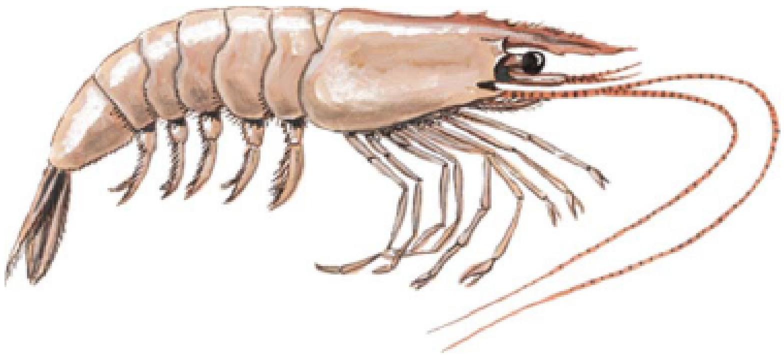
Whiteleg shrimp

Litopenaeus vannamei



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Nicaragua

Ponds

Assessment ID 28251

February 5, 2024

Seafood Watch Standard used in this assessment: Aquaculture Standard v3.2

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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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.

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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 brood stocks 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)

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

Once a score and rating has been assigned to each criterion, an overall seafood recommendation is developed on additional evaluation guidelines. Criteria ratings 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

This assessment was originally published in November 2018 and reviewed for any significant changes in August 2023. No changes were made to the body of the report. See Appendix 3 for details of review.

Farmed white-leg shrimp from ponds in Nicaragua

Criterion	Score	Rank	Critical?
C1 Data	3.86	YELLOW	
C2 Effluent	4.00	YELLOW	NO
C3 Habitat	0.27	RED	YES
C4 Chemicals	0.00	RED	NO
C5 Feed	6.19	YELLOW	NO
C6 Escapes	3.00	RED	NO
C7 Disease	4.00	YELLOW	NO
C8X Source	–2.00	GREEN	NO
C9X Wildlife mortalities	–4.00	YELLOW	NO
C10X Secondary species escape	0.00	GREEN	
Total	**15.32**		
Final score (0–10)	**2.19**		

OVERALL RANKING

Final Score	2.19
Initial rank	RED
Red criteria	3
Interim rank	RED
Critical Criteria?	YES

FINAL RANK

RED

Scoring note: scores range from 0 to 10, where 0 indicates very poor performance and 10 indicates the aquaculture operations have no significant impact. Criteria 8X, 9X, and 10X are exceptional criteria, where 0 indicates no impact and a deduction of –10 reflects a very significant impact. Two or more Red criteria result in a Red final result.

Summary

The final score for farmed white-leg shrimp from Nicaragua is 2.19 out of 10, and with three Red criteria, the final recommendation is “Avoid.”

Executive Summary

This assessment was originally published in November 2018 and was reviewed for any significant changes in August 2023. See Appendix 3 for the details and findings of the review. Also note that other than Appendix 3, no other text has been changed from the 2018 report. That is, the only updated information, following the review, is in Appendix 3.

This assessment covers the production of white-leg shrimp (*Litopenaeus vannamei*) in ponds in Nicaragua and focuses on semi-intensive farming, which represents >80% of total harvests and a majority of exports to the United States. The industry is concentrated in the northwest of the country in the Estero Real at the southern end of the Gulf of Fonseca and produces approximately 25,000 metric tons (MT) per year (24,557 MT in 2015) from a total of approximately 14,700 hectares (ha) of ponds. Exports to the United States have been variable but were 1,839 MT in 2017 (down from approximately 5,000 MT in the mid-2000s).

This Seafood Watch assessment includes criteria covering impacts associated with effluent, habitats, wildlife and predator interactions, chemical use, feed production, escapes, introduction of secondary species (other than the farmed species), disease, the source stock, and general data availability.

Data on Nicaragua shrimp farms were generally scarce, and typically of questionable temporal validity. Information requests to the Nicaraguan Institute of Fisheries and Aquaculture (INPESCA), the Ministry of Environment and Natural Resources (MARENA), and to producers and feed mills were all unsuccessful. Academic research in the region is also limited and often dated. Data from the producers are also scarce except for one useful 2018 audit report from two farms certified to the Aquaculture Stewardship Council's Farmed Shrimp standard. Overall, the final score for Criterion 1—Data was 3.9 out of 10.

There is little information with which to assess the effluent impacts of Nicaraguan shrimp farms directly, particularly the cumulative impacts from all the farms in the Estero Real, but information from local communities/authorities and government reports shows some concerns. The available specific data on nutrient inputs (primarily from an ASC audit report of two farms) indicate that, although both feed and nitrogen fertilizer are used, water exchange is relatively low and it appears likely that at least the large farms have relatively low nitrogen discharges per ton of production (20.9 kg N per MT of shrimp). There are legal requirements in place relating to farm effluent concentration limits, but there is little accessible information on the management and regulatory systems in place to address total discharges from any one farm or the potential cumulative impacts from multiple farms. Given the limited information, the Risk Assessment was used, and the final score for Criterion 2—Effluent is 4 out of 10.

The majority of Nicaragua's shrimp farms are located in the Estero Real, an ecologically important area that includes the country's largest extension of mangrove forests. The majority of shrimp farms were built on hypersaline mud and sand flats within broader mangrove areas, with little direct loss of mangrove trees; however, these sand and mud flats represent part of the broader ecosystem, and the seasonal dry forest has been considered the most endangered terrestrial ecosystem in the tropics. The Estero Real is a shorebird reserve of hemispheric importance for resident and migratory birds, and areas of greatest concentration of birds are under the direct influence of thousands of hectares of shrimp farming. The farm activities directly influence the feeding habitat and refuge of shorebirds. Overall, the wetlands (i.e., including the salt flat areas) in the Estero Real region have been greatly reduced, especially toward the mouth of the river where they have been converted into shrimp ponds. And, although the majority of pond construction occurred before 1999, there has been substantial construction since the area was protected (in 1983) and then designated as a Ramsar site (in 2001).

These habitat conversions represent an extensive change to the estuarine ecosystem, and the ecological effects of changes to the hydrology of the broader habitats from pond construction continue to be uncertain. The regulatory systems in Nicaragua for managing high-value habitats are complex and unclear. There is evidence of permitting processes in place in some (independently certified) farms, but there is little readily available content on habitat connectivity, cumulative impacts, or enforcement. Satellite images show recent construction of ponds in salt flats and dry forests in the last 5 years. Overall, the final score for Criterion 3—Habitat is 0.27 out of 10, which reflects the critical concerns that remain regarding the habitat impacts of shrimp farms in Nicaragua.

There are no reliable data available on the current use of chemicals in Nicaraguan shrimp farms. Three antibiotics are currently authorized for use in aquaculture in Nicaragua, and there is now-dated evidence that one of them (oxytetracycline) was used by a small proportion of farms in the past (2010), and circumstantial evidence that a second (enrofloxacin) has been supplied in medicated feeds to shrimp farms in 2014. The only specific recent farm data from a total of four farms audited by the ASC and the European Commission show that antibiotics (or other chemicals) have not been used. Without any recent evidence on chemical use from all shrimp farms in Nicaragua, or data from feed mills and/or the relevant authorities, the use of both highly important and critically important antibiotics is largely unknown, and the final score for Criterion 4—Chemical Use is 0 out of 10, on a precautionary basis.

The majority of shrimp culture (semi-intensive) in Nicaragua relies on artificial food in pellet form, in addition to natural food in the ponds stimulated by added fertilizer. Information requests to three feed companies were not met, but useful data on those companies' feeds were available in a 2018 ASC audit report, so they were considered to be a useful reflection of the country as a whole. Using a (precautionary) economic feed conversion ratio of 1.56 and an average inclusion of 14.5% fishmeal and 1.5% fish oil in the feeds, the Feed Fish Efficiency Ratio (FFER) was 0.7 for fishmeal (the fish oil came from by-products and was therefore not included in the calculation). This indicates that, from first principles, 0.7 tons of wild fish are required to produce 1 ton of farmed shrimp. The source fisheries for fishmeal were not known, and the adjusted Wild Fish Use score is 6.9 out of 10. A net edible protein loss of 55.8 % was calculated, based on an assumption that all nonmarine feed ingredients were edible crops. A combined ocean and land area of 7.0 ha is required to supply the amount of feed ingredients necessary to produce 1 ton of farmed shrimp. Overall, the final score for Criterion 5—Feed is 6.2 out of 10.

Shrimp can escape from ponds during daily water exchanges and specific events such as harvest. In addition, the area is prone to flooding in peak rainy seasons, and the destruction of one-quarter of the shrimp ponds in Nicaragua during Hurricane Mitch in 1998 highlighted the storm and flood risk. The majority of production in Nicaragua is considered to be based on multigeneration, selectively bred broodstock, with genetic and phenotypic differentiation from wild shrimp populations. Therefore, although the risk of genetic introgression to the genetically diverse wild populations is perhaps low, the high escape risk means that, when Factors 6.1 and 6.2 are combined, the final score for Criterion 6—Escapes is 3 out of 10.

Shrimp farming globally, including in Nicaragua, has suffered a series of bacterial and viral disease outbreaks, creating serious economic challenges for the industry. No recent data on routine disease monitoring could be obtained from Nicaragua, but dated information shows that a wide range of pathogens have been reported, with the white spot syndrome virus (WSSV), necrotizing hepatopancreatitis (NHP), and bacterial vibriosis being the most common. Recent anecdotal evidence shows that emerging global shrimp pathogens such as early mortality syndrome (EMS) are also present in Nicaragua. There is no evidence of farmed shrimp diseases affecting wild shrimp populations in Nicaragua, but examples of disease transmission can be found elsewhere (e.g., in Mexico). With limited information, the Seafood Watch Risk-Based Assessment was used. Based on the open nature of the production system, which remains vulnerable to the introduction, amplification, and discharge of pathogens, the final score for Criterion 7—Disease is 4 out of 10.

No current information on the scale of use of captive-bred broodstock, postlarvae, or juveniles could be found. Dated information from 2009 to 2010 shows that, although 100% of artisanal and extensive producers still used wild-caught juveniles (potentially from both passive and active collection), 75% of semi-intensive producers at that time used captive-bred sources. The use of captive-bred stocks is likely to have increased since then; however, even though the exact figure is considered to be somewhere between 75% and 100%, and likely closer to the latter, there is no information with which to make an informed estimate of the current level. The figure of 100% captive-bred stocks was used in order to maintain consistency with Criterion 6—Escapes, where 100% was used on a precautionary basis.[2] Therefore, the final score for Criterion 8X is a deduction of –0 out of –10.

Shrimp ponds attract a variety of predators, particularly birds, but no specific data on predator mortalities in Nicaragua were found. A list of relevant local species in the ASC audit reports included several species of birds, but they were all listed as “Least Concern” by the International Union for the Conservation of Nature (IUCN). This gives some confidence that any

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[2] Note: if the figure of 75% were used, the final score for this criterion would be a deduction of –2 out of –10, and the overall final recommendation for this assessment would remain the same.

mortalities are unlikely to significantly affect the species' population sizes, so the final score for Criterion 9X—Wildlife and Predator Mortalities is –4 out of –10.

No data could be found on current live animal importations; however, though it is possible that some broodstock continue to be imported into Nicaragua for breeding programs, these would be considered to come from specialist breeding facilities with high biosecurity. Although it is also possible that there is some international exchange of broodstock or postlarvae with neighboring Honduras, these regions share the same waterbody in the Gulf of Fonseca. Therefore, trans-waterbody shipments of live animals that risk the unintentional introduction of nonnative species are not currently considered to be significant. The final score for Criterion 10X—Escape of Secondary Species is a deduction of –0 out of –10.

Overall, this assessment of white-leg shrimp aquaculture in Nicaragua was limited by poor data availability. The final numerical score is 2.2 out of 10, and there is a critical conservation concern regarding habitat conversion and high concerns regarding chemical use and escapes. The final recommendation is "Avoid."

Introduction

Scope of the analysis and ensuing recommendation

Species

White-leg shrimp, *Litopenaeus vannamei* (formerly known as *Penaeus vannamei*)

Geographic Coverage

Nicaragua

Production Method(s)

Ponds (semi-intensive)

Species Overview

Brief overview of the species

Litopenaeus vannamei lives in tropical marine habitats and is native to the Eastern Pacific coast from Sonora, Mexico in the north to Tumbes, Peru in the south. Thus, it is native to the Pacific coast of Nicaragua. Like all Penaeid species, adults live and spawn in the open ocean, while postlarvae (PL) migrate inshore to spend their juvenile, adolescent, and sub-adult stages in coastal estuaries, lagoons, or mangrove areas (FAO 2006).

Production system

Shrimp are farmed in ponds in Nicaragua, located primarily in the northwest of the country (Figure 1, and more detail in Figure 6) along the estuary Estero Real in the Chinandega department, where 98% of the national production is concentrated (Rivas 2013). The remainder is in the Léon department (adjoining Chinandega department to the south, and therefore also on the Pacific coast). The focus of this assessment is on dominant production in the Estero Real.

Shrimp farming in ponds can be managed at differing intensities, mostly defined by stocking densities, water exchange, the use of mechanical aeration, and the reliance on artificial feed. According to the National Institute of Fisheries and Aquaculture (INPESCA), Nicaragua has a mix of extensive, semi-intensive, intensive, and artisanal production, but in 2015, 83% of total shrimp harvests came from semi-intensive ponds (INPESCA 2016), and these are the focus of this assessment.

As an approximate guide (from FAO 2009), semi-intensive ponds of typically 1 to 5 hectares (ha) are stocked with hatchery-produced seeds at 10 to 30 post larvae (PL)/m². Regular water exchange is by pumping, pond depth is 1.0 to 1.2 m, and aeration is at best minimal. The shrimp feed on natural foods enhanced by pond fertilization, supplemented by formulated diets two to three times daily. Production yields in semi-intensive ponds range from 500 to 2000 kg/ha/crop, with two crops per year.

