31.72
Protein OUT		14
Net protein gain or loss (%)		-55.86
	Critical?	NO
F5.2 Net protein Score	**4.00**	

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 (%)	4.5
eFCR	1.75
Average Primary Productivity (C) required for aquatic feed ingredients (ton C/ton fish)	*69.7*
Average ocean productivity for continental shelf areas (ton C/ha)	*2.68*
Ocean area appropriated (ha/ton fish)	2.05

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

Inclusion level of crop feed ingredients (%)	75
Inclusion level of land animal products (%)	14
Conversion ratio of crop ingredients to land animal products	*2.88*
eFCR	1.75
Average yield of major feed ingredient crops (t/ha)	*2.64*
Land area appropriated (ha per ton of fish)	0.76

Value (Ocean + Land Area)	**2.81**

F5.3 Feed Footprint Score	**9.00**

C5 Feed Final Score	**7.90**	**GREEN**
	Critical?	**NO**

Criterion 6: Escapes

Final C6 Score	**7.00**	**GREEN**
	Critical?	**NO**

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	100	
C8 Source of stock Final Score	**10**	**GREEN**

Exceptional Criterion 9X: Wildlife and predator mortalities

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

Exceptional Criterion 10X: Escape of unintentionally introduced species

Escape of unintentionally introduced species parameters	Score	
F10Xa International or trans-waterbody live animal shipments (%)	0.00	
F10Xb Biosecurity of source/destination	6.00	
C10X Escape of unintentionally introduced species Final Score	**-4.00**	**GREEN**