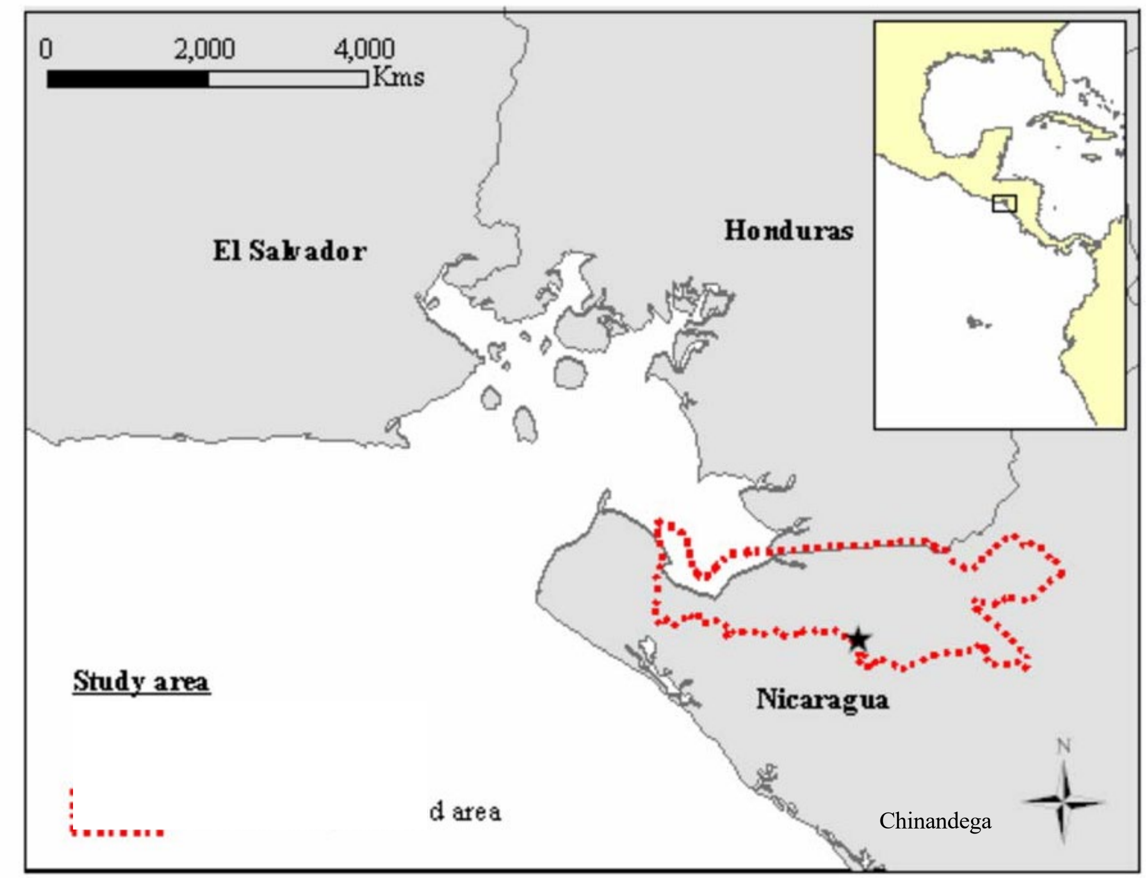

Figure 1: Estero Real region (in red), adapted from (Benessaiah 2008).

No robust data on daily water exchange rates in Nicaragua could be found, but the FAO country profile (FAO 2005) reports that high water-exchange rates (that were on the order of 10% to 20% per day) were reduced to close to zero in the early 2000s after an outbreak of white-spot disease in 1999. In 2001, traditional semi-intensive shrimp ponds in Nicaragua were reported to be managed with zero water exchange through the dry season to avoid introduction of disease (Cummings 2001). In contrast, recent specific audited examples available from two Nicaraguan farms certified to the Aquaculture Stewardship Council's (ASC) Shrimp Standard report a 4% water exchange/day (ASC 2018).

Production Statistics

Production of farmed shrimp began in Nicaragua in the early 1990s, increasing to a peak of 30,528 MT in 2014 followed by a decline to 24,557 MT in 2015 (Figure 2) (data from FAO[3] and INPESCA's annual fisheries and aquaculture report).[4] INPESCA data also show that the total pond area increased accordingly but was relatively stable at approximately 11,000 ha from

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[3] UN Food and Agriculture Organisation. Fishstat.

[4] Anuario Pesquero y Acuicola; INPESCA, http://www.inpesca.gob.ni/index.php?option=com_content&view=article&id=18&Itemid=100

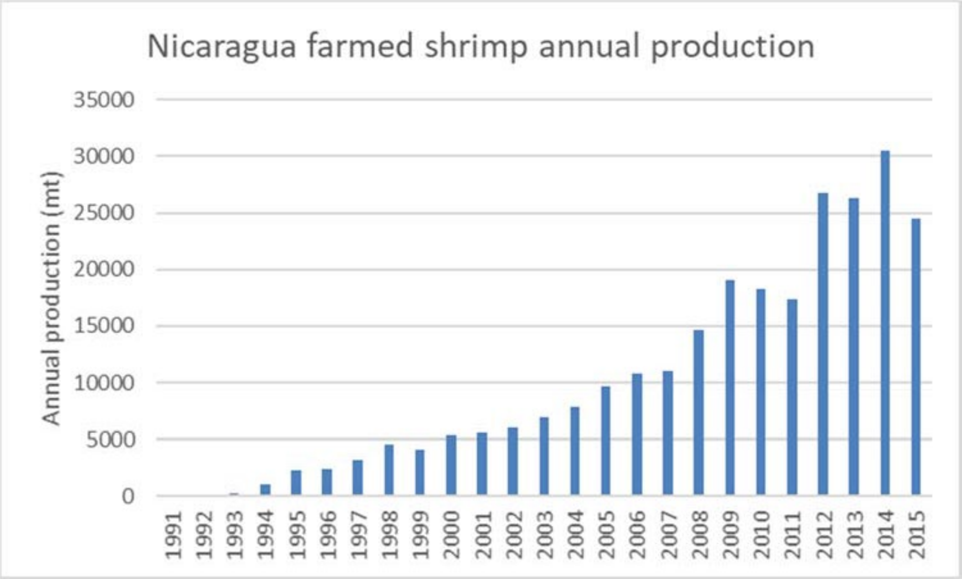

Figure 2: Production of farmed shrimp in Nicaragua (1991 to 2006 data from FAO, FishStat, and 2006 to 2015 from INPESCA).

2006 to 2013 (Figure 3). There was a sharp increase to 14,742 ha in 2014, but because additional categories[5] were included in the INPESCA data for 2014 and 2015, it is not clear if this is a genuine increase in total pond area.

Semi-intensive production dominates the total area of shrimp ponds in Nicaragua; data from INPESCA (2016) show that, in 2015, the total area of ponds was 14,742 ha. Of this acreage, 90% (13,314 ha) was semi-intensive, compared to 7% in artisanal production and 3% in extensive production. There were 418,562 lb of shrimp harvested from intensive systems, but the pond area does not register (i.e., is zero) in these reported figures (Figure 4).

Two endemic species, white shrimp (*L. vannamei*) and blue shrimp (*L. stylirostris*), were initially cultured (FAO 2005), but production of blue shrimp remained low and no recent references can be found to indicate any significant ongoing production. Data from INPESCA are not distinguished by species, and for the purposes of this assessment, production is considered to be dominated by white shrimp.

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[5] Before 2014, production was categorized under companies (empresas) and cooperatives (cooperativas). From 2014, collectives (collectivos) and individuals (individuales) were added. The definitions of each are not immediately clear in the INPESCA document, but production is dominated by empresas.

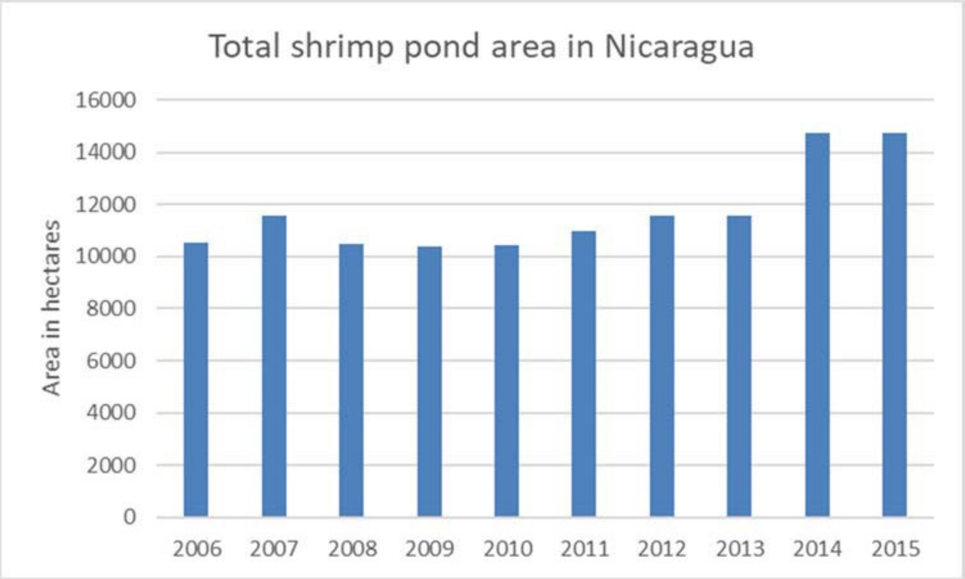

Figure 3: Total shrimp pond area in Nicaragua, from 2006 to 2015. Data from INPESCA.

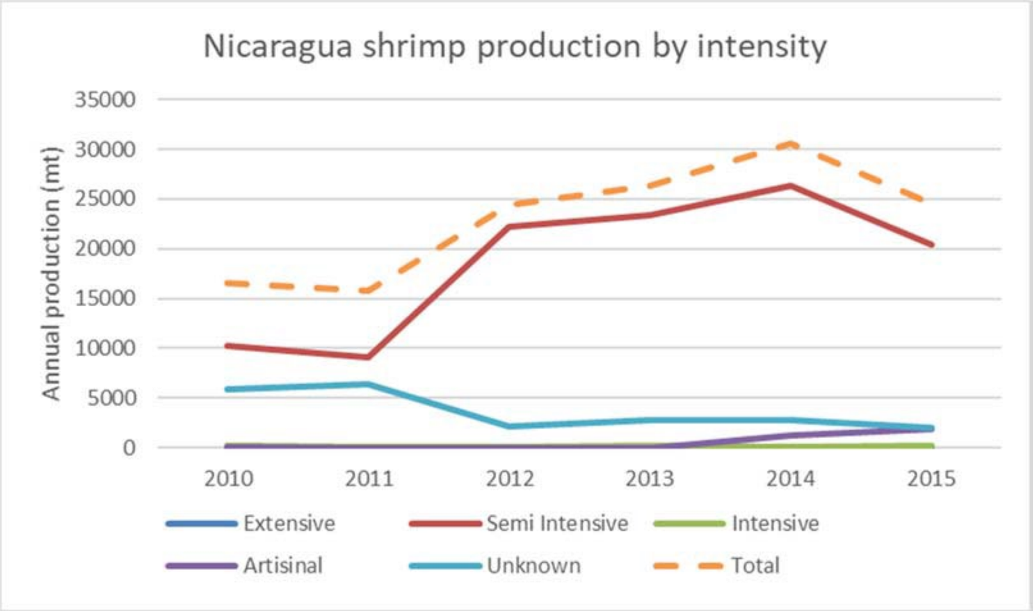

Figure 4: Breakdown of Nicaraguan shrimp production by categorized intensity. Data analyzed from INPESCA's annual fisheries and aquaculture reports.

Import and Export Sources and Statistics

In 2015, Nicaragua exported 97% of all the shrimp produced in its territory (23,850 tons) (INPESCA 2016). United States imports of shrimp from Nicaragua have been highly variable, fluctuating between approximately 2,000 MT and 5,000 MT in the last 10 years, with the most recent data showing that 1,839 MT were imported in 2017 (Figure 5) (USDA ERS 2018).

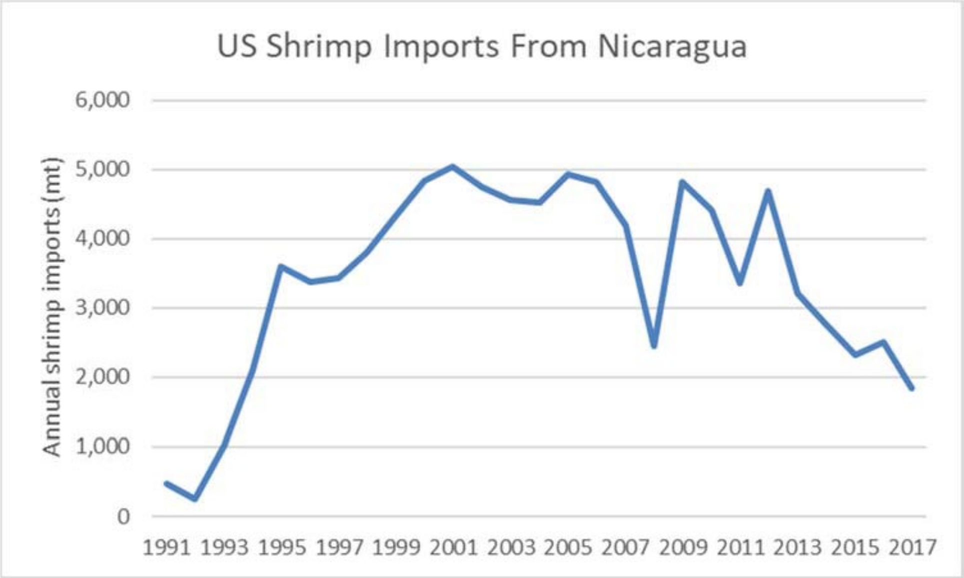

Figure 5: U.S. shrimp imports from Nicaragua. Note: these data do not distinguish farmed from wild shrimp. Data from USDA ERS (2018).

Total exports of seafood from Nicaragua (all species) to the United States have been relatively stable since 2009 at approximately 9,000 MT (8,625 MT in 2015), and although the export destinations for farmed shrimp are unspecified, the main export countries for Nicaraguan seafood (all species) are the United States, Spain, France, and China (INPESCA 2016).

Common and Market Names

Scientific Name	*Litopenaeus vannamei*
Common Name (English)	White shrimp, white-leg shrimp, Pacific white shrimp, Pacific white-leg shrimp.
Spanish	Camarón patiblanco, Camarón blanco
French	Crevette à pattes blanches

Product forms

INPESCA (2016) indicates that farmed shrimp are exported from Nicaragua as whole shrimp or tails; fresh and frozen.

Analysis

Scoring Guide

- With the exception of Criteria 8X, 9X and 10X, all scores result in a zero to ten final score for the criterion and the overall final rank. A zero score indicates poor performance, while a score of ten indicates high performance. In contrast, the two exceptional factors result in negative scores from zero to minus ten, and in these cases zero indicates no negative impact.
- The full Seafood Watch Aquaculture Criteria that the following scores relate to are available here: http://www.montereybayaquarium.org/cr/cr_seafoodwatch/sfw_aboutsfw.aspx
- The full data values and scoring calculations are available in Appendix 2.

Note: the large majority (>80%) of shrimp production in Nicaragua occurs in semi-intensive ponds, and it is assumed here that this production method is responsible for the large majority of imports to the United States. Therefore, though different practices may occur in the minor production systems (potentially with greater environmental concerns), this assessment is based solely on semi-intensive production for export.

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: having robust and up-to-date information on production practices and their impacts publicly available.

Criterion 1 Summary

Data Category	Data Score
Industry or production statistics	7.5
Management	2.5
Effluent	2.5
Habitat	5.0
Chemical use	2.5
Feed	5.0
Escapes	5.0
Disease	5.0
Source of stock	2.5
Predators and wildlife	2.5
Introduced species	2.5
Other (e.g., GHG emissions)	Not Applicable
Total	

C1 Data Final Score (0–10)	**3.9**	**YELLOW**

Brief Summary

Data on Nicaragua shrimp farms were generally scarce, and typically of questionable temporal validity. Requests to INPESCA and MARENA and to producers and feed mills were all unsuccessful. Academic research in the region is also limited and often dated. Data from the producers are also scarce, except for one useful ASC audit report that helped to inform several criteria. Overall, the final score for Criterion 1—Data was 3.9 out of 10.

Justification of Rating

Although various sources of data were obtained for this assessment, written and verbal requests to the Nicaraguan Institute of Fisheries and Aquaculture (El Instituto Nicaragüense de la Pesca y Acuicultura; INPESCA) and the Ministry of Environment and Natural Resources (Ministerio del Ambiente y Los Recursos Naturales, Medio Ambiente; MARENA), in addition to producers and feed companies in Nicaragua, received no responses at the time of writing. Data limitations are discussed in each criterion as relevant and noted in the following text.

Industry and Production Statistics

Production statistics on the shrimp farming industry are published annually (Anuarios Pesqueros) by INPESCA,[6] but are currently 2 to 3 years out of date (2015 is the latest year available, published in 2016). Other data on production are available from the FAO with a similar timeline. INPESCA breaks down the production data according to the type of production system, and also provides figures on the total pond areas of each since 2006. Some minor uncertainties exist in statistical categorization, but overall, the data score for industry and production statistics is 7.5 out of 10.

Management and Regulations

INPESCA's website has a section on fisheries and aquaculture regulations, but only the basic Fisheries and Aquaculture Law (489) was available. Law 489 includes minimal content on practical aquaculture legislation. It was not possible to find any regional or industry management measures or information on enforcement. Nicaragua's *Manual of Best Practices for Aquaculture* (BAP), produced by the Ministry of Agriculture, Fisheries, and Forestry (Ministerio Agropecuario y Forestal; MAGFOR, 2008), is available online[7] and includes useful information on a variety of practical shrimp farming practices. But even though the manual appears to reflect the country's regulatory requirements, how the manual's recommendations are enacted or enforced is not specifically known. Information requests to INPESCA and to producers were not successful. Therefore, a data score of 2.5 out of 10 is given for this data category.

Effluent

Data on effluent monitoring from Nicaraguan shrimp farms are quite limited. The Nicaraguan institute for environmental capacity, research, and development (Instituto de Capacitación, Investigación y Desarrollo Ambiental; CIDEA) and MARENA have been monitoring environmental impacts on the Estero Real since 1990 but they do not publish reports online. Direct requests for information were not successful. Initiated in 2009, INPESCA and the FAO organized a series of six workshops (the last was in 2013) to develop an ecosystem approach for fisheries and aquaculture in the Estero Real (Enfoque Ecosistémico a la Pesca y la Acuicultura en el Estero Real; EEPA), but it has not been possible to find direct evidence of implementation measures resulting from this work (e.g., FAO 2014). Nicaragua's BAP Manual has content relating to wastewater management, monitoring, and effluent limits, but the legal relevance of this document and its enforcement are uncertain. This assessment relied mostly on data published in an audit of two ASC-certified farms (ASC 2018) within the risk assessment option. For those reasons, a low data score of 2.5 out of 10 was given to the Criterion 2—Effluent.

Habitat

The mangrove habitats of Estero Real have gained some attention regarding shrimp farming; a small number of specific studies have been based on satellite images of land conversion (e.g., Benessaiah 2008). Images within these studies or articles (e.g., Nat Geo 2007) provide a

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[6] http://www.inpesca.gob.ni/

[7] http://www.bvsde.org.ni/

timeframe of habitat conversion that has the potential to be extended to the present day, using Google Earth. Information on the importance of the area to resident and migratory birds is available from Birdlife International, and from bird population studies such as Morales et al. (2014). Although a controversial topic, sufficient information is available to have some confidence in the land conversion of shrimp farms in the region, but the timeframes and overall ecological impacts continue to have some uncertainty. The data score is 5 out of 10.

Chemical Use

Detailed information on chemical use in Nicaraguan shrimp farms was not available in either the public domain or the scientific literature. A basic list of chemicals and their approximate use was available from an INPESCA/FAO workshop report from 2010, and a European Commission audit report of farms and feed mills provides background information on chemical use regulation and oversight (DG-SANCO 2014). The only specific data points available were from the ASC audit reports of two farms. Other circumstantial data were limited, and the data score for chemical use is 2.5 out of 10.

Feed

The main shrimp feed producers in Nicaragua are Purina-Cargill, Nicovita-Vitapro, and Diamasa-Skretting, but detailed data on typical feed compositions were not available and direct requests for information were not successful. Nevertheless, the ASC audit report (ASC 2018) had useful information for the feeds of these three companies and enabled the calculations to be completed with moderate confidence—on the assumption that the feeds listed were representative of each company's typical feeds in the region. The data score for feed is 5 out of 10.

Escapes

No specific data on escapes were available, and the escape risk was based on tentative values for water exchange obtained from ASC (2018) and on well-documented events such as Hurricane Mitch in 1998. Regarding invasiveness, useful studies are available indicating the genetic variability of both domesticated shrimp, and the wild populations with which they may interact (e.g., Vela-Avitúa et al. 2013 and Perez-Enriquez et al. 2018). With considerable ongoing uncertainty, the data score for escapes is 5 out of 10.

Disease

There is a substantial amount of information on diseases affecting shrimp farms globally, but little specific data are available from Nicaragua. FAO (010) provides a list of reported diseases and their importance, but more recent information on these and other emerging diseases was not available. Some nonspecific references are available to demonstrate the theoretical risk of pathogen transfer from farmed to wild shrimp, mostly in Mexico; for example, Lightner 2011, Aguirre-Guzmán et al. 2010, Sauceda and Martínez 2016, and Mendoza-Cano and Enríquez-Espinoza 2016. The data score for disease is 5 out of 10.

Source of Stock

INPESCA and FAO have data on the use of wild and hatchery-produced postlarvae from 2009 to 2010, but it is considered highly likely that the situation has changed since then. Soto et al. (2013) reported that wild shrimp postlarvae continue to be utilized at that time, but the types of production systems using them (e.g., artisanal or semi-intensive) were not specified. Information requests to INPESCA and to producers were not successful. The MAGFOR (2008) has recommendations on the use of hatchery-raised postlarvae, but their enactment or enforcement is uncertain. The data score is 2.5 out of 10.

Wildlife and Predator Mortalities

No specific data on predator occurrence and mortalities in Nicaragua were found. This assessment relied on anecdotal information, such as a list of relevant species in the region from the ASC audit reports and recommendations in Nicaragua's MAGFOR (2008). The data score is 2.5 out of 10.

Escape of Secondary species

No specific data on international or trans-waterbody movements of live shrimp could be found, but the assumed high rate of use of domesticated broodstocks implies that importations may be limited to small numbers from specialist, biosecure operations. The data score is 2.5 out of 10.

Conclusions and Final Score

Data on Nicaragua shrimp farms were generally scarce, and typically of questionable temporal validity. Requests to INPESCA and MARENA and to producers and feed mills were all unsuccessful. Academic research in the region is also limited and often dated. Data from the producers are also scarce, except for one useful ASC audit report. Overall, the final score for Criterion 1—Data was 3.9 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: not allowing effluent discharges to exceed, or contribute to exceeding, the carrying capacity of receiving waters at the local or regional level.

Criterion 2 Summary

Effluent parameters		**Value**	**Score**
F2.1a Waste (nitrogen) production per of fish (kg N ton^{-1})		67.5	
F2.1b Waste discharged from farm (%)		31.0	
F2.1 Waste discharge score (0–10)			7
F2.2a Content of regulations (0–5)		2	
F2.2b Enforcement of regulations (0–5)		1	
F2.2 Regulatory or management effectiveness score (0–10)			0.8
C2 Effluent Final Score (0–10)			4.0
Critical?		NO	YELLOW

Brief Summary

There is little information with which to assess the effluent impacts of Nicaraguan shrimp farms directly, particularly cumulative impacts from all the farms in the Estero Real, but information from local communities/authorities and government reports show some concerns. The available specific data on nutrient inputs (primarily from an ASC audit report of two farms) indicate that, although both feed and nitrogen fertilizer are used, water exchange is relatively low and it appears likely that at least the large farms have relatively low nitrogen discharges per ton of production (20.9 kg N per MT of shrimp). There are legal requirements in place relating to farm effluent concentration limits, but little accessible information on the management and regulatory systems in place to address total discharges from any one farm or the potential cumulative impacts from multiple farms. Given the limited information, the Risk-Based Assessment was used, and the final score for Criterion 2—Effluent is 4 out of 10.

Justification of Rating

The amount of waste discharged from shrimp farms can be highly variable and dependent on various farm practices including feeding rates, water exchange, use of settling ponds or other treatment at exchange or harvest, and sludge disposal. Similarly, the impacts of those waste discharges can be highly variable depending on the characteristics of the receiving waterbody. According to ASC (2018), the Nicaraguan government has established an effluent monitoring program as part of the National Environmental Plan, but no details or data could be obtained either online or from contacts with the Nicaraguan Institute of Fisheries and Aquaculture (INPESCA) and the Ministry of Environment and Natural Resources (MARENA). In a community study, pollution from the effluents of shrimp ponds was identified as harmful for aquatic species in the Estero Real, and industrial shrimp farms were often blamed by local populations (Benessaiah and Sengupta 2014b). Starting in 2009, INPESCA and the FAO organized a series of six workshops (the last was in 2013) to develop an ecosystem approach for fisheries and aquaculture in the Estero Real (Enfoque Ecosistémico a la Pesca y la Acuicultura en el Estero Real; EEPA), but it has not been possible to find direct evidence of implementation measures resulting from this work (e.g., FAO 2014). For example, the third workshop in 2010 concluded that the Estero Real region can greatly and immediately benefit from even a rough estimate of the estuary's carrying capacity and a program of improved monitoring (INPESCA 2010) (FAO 2012), but it is not known if this has been conducted and the results subsequently acted upon. An example overview of a shrimp farm discharge point can be seen in Figure 9 in Criterion 3—Habitat.

Although relative effluent limits are specified in Nicaragua's manual of best aquaculture practices (BAP, as discussed in Factor 2.2a below), no specific monitoring data or references to the effluent impacts of pollution from shrimp farms in the Estero Real were apparent in scientific literature or in the public domain. Because the effluent data quality and availability is moderate/low (i.e., Criterion 1—Data score of 2.5), the Seafood Watch Risk-Based assessment was used.

Risk-Based Assessment

This method involves assessing the amount of waste produced by the fish and then the amount of that waste that is discharged from the farm. The effectiveness of the regulatory system in managing wastes from multiple farms is used to assess the potential cumulative impacts from the industry as a whole.

Factor 2.1—Waste Discharged per ton of Shrimp Production

Factor 2.1a—Biological waste production per ton of shrimp

Nitrogen inputs to shrimp farming are primarily in the form of feed and fertilizer. INPESCA (2009) reported (at that time) that all the semi-intensive farms are reported to be using fertilizer, but it is not known if this is still the case, nor is the type or quantity of fertilizer known. Similarly, no relevant industry-wide feed data could be obtained. Therefore, while accepting that the data may not accurately reflect other farms in Nicaragua and given the absence of other data, this assessment relies on the information in the recent audit report of two farms in Nicaragua certified to the ASC shrimp standard (ASC 2018).

Regarding fertilizer, the audit report shows the fertilizer "Fertiplus" is used (containing sodium nitrate, potassium, and potassium nitrate). In a 2-year period (2015 to 2017), 946.9 MT of fertilizer containing 56.1 MT of nitrogen were used to produce 3,233.6 MT of shrimp; i.e., 17.4 kg N per MT of shrimp production.

Regarding feed, the average protein content was 31.5%, and the economic feed conversion ratio (eFCR) was 1.56[8] (ASC 2018). In total, the combined fertilizer and feed[9] give an estimated total nitrogen input of 96.0 kg N per MT of shrimp production. Given a nitrogen content of harvested shrimp of 17.8% (Boyd et al. 2007), the nitrogen in harvested shrimp is 28.5 kg N per MT.

Overall, there is a net waste nitrogen production of 67.5 kg N per MT of shrimp. Factor 2.1b estimates how much of this waste is discharged from the farm.

Factor 2.1b—Production system discharge

As noted in the introduction, the FAO reported that water exchange rates were reduced to close to zero in the early 2000s, and at a similar time, traditional semi-intensive shrimp ponds in Nicaragua were reported to be managed with zero water exchange through the dry season to avoid introduction of disease (Cummings 2001). But no data on water exchanges representative of current practices in the country as a whole could be found.

Nicaragua's BAP manual (MAGFOR 2008) states:

The percentage of water exchange should be kept to a minimum, so that it does not affect the environment and reduces stress in shrimp. Reduce water exchange by retaining water in ponds for a longer time so there is a greater opportunity for nitrogen and phosphorus to be extracted by natural processes. When draining the ponds, try to minimize the speed of the water outgoing to prevent sediment from being resuspended from the bottom of the ponds.

The recent ASC audit report (ASC 2018) reports an average 4% daily water exchange, and though potentially higher than the national average based on the references to the early 2000s, this value is used on a precautionary basis.

Further regarding sediment and sludge, Nicaragua's BAP manual (MAGFOR 2008) states: "In the construction of new shrimp farms, provision should be made for implementation of a sedimentation pond to collect the sludge in drainage water and particularly at harvest. Such settling ponds should represent approximately one-third the area of the total production ponds." In addition to only apparently relating to "new" farms, it is not known how these best practices are enacted or enforced, and therefore how many farms operate sedimentation ponds.

The ASC audit report for the two certified farms notes there is no sludge discharge beyond the farm, and sediments from the ponds are used to reinforce the pond embankments (ASC 2018). Though it may be reasonable to assume that sludge dredged from the ponds is also retained as

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[8] Note: there is a considerable discrepancy in the FCR data in the ASC (2018) audit report. This is discussed in Criterion 5—Feed.

[9] Using a protein to nitrogen conversion factor of 0.16.

typical practice in Nicaragua,[10] the 2008 recommendation on the use of settling ponds relates to new farms only, so the uptake is uncertain. Therefore, an adjustment is made for retention of dredged sludge, but not for the use of settling ponds during water exchange or harvest.

Overall, considering the daily water-exchange rate (4%) and the apparent retention of dredged sludge, 31% of the wastes produced by the shrimp, or 20.9 kg N MT^{-1} shrimp, are considered to be discharged from the farm (see the Seafood Watch Aquaculture Standard for further information on these calculations). This corresponds to a Factor 2.1 score of 7 out of 10.

Factor 2.2—Management of Farm-Level and Cumulative Impacts

Factor 2.2a—Content of effluent management measures

Aquaculture farms have to comply with the overarching Fisheries and Aquaculture Law (Decreto 9-2005), as well as the "Dispositions for the control of contamination from discharge of domestic, industrial and agricultural residual water" (Decreto 33/95) and the law on the environment "Ley General del Ambiente" (Decreto 217). Some of these regulations are available (in Spanish) from INPESCA, but details of their practical implementation are not readily accessible, and the typical effluent management practices on shrimp farms in Nicaragua are unclear.

Nicaragua's BAP manual (MAGFOR 2008) lists water quality requirements, which are the same as MARENA's regulatory requirements. They are listed in Table 1 and include an initial value at the time of certification to the BAP and a final value that must be met after 5 years. As stated previously, although the BAP manual includes the Nicaraguan regulatory requirements, there is clearly other content that is advisory in nature (e.g., "the percentage of water exchange should be kept to a minimum") and it is not known how the content is enacted or enforced at shrimp farms.

Table 1: Water quality requirements from the BAP Manual (MAGFOR 2008).

Parameter	Units	Initial Value	Final Value	Monitoring
pH	mg/l	6.0–9.0	6.0–9.0	Monthly
Suspended solids	mg/l	<100	<50	3 months
Soluble phosphorous	mg/l	<0.5	<0.3	Monthly
Ammonia nitrogen	mg/l	<5	<3	Monthly
Biological oxygen demand	mg/l	<100	<50	3 months
Dissolved oxygen	ppt	>4	>5	Monthly

Though these values are considered to be specific effluent limits, they are relative; that is, the limits are for "per liter" concentrations, and therefore are not related in any way to the total effluent volumes. Thus, these limits do not give any indication of a farm's total nutrient

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[10] Inspection of satellite photos of the Estero Real shows that many farms have long canals linking the production ponds to the natural waterways of the Estero (for example, see Figure 9 in Criterion 3—Habitat). It appears unlikely that sludge would either be dumped into these canals for discharge, or that it would be transported similar distances to be dumped into natural waterways.

discharge (i.e., concentration per liter multiplied by the total volume discharged) or of the cumulative load of multiple farms discharging into the same waterbody. It is also not known if the water quality monitoring must be conducted during peak discharges such as harvest. Therefore, the score for Factor 2.2a is 2 out of 5.

Factor 2.2b—Enforcement of effluent management measures

The implementation of the laws noted above is the responsibility of the Ministry of Environment and Natural Resources (MARENA) and the Instituto Nicaragüense de Acueductos y Alcantarillado Sanitario (roughly translated as The Nicaraguan Institute of Aqueducts and Sanitary Sewers; INAA), in collaboration with the municipalities, but no specific data on the enforcement of effluent management measures could be found. A request for monitoring reports was made to the relevant authorities, but there was no response. A long-term water quality assessment by the Nicaraguan Institute for Environmental Capacity, Research, and Development (Instituto de Capacitación, Investigación y Desarrollo Ambiental; CIDEA) of the Estero Real found no conclusive evidence that shrimp farms were degrading the estuary (FAO 2012). But it had previously been reported that the Estero Real in its upper and medium parts receives organic and inorganic matter from the aquaculture farms' wastewater, which could have a negative impact on the surrounding biodiversity (UCA-MARENA 2001). Moreover, the CIDEA results were judged unreliable by the municipalities of Puerto Morazán and Somotillo, and pollution from the effluents of shrimp ponds were identified as harmful for aquatic species (Benessaiah and Sengupta 2014b).

Because of the minimal evidence of monitoring or compliance data, the score for Factor 2.2b is 1 of 5. When combined with the Factor 2.2a score of 2 out of 5, the final Factor 2.2 score is 0.8 out of 10, reflecting the quite limited understanding of the aquaculture regulatory and management system in Nicaragua.

Conclusions and Final Score

There is little information with which to assess effluent impacts in Nicaragua from shrimp farms resulting from feed and fertilizer inputs when water is exchanged, and particularly the cumulative impacts of all the farms in the Estero Real. Contradicting information from local communities/authorities and government reports shows that there are some concerns regarding potential effluent impacts. The limited data indicate that shrimp farms have relatively low nitrogen discharges per ton of production (20.9 kg N per MT of shrimp), but there is little information on the management and regulatory system in place to address potential cumulative impacts. Overall, Factors 2.1 and 2.2 combine to result in a final score of 4 out of 10 for Criterion 2—Effluent.

Criterion 3: Habitat

This assessment was originally published in November 2018 and reviewed for any significant changes in August 2023. See Appendix 3 for details of review.

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: being located at sites, scales and intensities that maintain the functionality of ecologically valuable habitats.

Criterion 3 Summary

Habitat parameters	Value	Score
F3.1 Habitat conversion and function		0
F3.2a Content of habitat regulations	2	
F3.2b Enforcement of habitat regulations	1	
F3.2 Regulatory or management effectiveness score		0.8
C3 Habitat Final Score (0–10)		**0.27**

Brief Summary

The majority of Nicaragua's shrimp farms are located in the Estero Real, an ecologically important area that includes the country's largest extension of mangrove forests. Most shrimp farms were built on hypersaline mud and sand flats within broader mangrove areas, with little direct loss of mangrove trees, but these sand and mud flats represent part of the broader ecosystem, and the seasonal dry forest has been considered to be the most endangered terrestrial ecosystem in the tropics. The Estero Real is a shorebird reserve of hemispheric importance for resident and migratory birds, and the areas of greatest concentration of birds are affected by thousands of hectares of shrimp farming. The farm activities directly influence the feeding habitat and refuge of shorebirds. Overall, the wetlands (i.e., including the salt flat areas) in the Estero Real region have been greatly reduced, especially toward the mouth of the river, where they have been converted into shrimp ponds. Although the majority of pond construction occurred before 1999, there has been substantial construction since the area became protected (in 1983) and designated as a Ramsar site (in 2001).

These habitat conversions represent an extensive change to the estuarine ecosystem, and the ecological effects of changes to the hydrology of the broader habitats from pond construction continue to be uncertain. The regulatory systems in Nicaragua for managing high-value habitats are complex and unclear. There is evidence of permitting processes in place in some (independently certified) farms, but there is little readily available content on habitat connectivity, cumulative impacts, or enforcement. Satellite images show recent construction of ponds in salt flats and dry forests in the last 5 years. Overall, the final score for Criterion 3—

Habitat is 0.27 out of 10, reflecting the critical concerns that remain regarding the habitat impacts of shrimp farms in Nicaragua.

Justification of Rating

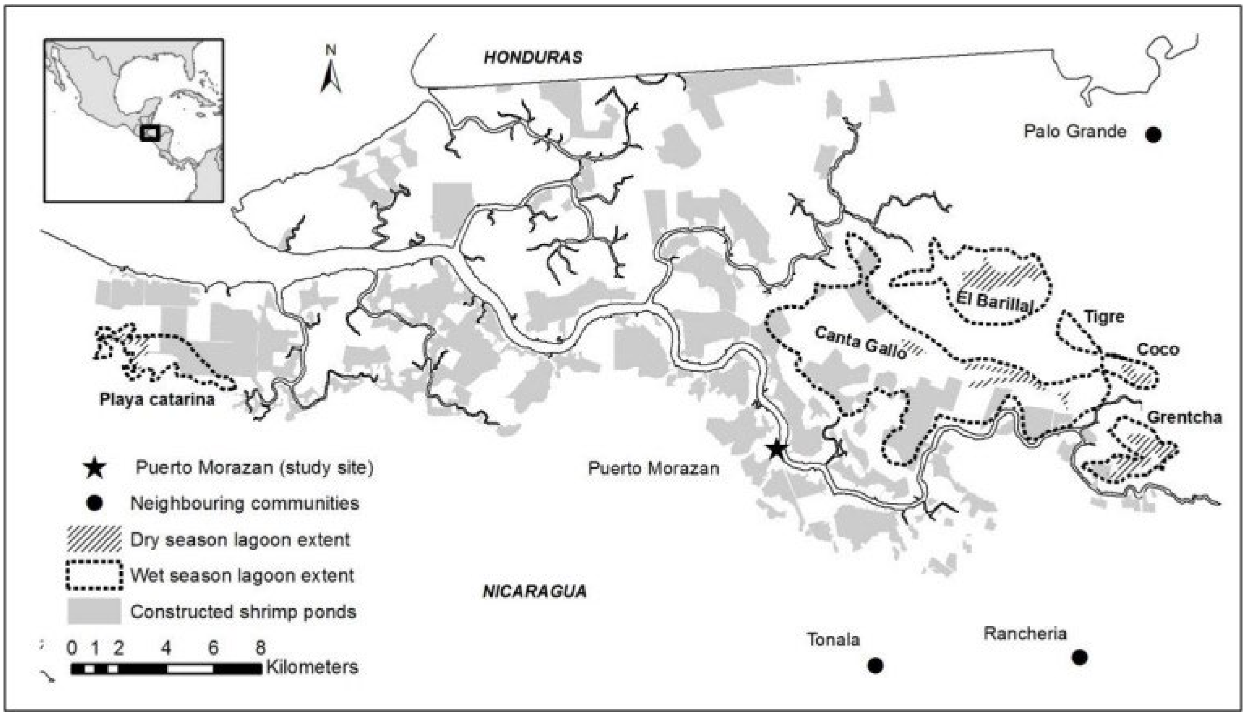
Factor 3.1—Habitat Conversion and Function

As noted previously, nearly all of Nicaragua's shrimp farms are located in the northwest of the country along the Estero Real (Rivas 2013). The Estero Real is part of the Gulf of Fonseca, an extremely fertile 70,000 ha of interdependent patches of mangroves, salt flats, marshes, and lagoons shared by Honduras, El Salvador, and Nicaragua (Ramsar 2000). The Estero Real in Nicaragua contains the country's largest extension of mangrove forests, encompassing 23,000 ha where *Rhizophora* spp. and *Avicennia* spp. are the predominant trees (Carvalho et al. 1999). On a broader scale, Sasa et al. (2015) note that the Estero Real is one of the four largest and most important wetlands along the Central American Pacific coast (alongside Bahía de Jiquilisco in El Salvador, the Región Occidental de Nicaragua in western Nicaragua, and the Lower Basin of the Tempisque River in northwestern Costa Rica).

This region is characterized by a warm climate and a highly seasonal rainfall regime that allows the development of seasonal dry forest, perhaps the most endangered terrestrial ecosystem in the tropics (Janzen 1988). In addition, two main seasons (wet and dry) regulate seasonal lagoons that expand as sea waters meet with surface water from the highlands (Figure 6); these lagoons are important, biodiverse habitats, hosting aquatic larvae during part of their reproductive cycle and providing refuge to migratory birds (Núñez-Ferrera 2003)(Vásquez et al. 2005). The ecological importance of the region is reflected in the recognition of the Estero Real as a protected area as early as 1983, and as a Ramsar site in 2001 (Benessaiah and Sengupta 2014a).

Along the Pacific coast of Central America, more than 70% of the original area covered by seasonal wetlands has been transformed into lands for agriculture, aquaculture production, or urban development (Sasa et al. 2015). Shrimp farming grew rapidly through the 1990s in Nicaragua. Figure 7 shows that no farms were present in the Estero Real in 1987, although they were very apparent in 1999. According to (FAO 2007), mangrove forest loss in Nicaragua was up to 2.3% per year from 1980 to 2000, and shrimp farming was at times heavily criticized for "mangrove destruction" (e.g., Nat Geo 2007). But according to a study based on satellite images from 1987 and 2006, mangroves (including both primary mangroves and secondary succession from previous clearance) constituted only a minor part of the land converted to shrimp farms in the Estero Real, with a total conversion of 13 ha/year (Benessaiah 2008). In contrast, the same study showed that salt and mud flats on slightly higher ground behind the mangroves represented 75% of the lands converted to shrimp ponds in the same period.

Figure 6: Map of Estero Real showing the extent of seasonal lagoons in the wet and dry season and the extent of shrimp ponds in 2006. Image copied from Benessaiah and Sengupta (2008).



According to Soares et al. (2017), because mangroves occur in intertidal zones, soil salinity is a key environmental factor controlling the structure, function, and distribution of this ecosystem. In arid or seasonally dry regions that are subjected to occasional tidal flooding (such as western Nicaragua, where evapotranspiration is higher than precipitation), hypersaline conditions occur; therefore, beyond the mangrove channels, the vegetation becomes drier, with *Avicennia* forest becoming stunted on higher ground until it disappears and is replaced by extensive salt flats with no vegetation (CATIE/IUCN 1990).

Figure 8 shows an image from 2018 covering the same area as Figure 7; outlined in red, it shows the current pond boundaries and the further extension of farms from 1999 to the present. Both figures show that the majority of farms have been built on the saline sand and mud flats. Figure 9 shows more data from Benessaiah (2008), with a breakdown of the different types of land conversion. Sand flats were favored by shrimp farmers because of the reduced costs (in terms of labor and finances) associated with the construction phase and because they provide optimal soil chemical conditions for shrimp productivity, as opposed to mangrove soils, which are too acidic (Moreno 2001).

Figure 7: Satellite images of Estero Real in 1987 and 1999, showing the development of shrimp farms. Image copied from Nat Geo (2007).

Figure 8: Satellite image of Estero Real in 2018 showing the same area as in Figure 7. Shrimp farms are highlighted with red approximate outlines. Base image copied from Google Earth.

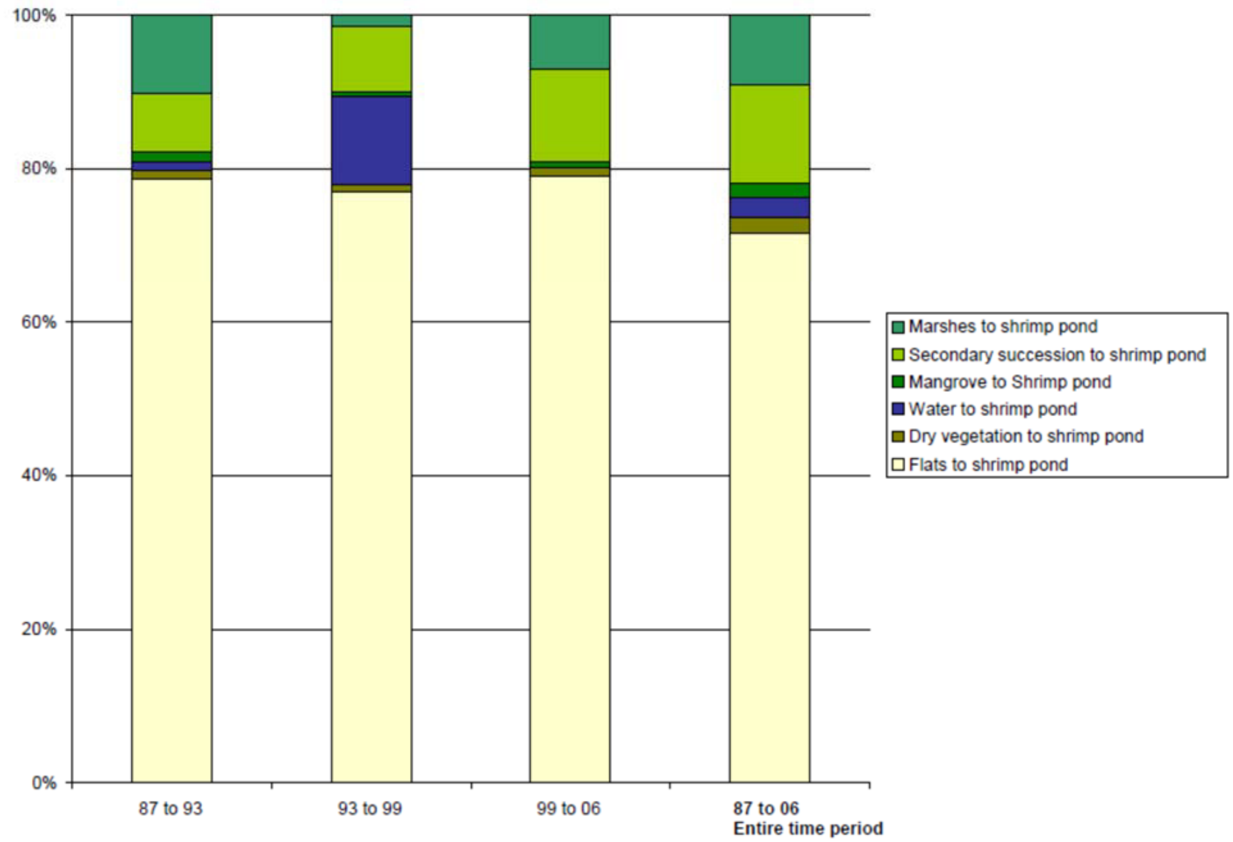


Figure 9: Contribution of each land cover type to shrimp aquaculture (%), in the Estero Real, Gulf of Fonseca, Nicaragua (1987 to 2006) (Benessaiah 2008).

Benessaiah and Sangupta (2014) reported that establishing shrimp ponds on salt flats raised little community resistance, given that these were considered barren areas of little interest beyond the occasional firewood and shellfish collection. But it is important to note that these areas are considered part of the wetland ecosystem, and as noted above, the seasonal dry forest has been considered to be the most endangered terrestrial ecosystem in the tropics (Janzen 1988). Sasa et al. (2015) note that the wetlands (i.e., including the salt flat areas) in the Estero Real region have been greatly reduced, especially toward the mouth of the river, where they have been converted into shrimp ponds.

In addition to the Ramsar designation, the Estero Real qualifies as a Shorebird Reserve of hemispheric importance to resident and migratory birds, according to the criteria of the Hemispheric Network of Shorebird Reserves (Morales et al. 2014). These authors report that the areas of greatest concentration of birds are under the direct influence of thousands of hectares of shrimp farming activities; for example, they state that at least 20,000 ha of bird areas are dedicated to shrimp farming, which directly influences the feeding habitat and refuge of shorebirds. The construction of ponds has reduced the refuge areas at high tide with the result that the pond dykes are now becoming the resting areas used by birds waiting for lower tides; however, there are greater levels of disturbance in these locations from farm activities.

Nicaragua's manual of best aquaculture practices (MAGFOR 2008) states: "shrimp facilities will not damage or alter the conditions of coastal wetlands, mangrove forests or areas of aquatic vegetation or other ecological systems near the sites of production. There must be no net conversion of critical coastal ecosystems. The mangrove ecosystems and wetlands will not be used for development of new production areas of the shrimp industry, only the salt pans free of vegetation." Despite the accepted primary use of salt and mud flats (i.e., salt pans) for the construction of ponds and the relatively minor direct loss of mangrove stands (Figure 9), the above information indicates that the salt flats and dry forest habitats are an integral part of the broader mangrove ecosystem in the area. Further, Sasa et al. (2015) note that, even though their assessment indicates the very good quality of the Estero Real according to the ECELS[11] index of wetland disturbance, the reduction of wetlands in the Estero Real represents not only a significant loss of biological diversity but also a noticeable decrease of the flow of materials and biomass from the aquatic to the surrounding dry forest.

In addition to any direct loss of mangrove habitat, the wider coastal dynamics must also be considered, because shrimp ponds also indirectly affect mangroves through changes in hydrology, increased sedimentation, and water contamination (Martinez-Alier 2001)(Valiela et al. 2001)(Lugo 2002)(Walters et al. 2008). Morales et al. (2014) note that the interruption of water flows in the mangroves and broader area has as-yet uncertain effects on the long-term functioning of the Estero Real, and Sasa et al. (2014) also report a general lack of knowledge on the limnological characteristics and seasonal dynamics of these systems.

Recent Habitat Conversion

Figures 7 and 8 show that there has been a substantial increase in pond area in the region between 1999 and 2018, particularly north of the main river. Figure 3 in the Introduction showed that the total pond area had remained largely stable at approximately 11,000 ha from 2006 to 2013, with an increase to 14,742 ha in 2014. As noted, it is not known if this is a genuine increase in pond area or a result of updated reporting categories, but further examination of historic images in Google Earth shows that there has indeed been recent conversion of salt flats and dry forests. Figure 10 (from 2010) and Figure 11 (from 2018) show an area of Estero Real where new ponds have been constructed in salt flat areas between 2012 to 2015 (these dates are accurate plus or minus one year due to the available historic images in Google Earth). An example of recent dry forest conversion (between 2014 and 2016) is also shown in Appendix 1.

Given the Ramsar designation (2001) and the protected status of the Estero Real region since 1983, the legal status of these recent conversions is not known. As described in Factor 3.2, there is little readily available information with which to comprehend the exact content of the Nicaraguan regulations regarding mangrove conversion, but there is no evidence here to robustly conclude that the recent pond constructions were illegal.

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[11] ECELS is the Index of Conservation Status of Shallow Lentic Ecosystems (ECELS), and gives an indication of the alteration of wetland habitats. See Sasa et al. (2014).

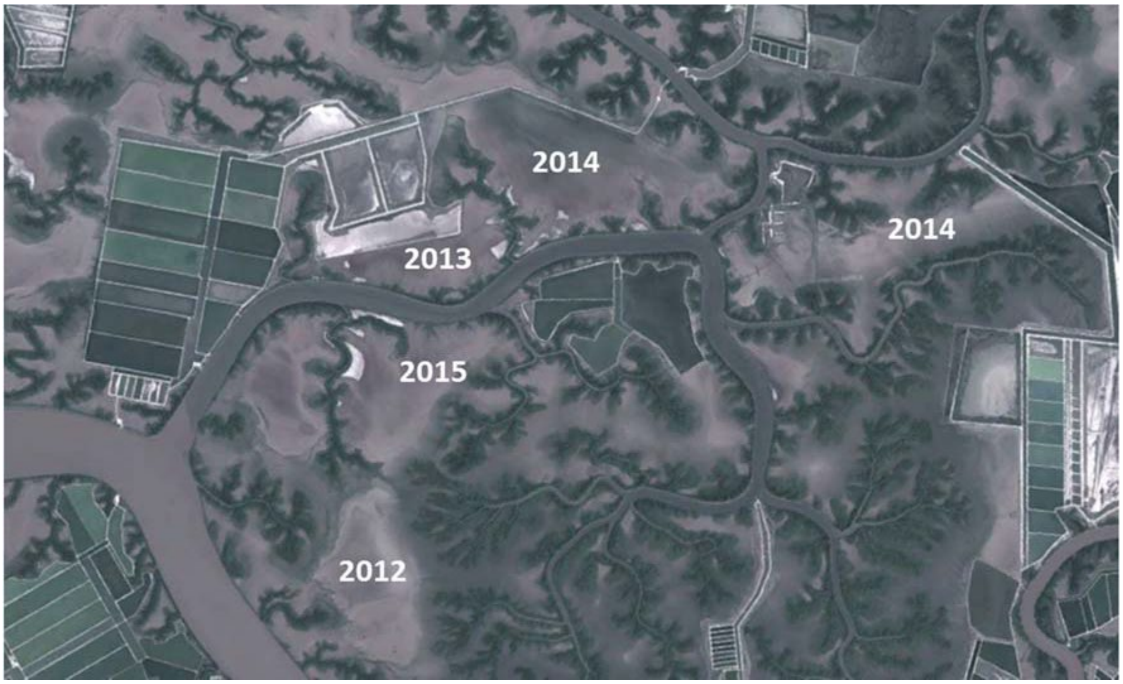

Figure 10: Satellite image of a part of Estero Real taken in 2010. The dates refer to the subsequent construction of ponds as shown by comparison to Figure 11 taken in 2018. Base image copied from Google Earth.

Figure 11: Satellite image of the same part of Estero Real as Figure 10 taken in 2018. New ponds can be seen by comparing to Figure 10 with the dates of construction also shown in Figure 10. Base image copied from Google Earth.

Overall, Sasa et al. (2014) conclude that wetlands in this region have been greatly reduced, especially toward the mouth of the river, by the construction of shrimp ponds. Even though the damages that have been caused to the mangroves in Nicaragua are much smaller compared to the damage to mangroves in other countries (FAO 2010), the Nicaraguan government's Sistema Nacional de Información Ambiental (SINIA)[12] states that the construction of ponds has contributed to the impoverishment, alteration, and contamination of life in the mangrove swamp, representing an extensive change to the estuarine ecosystem. There are also changes to the hydrology of the broader habitats by pond construction, the ecological effects of which continue to be uncertain. There has been substantial development of shrimp ponds since the designation of the Estero Real as a Ramsar site in 2001, and there is evidence of recent (less than 5 years) conversion of salt flats and dry forests to new ponds. This ongoing loss of habitat functionality in these high-value habitats results in a final score for Factor 3.1 of 0 out of 10.

Factor 3.2—Farm Siting Regulation and Management

Factor 3.2a—Content of habitat management measures

Nicaragua initiated its Law of Fishing and Aquaculture (Ley de Pesca y Acuicultura, Ley No. 489) in 2004. The law's text (in Spanish) is available from INPESCA[13] (although a more effective portal is the FAOLEX database),[14] and INPESCA is the competent authority for its application. The legal document for Law 489 is difficult to interpret and is further complicated by its implementing regulation (Decree No. 9/05 of 2005). In addition, Nicaragua has Law No. 690 on the Development of Coastal Zones (Ley para el desarrollo de las zonas costeras) from 2009, but this was amended in 2015 (Ley No. 913) and implemented by Decreto No. 78/09. Because of the complexity of these documents and their translation, it is not possible to robustly interpret the habitat management measure in place for the Estero Real. As noted above, Nicaragua's manual of best aquaculture practices (MAGFOR 2008) intends to restrict ongoing pond construction to areas without vegetation, but the legal status of the manual is unclear.

One practical example of the site permitting process within the Estero Real is provided by the ASC-certified sites constructed in 2006, which received a "Concession Ministry Agreement Certificate" from the Concessions Administration of the Direction of Natural Resources of the Promotion, Industry, and Commerce Ministry. They also received an Environmental Permit according to the Environmental Impact Assessment under the Administrative Resolution No. 02-2007 from the Ministry of Environment and Natural Resources (MARENA) (ASC 2018). It is interesting to note that, due to their siting in a protected area, these now-certified farms required a variance request for compliance to the habitat requirements of the ASC Standard for shrimp.[15]

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[12] http://www.sinia.net.ni/multisites/NodoSINAP/index.php/sinap/areasprotegidas?layout=edit&id=17

[13] http://www.inpesca.gob.ni/index.php?option=com_content&view=article&id=36&Itemid=113

[14] http://www.fao.org/faolex/country-profiles/general-profile/en/?iso3=NIC

[15] https://www.asc-aqua.org/what-we-do/our-standards/

Although the region has been studied through several FAO/INPESCA workshops, which highlighted the need for carrying capacity studies (see Criterion 2—Effluent), no evidence of ecosystem-based management could be found regarding cumulative habitat impacts in the region. The ASC-certified example provides some evidence that a permitting or licensing system is in place, but because of the difficulty in identifying the precise Nicaraguan management systems that relate to habitat conversion and conservation for all farms, plus the uncertain status of the best practices manual and lack of obvious content on habitat connectivity and cumulative impacts, the score for Factor 3.2a is 2 out of 5.

Factor 3.2b—Enforcement of habitat management measures

Information on compliance to environmental standards is not available on governmental websites (MARENA, INPESCA, MIFIC), and direct requests to those departments for further information have received no response at the time of writing. The National System of Environmental Information (SINIA) may provide some information on enforcement activities, but the website is unreliable and typically not available. The example of the ASC-certified sites shows that, where documentation is available (i.e., at an audit), there is evidence of enforcement in the form of certificates and permits, but it is not known if this is the case for all farms. With little readily available evidence of monitoring or compliance data, and no evidence of penalties or infringements, there is little information with which to assess the effectiveness of the enforcement of regulations. Therefore, the score for Factor 3.2b is 1 out of 5. When combined with the Factor 3.2a score of 2 out of 5, the final Factor 3.2 score for farm siting and regulation is 0.8 out of 10, primarily reflecting the lack of readily available information and data with which to assess the content and effectiveness of the habitat management systems in the Estero Real.

Conclusions and Final Score

The majority of Nicaragua's shrimp farms are located in the Estero Real, an ecologically important area that includes the country's largest extension of mangrove forests. Most shrimp farms were built on hypersaline mud and sand flats within broader mangrove areas, with little direct loss of mangrove trees, but these sand and mud flats represent part of the broader ecosystem, and the seasonal dry forest has been considered to be the most endangered terrestrial ecosystem in the tropics. The Estero Real is a shorebird reserve of hemispheric importance for resident and migratory birds, and the areas of greatest concentration of birds are affected by thousands of hectares of shrimp farming. The farm activities directly influence the feeding habitat and refuge of shorebirds. Overall, the wetlands (i.e., including the salt flat areas) in the Estero Real region have been greatly reduced, especially toward the mouth of the river, where they have been converted into shrimp ponds, and though the majority of pond construction occurred before 1999, there has been substantial construction since the area was protected (in 1983) and designated as a Ramsar site (in 2001).

These habitat conversions represent an extensive change to the estuarine ecosystem, and the ecological effects of changes to the hydrology of the broader habitats from pond construction continue to be uncertain. The regulatory systems in Nicaragua for managing high-value habitats are complex and unclear. There is evidence of permitting processes in place in some (independently certified) farms, but there is little readily available content on habitat connectivity, cumulative impacts, or enforcement. Satellite images show recent construction of ponds in salt flats and dry forests in the last 5 years. Overall, the final score for Criterion 3—Habitat is 0.27 out of 10, reflecting the critical concerns that remain regarding the habitat impacts of shrimp farms in Nicaragua.

Criterion 4: Evidence or Risk of Chemical Use

This assessment was originally published in November 2018 and reviewed for any significant changes in August 2023. See Appendix 3 for details of review.

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: limiting the type, frequency of use, total use, or discharge of chemicals to levels representing a low risk of impact to nontarget organisms.

Criterion 4 Summary

Chemical Use parameters	Score	
C4 Chemical Use Score (0–10)	**0**	
Critical?	NO	**RED**

Brief Summary

There are no reliable data available on the current use of chemicals in Nicaraguan shrimp farms. Three antibiotics are currently authorized for use in aquaculture in Nicaragua, and there is now-dated evidence that one of them (oxytetracycline) was used by a small proportion of farms in the past (2010), and circumstantial evidence that a second (enrofloxacin) has been supplied in medicated feeds to shrimp farms in 2014. The only specific recent farm data from a total of four farms audited by the ASC and the European Commission show that antibiotics (or other chemicals) have not been used. Without any recent evidence on chemical use from all shrimp farms in Nicaragua, or data from feed mills and/or the relevant authorities, the use of both highly and critically important antibiotics is largely unknown, so the final score for Criterion 4—Chemical Use is 0 out of 10 on a precautionary basis.

Justification of Rating

Since 2011, the “Reglamento Tecnico Centroamericano” (RTCA 65.05.51:08) has been applicable in Nicaragua and describes the legal provisions for the authorization/registration, distribution, and use of veterinary medicinal products (DG-SANCO 2014). Agreement 4 of RTCA lists eight pharmacologically active substances for which the use in food-producing animals is prohibited (dimetridazole, nitrofurans, sulphathiazole, vancomycin, strychnine, chloramphenicol, stilbenes, and organochlorines). In Nicaragua, the Department for Registration and Control of Livestock Supplies within the Directorate of Animal Health (Dirección de Salud Animal—DISAAN) is the central competent authority for authorization of veterinary medicinal products, and it has registrations for three antibiotic products that can be used in farmed crustaceans: enrofloxacin, florfenicol, and oxytetracycline (DG-SANCO 2014).

Beyond this background information, no routine farm-level data on the types, quantities, or frequency of the use of chemicals on shrimp farms in Nicaragua could be found. At the feed mill, records on purchase of premixes, applications of farms/companies for medicated feed, and monthly records on the production of medicated feed were present during DG-SANCO's audits, and monthly reports on the production of medicated feeds must be sent from the feed mills to the Department for Registration and Control of Livestock Supplies within DISAAN (DG-SANCO, 2014). Unfortunately, these records do not appear to be publicly available, and attempts to contact DISAAN, INPESCA, feed mills, and shrimp producers for information were not successful. Nicaragua's BAP Manual (MAGFOR 2008), in addition to other general advice, recommends: "The use of pharmacological agents, antibiotics and other chemical products must be considered as a last resort in farming operations of shrimp and in general, in aquaculture."

A 2010 presentation during the third INPESCA/FAO workshop on Estero Real (INPESCA 2010)(FAO 2012) provides some basic dated information on chemical use (Figure 12); otherwise, the only specific data points available were from the two ASC-certified farms for which the audit report shows that no antibiotics were used.

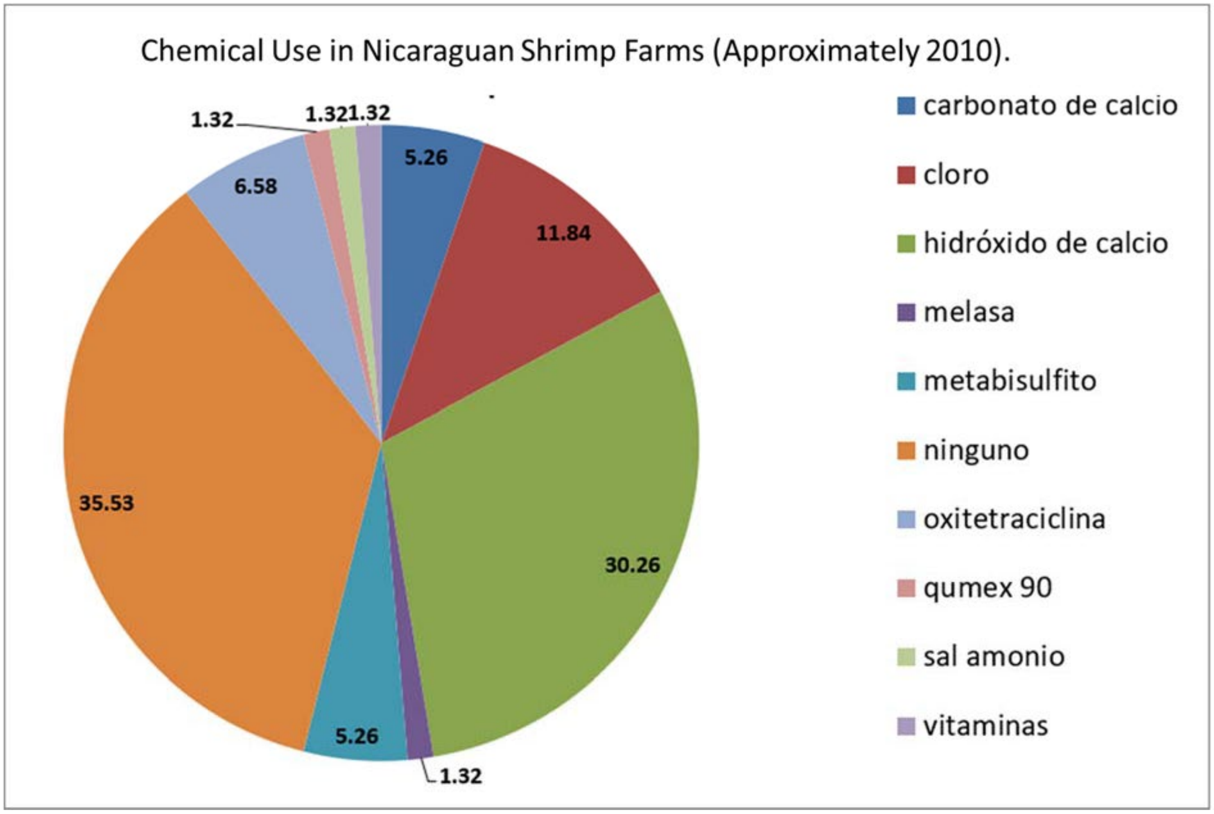

Figure 12: Chemical use in Nicaraguan shrimp ponds in approximately 2010. "Carbonato de calcio" = calcium carbonate; "cloro" = chlorine; "hidróxido de calcio" = calcium hydroxide; "melasa" = molasses; "metabisulfito" = metabisulphite; "ninguno" = none; "oxitetraciclina" = oxytetracycline; "qumex 90" = calcium hydroxide; "sal amonio" = ammonium salts; "vitaminas" = vitamins. Graph copied from FAO (2010).

Figure 12 shows that over one-third of the farms (in approximately 2010) used no chemicals. The majority of chemicals that were used are for pond preparation, disinfection, and fertilization, and are typically considered to be of low environmental concern. Antibiotics or pesticides are generally the focus of this criterion, and though Figure 12 does not show any pesticide use, it shows that 6.58% of farms at that time used the antibiotic oxytetracycline. It must be emphasized that the data in Figure 12 cannot be assumed to represent current practices.

Circumstantially, shrimp farming globally has been vulnerable to a series of bacterial and viral disease outbreaks, causing serious economic challenges for the industry; in the case of bacterial pathogens such as the suite of *Vibrio* species affecting shrimp, antibiotics such as enrofloxacin, florfenicol, and oxytetracycline may be used to counteract them (del Carmen Bermúdez-Almada et al. 2014). Other circumstantial evidence that there is at least some antibiotic use in Nicaraguan shrimp farms is available from DG-SANCO (2014), whose audits of feed mills showed that there were periods when medicated feeds containing oxytetracycline or enrofloxacin had been delivered to farms (unfortunately, no further details were provided). In contrast, the DG-SANCO audits of two farms showed that no chemicals had been used. Under Agreement 2 of RTCA, the competent authority must establish a list of veterinary medicinal products, which require a veterinary prescription; however, according to DG-SANCO (2014), this list is not yet published in Nicaragua, and the dispensing of antibiotics does not need a veterinary prescription.

Considering any other available indication of chemical use in Nicaragua, a 2005 report (now dated) by the World Bank reported that there was no evidence to suggest Nicaragua was using illegal antibiotics in shrimp farms, and no information was found that indicated that Nicaragua shrimp commerce (i.e., exports) had been hindered by the use or detection of antibiotics (Cato et al. 2005); indeed, no farmed shrimp products from Nicaragua were included in any United States FDA Import Alerts[16] regarding antibiotics, nor were there any import refusals[17] of Nicaraguan farmed shrimp products because of antibiotics, according to available data dating back to 2002.

Although Carmen Bermúdez-Almada et al. (2014) acknowledged that (in their Mexican study) the current trend is to restrict or reduce the use of antibiotics in shrimp aquaculture because of the emergence of bacterial resistance, ecological problems, the restriction of exports, and impacts on human health, there is no robust and/or recent information with which to conclude that the lack of antibiotics used in the two Nicaraguan ASC-certified farms is representative of the broader industry, or that the 2010 data available from the FAO is representative of current practices.

Oxytetracycline is listed as “Highly important to human medicine” by the World Health Authority (WHO 2017), and enrofloxacin is listed as “Critically important.” Antibiotic use

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[16] https://www.accessdata.fda.gov/cms_ia/country_NI.html

[17] https://www.accessdata.fda.gov/scripts/ImportRefusals/index.cfm

potentially varies substantially in response to emerging diseases, so the lack of recent chemical use data means that the current use must be considered unknown.

Conclusions and Final Score

Three antibiotics are currently authorized for use in aquaculture in Nicaragua. There is evidence that oxytetracycline has been used by a small proportion of farms in the past (2010), and there is circumstantial evidence that enrofloxacin has been supplied in medications to shrimp farms in 2014. The only specific recent farm data from a total of four farms in ASC and DG-SANCO audits show that antibiotics (or other chemicals) have not been used. Without any recent data on antibiotic use from all shrimp farms, from feed mills, or from the relevant authorities in Nicaragua, the use of both highly and critically important antibiotics is largely unknown, so the final score for Criterion 4—Chemical Use is 0 out of 10 on a precautionary basis.

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: sourcing sustainable feed ingredients and converting them efficiently with net edible nutrition gains.

Criterion 5 Summary

Feed parameters	value	score	
5.1a—Feed Fish Efficiency Ratio (FFER)	0.7	8.3	
5.1b—Sustainability of the Source of Wild Fish		–10	
5.1—Wild Fish Use		6.9	
5.2a—Protein Input	42.1		
5.2b—Protein Output	18.6		
5.2—Net Protein Gain or Loss	–55.8	4	
5.3—Feed Footprint	7.0	7	
C5 FEED Final Score		**6.2**	**YELLOW**
Critical	No		

Brief Summary

The majority of shrimp culture (semi-intensive) in Nicaragua relies on artificial food in pellet form, in addition to natural food in the ponds stimulated by added fertilizer. Information requests to three feed companies were not met, but useful data on feeds from those companies were available in a 2018 ASC audit report, so they were considered a useful reflection on the country as a whole. Using a (precautionary) economic feed conversion ratio of 1.56 and an average inclusion of 14.5% fishmeal and 1.5% fish oil in the feeds, the Feed Fish Efficiency Ratio (FFER) was 0.7 for fishmeal (the fish oil came from by-products and was therefore not included in the calculation). This indicates that, from first principles, 0.7 tons of wild fish are required to produce 1 ton of farmed shrimp. The source fisheries for fishmeal were not known, and the adjusted Wild Fish Use score is 6.9 out of 10. A net edible protein loss of 55.8% was calculated, based on an assumption that all nonmarine feed ingredients were edible crops. A combined ocean and land area of 7.0 ha is required to supply the amount of feed ingredients necessary to produce 1 ton of farmed shrimp. Overall, the final score for Criterion 5—Feed is 6.2 out of 10.

Justification of Rating

In Nicaragua, shrimp are mostly farmed under semi-intensive conditions that depend largely on commercial pelleted feed in addition to natural productivity in the ponds stimulated by added fertilizer. Information requests were made to three feed companies operating or marketing in Nicaragua (Purina-Cargill, Nicovita-Vitapro, and Diamasa-Skretting), but no responses were received at the time of writing; however, some composition data from each of these company's feeds are available in the ASC audit report for the two certified farms (ASC 2018). These data are from production cycles between 2015 and 2017, and although some values are unclear, they are used in the following feed calculations in the absence of more-representative alternatives. The Seafood Watch Aquaculture Standard assesses three feed-related factors: wild fish use (including the sustainability of the source), net protein gain or loss, and the feed "footprint" or global area required to supply the ingredients.

Factor 5.1—Wild Fish Use

Factor 5.1a—Feed fish efficiency ratio (FFER)

Concentrating on the larger sized feeds (i.e., those used for the bulk of the weight gain of the shrimp),[18] the three feeds have an overall range of inclusion levels as follows (ASC 2018):

- Inclusion level of fishmeal from whole fish: 5 to 15%
- Inclusion level of fishmeal from by-products: 2 to 7%
- Inclusion level of fish oil from whole fish: 0% in all feeds
- Inclusion level of fish oil from by-products: 1 to 2%

After evaluating all the (larger) sizes of feed from the three feed companies, it is considered that the mean values of each of these ranges are the best representation of the feeds used in Nicaragua (i.e., mean fishmeal from whole fish is 10%, and mean fishmeal from by-products is 4.5%, giving a total fishmeal inclusion of 14.5%, of which 31% is from by-products).

Regarding the economic feed conversion ratio (eFCR), the value in the ASC audit report is unclear, and the extrapolation of that value to the rest of the Nicaraguan shrimp farms is also risky. The audit report states the eFCR is 1.16, but also states a weighted average eFCR for the complete production cycles of 1.56. In contrast, calculations done for this assessment based on the figures provided in the audit report for total feed inputs and total biomass outputs give an eFCR of 0.38. The value of 1.16 was also stated for the same farms in a previous audit report (ASC 2015). Although now dated, INPESCA reported an average FCR for semi-intensive systems in Nicaragua of 1.11 (INPESCA 2009). Considering the range of values and the lack of available data from the broader industry, the highest value of 1.56 is used here on a precautionary basis, though it is considered to be somewhat high (for example, in a general feed report, Tacon et al. [2011] reported the eFCR of white shrimp to be 1.4). No information was available on the

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[18] For example, Nicovita has six sizes: 0.3, 0.5, 0.8, 1.2, 2.0 and 2.5mm, and the latter three have been used.

fishmeal and fish oil yield, and the default values in the Seafood Watch Standard from Tacon and Metian (2008) of 22.5% and 5%, respectively, were used. These values and resulting FFER values are shown in Table 2.

Table 2: FFER data points and calculated values

Parameter	Value
Average fishmeal inclusion level	14.5%
Percentage of fishmeal from by-products	31%
Fishmeal yield (from wild fish)	22.5%
Average fish oil inclusion level	1.5%
Percentage of fish oil from by-products	100%
Fish oil yield (from wild fish)	5%
Feed Conversion ratio (FCR)	1.56
Calculated values	
Feed Fish Efficiency Ratio (FFER) (fishmeal)	0.69
Feed Fish Efficiency Ratio (FFER) (fish oil)	0.00
Seafood Watch FFER Score (0–10)	**8.27**

The final FFER value is based on the larger of the two values; i.e., 0.69 for fishmeal, which means that, from first principles, it takes less than 1 kg (0.69 kg) of wild fish to provide the fishmeal needed to grow 1 kg of whole shrimp. Based on these data, the score for Factor 5.1a—Feed Fish Efficiency Ratio is 8.27 out of 10.

Factor 5.1b—Sustainability of the source of wild fish

No information could be obtained on the source fisheries used to produce the fishmeal and fish oil used in Nicaraguan shrimp feeds. As noted, information requests to all three companies were not responded to, and no information is provided in the ASC audit reports. Therefore, the source fisheries are unknown, and the score for Factor 5.1b is –10 out of –10. This results in an adjustment of –1.39 to the Factor 5.1a score, giving a final Factor 5.1 score of 6.88 out of 10.

Factor 5.2—Net Protein Gain or Loss

Again, no specific country-wide data values could be obtained for Nicaragua. Although out of date, Tacon (2002) stated that a minimum of 30% of protein content is required for the aquaculture of *L. vannamei*, and the ASC (2018) audit report states a range of 28 to 35%. It is considered that the larger grow-out feeds representing the bulk of feed use will have the lower values. An academic feed study by Toruño and Vanegas (2015) used a “commercial” feed with 25% total protein. Considering this range of values, an intermediate value of 30% is used.

With an assumed protein content of fishmeal of 66.5%, the 14.5% inclusion in the feed is calculated to represent 32.1% of the total protein in the feed (22.2% from fishmeal made from whole fish, and 9.9% from fishmeal made from inedible by-products). Without further data, the remaining 67.9% of the total protein is considered to come from “edible” crop ingredients.

With the eFCR of 1.56, there is an edible protein input of 42.1 kg protein per 100 kg of harvested shrimp.Regarding protein outputs, the protein content of whole shrimp (*L. vannamei*) is 17.8% (Boyd et al. 2007), and FAO (2001) states that the edible yield of shrimp is 45% (40% of whole shrimp is the head, and a further 15% in the shell, tail, and legs). Although shrimp processing wastes can be dried into a meal for further uses in animal feed (FAO 2001), it is not known if this is done in Nicaragua; therefore, the default of 50% utilization is used. After an adjustment for the conversion of crop protein to animal proteins, the edible protein output is 18.6 kg protein per 100 kg shrimp (Table 3).

Table 3: Protein data points and calculated values

Parameter	Value
Protein content of feed	30%
Percentage of total protein from nonedible sources (by-products, etc.)	10.0%
Percentage of protein from edible sources	90.0%
Percentage of protein from crop sources	67.9%
Feed Conversion Ratio	1.56
Protein INPUT per ton of farmed shrimp	421.4 kg
Edible yield of harvested shrimp	45%
Protein content of whole harvested shrimp	17.8%
Percentage of farmed shrimp by-products utilized	50%
Utilized **protein OUTPUT** per ton of farmed shrimp	186.4 kg
Net protein loss	–55.8%
Seafood Watch score (0–10)	**4**

Overall, there is a net edible protein loss of 55.8%, which corresponds to a score of 4 out of 10 for Factor 5.2.

Factor 5.3—Feed Footprint

By considering the marine, terrestrial crop, and terrestrial land animal ingredients, this factor provides an estimate of the ocean and land area required to produce the ingredients to produce the feed required per ton of farmed shrimp. Based on the available data cited previously, the calculation was based on an inclusion level of aquatic feed ingredients of 16.0% and an inclusion level of crop feed ingredients of 84% (Table 4).

Based on the average productivity values for oceans and agricultural land, the area of ocean necessary for production of marine ingredients required for 1 ton of for *L. vannamei* species is 6.5 ha, and the area of land necessary for production of terrestrial crop ingredients is 0.5 ha. The overall feed footprint is 7.0 ha/ton of farmed fish. This results in a final Factor 5.3 score of 7 out of 10.

Table 4: Feed footprint data points and calculated values.

Parameter	Value
Inclusion level of aquatic feed ingredients	16.0%
Inclusion level of crop feed ingredients	84.0%
Inclusion level of land animal ingredients	0.0%
Ocean area used per ton of farmed shrimp	6.5 ha
Land area used per ton of farmed shrimp	0.5 ha
Total area	7.0 ha
Seafood Watch Score (0–10)	**7**

Conclusions and Final Score

Although robust data from feed companies in Nicaragua was not available, the information available in the 2018 ASC audit report on feeds from the same companies is considered a useful reflection on the country as a whole. Thus, the FFER is calculated to be 0.69 for fishmeal, and there is an estimated net loss of 55.8% of edible protein inputs. The associated feed footprint is estimated to be 7.0 ha/ton of combined ocean and land areas. Overall, the three factors combine to give a final Criterion 5—Feed numerical score of 6.2 out of 10.

Criterion 6: Escapes

This assessment was originally published in November 2018 and reviewed for any significant changes in August 2023. See Appendix 3 for details of review.

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: preventing population-level impacts to wild species or other ecosystem-level impacts from farm escapes.

Criterion 6 Summary

Escape parameters	**Value**	**Score**
F6.1 System escape risk	2	
F6.1 Recapture adjustment	0	
F6.1 Final escape risk score		2
F6.2 Invasiveness		4
C6 Escape Final Score (0–10)		**3**
Critical?	NO	**RED**

Brief Summary

Shrimp can escape from ponds during daily water exchanges and specific events such as harvest. In addition, the area is prone to flooding in peak rainy seasons; the destruction of one-quarter of the shrimp ponds in Nicaragua during Hurricane Mitch in 1998 highlighted the storm and flood risk. The majority of production in Nicaragua is considered to be based on multigeneration, selectively bred broodstock with genetic and phenotypic differentiation from wild shrimp populations. Therefore, although the risk of genetic introgression to the genetically diverse wild populations is perhaps low, the high escape risk means that when Factors 6.1 and 6.2 are combined, the final score for Criterion 6—Escapes is 3 out of 10.

Justification of Rating

L. vannamei is native to the Nicaraguan coast (FAO 2006), and the escape of genetically distinct shrimp from farms will result in some genetic interactions with the wild populations. This criterion assesses the risk of escape and the "invasiveness" of the escaping stock.

Factor 6.1—Escape Risk

There is an inherent risk of escape in pond-based shrimp aquaculture because of the exchange of pond water with the surrounding waterbody during daily operations (and during harvest if ponds are drained) and flooding when ponds are constructed in low elevation and/or storm-prone areas. As noted, the majority of shrimp farms in Nicaragua operate on a semi-intensive basis, with a daily water exchange considered to be approximately 4%. It is not currently known if ponds are drained at harvest and what measures, if any, are used to prevent escapes; now-dated references such as Sonnenholzner et al. (2002) and Cato et al. (2005) indicate that they were drained at harvest, but it is not known if this is still the case. The Nicaraguan BAP Manual (MAGFOR 2008) recommends to: "Install screens in the ponds to prevent the escape of shrimp to the environment and to prevent genetic contamination if there is domestication."

Sasa et al. (2015) and SINIA[19] (within MARENA) note that the Estero Real river occasionally floods during the peak of the rainy season, and one of the most significant impacts to the industry in Nicaragua was Hurricane Mitch, which destroyed approximately 25% of the ponds in October 1998. It seems likely that large amounts of shrimp would have escaped at that time. Although Hurricane Mitch was clearly an exceptional event, tropical storm Alma also made landfall in Nicaragua in 2008, and MARENA (2011) initiated a project to reduce the risk of increased flooding (and drought) in the area as a result of climate change. Because of the flood risk, the industry is still considered to be vulnerable to large escapes, resulting in a final Escape Risk score of 2 out of 10 for Factor 6.1.

Factor 6.2—Invasiveness

INPESCA (2009) and FAO (2010) reported that only 75% of semi-intensive producers in Nicaragua sourced seed from hatcheries in the late 2000s (the alternative being the active capture of wild juveniles with nets or the passive inflow of wild juveniles when filling ponds). Although this number may have increased since then because of prohibitions of small mesh fishing for juveniles, the disease risks of wild shrimp, and advancements in selective breeding and maturity of the industry (see Criterion 8X—Source of Stock), there is no robust evidence available from the industry to demonstrate this. For the purposes of this criterion, the same ratio is considered to be used (75% hatchery, 25% wild) at present.

Regarding the genetic differences between wild shrimp and farmed shrimp, although domestication of *L. vannamei* is advanced in many Central American countries, Doyle (2016) estimated that 50% of the Nicaraguan hatcheries are "copy hatcheries," which use laboratory-bred shrimps intended for grow-out as broodstock without authorization or knowledge of their biological relatedness or inbreeding status; this results in inbred offspring with reduced fitness. Beyond this, there is limited availability of information on the domestication of *L. vannamei* in Nicaragua. Cato et al. (2005) noted that all the larvae used in the early 2000s were from wild-caught sources, so hatcheries and selective breeding must have commenced after this time. It is of interest to note that there are no "specific pathogen free" (SPF) or "specific pathogen resistant" (SPR) strains available in Nicaragua (ASC 2018), and this is a further indication of a limited domestication program.

It is acknowledged that any domestication of wild animals results in a decline of genetic variability in the cultured population because of the selection for desirable production traits (e.g., Vela Avitúa et al. 2013), so any escaping farmed shrimp are likely to be genetically

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[19] http://www.sinia.net.ni/multisites/NodoSINAP/index.php/sinap/areasprotegidas?layout=edit&id=17

differentiated from wild conspecifics. The potential ecological impact of farm escapes to those wild populations is challenging to determine.

L. vannamei is native to the Pacific coastlines of Central America and northern South America (FAO 2006). Although studies on the species' genetic diversity are able to identify subpopulations along the coast, they note that, while genetic diversity is high in any one location, there was a lack of a specific geographical pattern and a low differentiation (i.e., genetic homogeneity) among estuaries (Perez-Enriquez et al. 2018)(Valles-Jimminez and Perez-Enriquez 2004). Therefore, given the high genetic diversity in the wild population as a whole plus the lack of highly discrete subpopulations [e.g., compared to salmon, in which genetic introgression from escapes into highly discrete genetic subpopulations is a high concern (Glover et al. 2017)], the potential for genetic introgression of farm shrimp escapes seems limited.

Overall, any escaping shrimp (other than the 25% of stocks sourced from wild juveniles) are considered to be domesticated, probably for multiple generations, and therefore genetically discernable and to some extent genetically differentiated from the wild stocks. This indicates an initial invasiveness score (Factor 6.2) of 2 out of 10; however, the potential impact to the more genetically diverse wild *L. vannamei* populations along the Central American coast seems limited (in addition to the partial use of wild juveniles). Thus, the score is increased to 4 out of 10, which is considered to be equivalent to three generations of selective breeding in the Seafood Watch Standard. Therefore, the score for Factor 6.2—Invasiveness is 4 out of 10.

Conclusions and Final Score

The risk of escape is considered to be high, based on the water exchange rates and the flood/storm risk. The majority of production is considered to be based on multiple generations of domesticated broodstock with genetic and phenotypic differentiation from wild shrimp populations. Therefore, although the risk of genetic introgression to the genetically diverse wild populations is perhaps low, the high escape risk means that when Factors 6.1 and 6.2 are combined, the final score for Criterion 6—Escapes is 3 out of 10.

Criterion 7: Disease; Pathogen and Parasite Interactions

Impact, unit of sustainability and principle

- Impact: amplification of local pathogens and parasites on fish farms and their retransmission to local wild species that share the same water body.
- Sustainability unit: wild populations susceptible to elevated levels of pathogens and parasites.
- Principle: preventing population-level impacts to wild species through the amplification and retransmission, or increased virulence of pathogens or parasites.

Criterion 7 Summary

Disease Risk-based assessment

Pathogen and parasite parameters	Score	
C7 Disease Score (0–10)	4	
Critical?	NO	YELLOW

Brief Summary

Shrimp farming globally, including in Nicaragua, has suffered a series of bacterial and viral disease outbreaks, creating serious economic challenges for the industry. No recent data on routine disease monitoring could be obtained from Nicaragua, but dated information shows that a wide range of pathogens has been reported, with white spot syndrome virus (WSSV), necrotizing hepatopancreatitis (NHP), and bacterial vibrioisis being the most common. Recent anecdotal evidence shows that emerging global shrimp pathogens, such as early mortality syndrome (EMS), are also present in Nicaragua. There is no evidence of farmed shrimp diseases affecting wild shrimp populations in Nicaragua, but examples of disease transmission can be found elsewhere (e.g., in Mexico). With limited information, the Seafood Watch Risk-Based Assessment was used. Based on the open nature of the production system, which remains vulnerable to the introduction, amplification and discharge of pathogens, the final score for Criterion 7—Disease is 4 out of 10.

Justification of Rating

Shrimp farming globally has experienced a series of bacterial and viral disease outbreaks that created serious economic challenges for the industry. The World Organization for Animal Health (OIE) lists major diseases affecting farmed *L. vannamei* and advice to control and avoid them. These diseases are white spot syndrome virus (WSSV), yellow head virus (YHV), Taura syndrome virus (TSV), infectious myonecrosis virus (IMNV), necrotizing hepatopancreatitis (NHP), and infectious hypoderma and haematopoietic necrosis virus (IHHNV) (World Organization for Animal Health [OIE] 2013).

Figure 13 shows a wide range of pathogens reported in Nicaraguan shrimp farms in approximately 2010 (FAO 2010). The dominant three are WSSV, NHP, and bacterial vibriosis. No detailed routine disease monitoring information could be found in Nicaragua. Efforts to contact INPESCA were unsuccessful, as were efforts to contact shrimp farming companies.

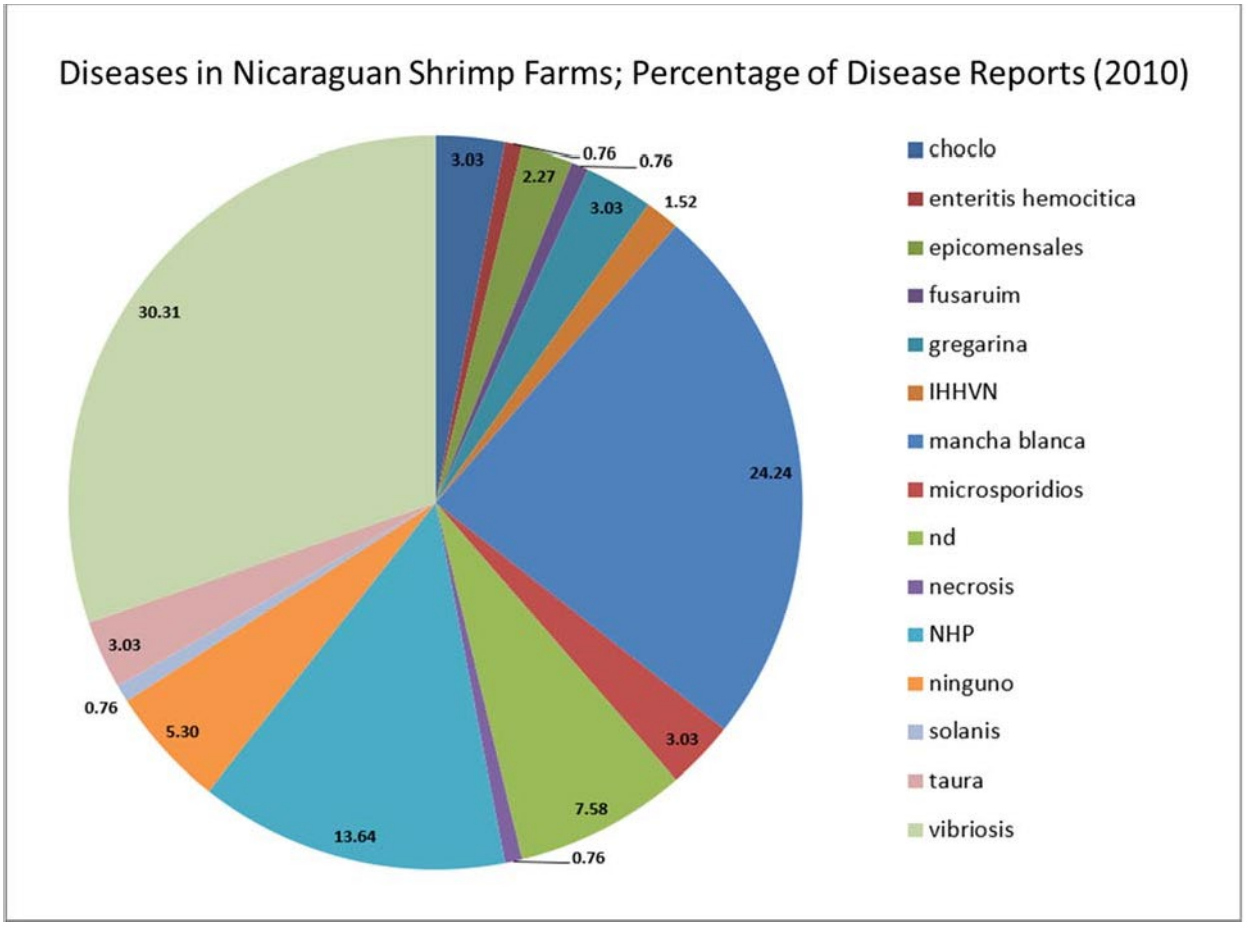

Figure 13: The most common diseases reported in Nicaraguan shrimp farms in approximately 2010. The graph is intended to demonstrate the variety of pathogens, and full translation is not provided; however, the dominant diseases are WSSV (dark blue; 24.24%), NHP (pale blue; 13.64%), and vibriosis (pale green; 30.31%). Graph copied from FAO (2010).

Historically, the introduction of the WSSV in 1999 caused large shrimp mortalities in Nicaragua (75% of the production) (Cato et al. 2005). Since then, measures were taken to better prepare the ponds and water and to reduce water exchange during grow-out, but despite these measures, WSSV still occurred at least until 2011 (Soledad et al. 2011). Other circumstantial information shows that Nicaragua and neighboring Honduras are two countries where farmed shrimp have tested positive for early mortality syndrome (EMS) (Whittaker 2015).

Nicaragua’s BMP Manual (MAGFOR 2008) was initiated to encourage sanitary improvements for all shrimp farms, and in 2013, trainings and workshops on early mortality syndrome (EMS) were organized by INPESCA (OIRSA 2013). More recently, the International Regional Organization for Agricultural Health (OIRSA) also organized trainings and monitoring programs in Nicaragua that focused on necrotizing hepatopancreatitis (NHP) as a major cause of EMS (OIRSA 2016).

Despite clear evidence of pathogens and disease occurrences on farms in Nicaragua, there is little evidence of potential impacts to wild shrimp populations from their transmission. To reduce the introduction of pathogens, it is common to reduce water exchange, and dated information shows that traditional semi-intensive shrimp ponds in Nicaragua had been managed with zero water exchange through the dry season to avoid introduction of WSSV (Cummings 2001). But as stated in previous criteria in this assessment, the current water exchange rate is uncertain but considered to be 4% per day based on ASC audit reports. Therefore, the potential exists for the amplification and transmission of shrimp pathogens from farms to wild shrimp populations.

The only demonstrated impact to wild shrimp is from the 1990s, when an IHHNV outbreak resulted in significant losses in both farms and wild fisheries for the blue shrimp, *P. stylirostris* (Lightner 2011). More recently, pathogens occurring in (and perhaps originating in) shrimp farms have been found in wild shrimp; for example, the presence of NHP in wild shrimp was confirmed in Mexico (Aguirre-Guzmán et al. 2010) as well as the occurrence of WSSV and NHP in wild shrimp (*L. setiferus* and *F. aztecus*) of the San Andrés Lagoon (Sauceda and Martínez 2016). Recently occurring pathogens may yet transfer to wild species; for example, decapod penstyldensovirus (PstDV1) is a widely spread shrimp pathogen that causes high mortalities in the shrimp *P. stylirostris*; in *L. vannamei*, it has been associated with induction of the runt deformity syndrome, and a high overall prevalence of PstDV1 (49.5%) in shrimp PL from hatcheries was found (Mendoza-Cano and Enríquez-Espinoza 2016).

Conclusions and Final Score

Although disease is considered to be a significant production problem in shrimp farming, and pathogens will be discharged to external waterbodies during water exchanges, there is no concrete evidence of impacts from farmed shrimp diseases on wild shrimp populations in Nicaragua. Therefore, the Seafood Watch Risk-Based Assessment was used in this case. Because the production system is open to the introduction and discharge of pathogens, the final numerical score for Criterion 7—Disease is 4 out of 10.

Criterion 8X: 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: using eggs, larvae, or juvenile fish produced from farm-raised brood stocks thereby avoiding the need for wild capture.

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

Criterion 8X Summary

Source of stock parameters	Score	
C8 Independence from unsustainable wild fisheries (0–10)	–2	
Critical?	NO	GREEN

Brief Summary

Dated information from 2009 to 2010 shows that, while 100% of artisanal and extensive producers used wild-caught juveniles (potentially from both passive and active collection), 75% of semi-intensive producers used captive-bred sources. Although the use of hatchery postlarvae may have increased since then, a 2013 report confirmed some ongoing use of wild juveniles. Because the 2009–10 figure of 25% wild juveniles is the only available figure on the source of juveniles used in the semi-intensive farms (i.e., the farms that are most likely to export to the United States), this value is used here, and the final score for Criterion 8X is a deduction of –2 out of –10.

Justification of Rating

No current information on the use of captive-bred broodstock, postlarvae, or juveniles could be found, and efforts to contact INPESCA and shrimp producers were unsuccessful. Although dated, information from 2009 to 2010 shows that, although 100% of artisanal and extensive producers used wild-caught juveniles (potentially from both passive[20] and active collection), 75% of semi-intensive producers used captive-bred hatchery sources (INPESCA 2009)(FAO 2010). The Nicaraguan BAP Manual (MAGFOR 2008) recommends: "Domesticated broodstock should be used as sources of larvae to improve biosecurity, reduce the incidence of diseases and increase production while reducing the pressure on wild populations. The use of domesticated shrimp allows to develop genetic selection program for better growth and resistance to diseases." Nevertheless, Soto et al. (2013) reported that wild shrimp postlarvae continue to be utilized (note that the type of system is not specified) because of their apparent

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[20] Note: the passive collection of wild juvenile shrimp while filling ponds or during water exchanges is not penalized in the Seafood Watch Aquaculture Standard.

hardiness and relatively low price, although the threat of disease is increasingly reducing such a practice.

The use of hatchery-produced postlarvae may have increased since these reports were published, because of prohibitions of small mesh fishing for juveniles (Regulation No. 489), the disease risks of stocking wild shrimp, and the general advancements in selective breeding [e.g., Doyle (2016)]; however, there is no information with which to confirm it.

Conclusions and Final Score

On a precautionary basis, the industry is still considered to be using 25% wild juveniles, and the final score for Criterion 8X—Source of Stock is a deduction of –2 out of –10.

Criterion 9X: Wildlife and Predator Mortalities

Impact, unit of sustainability and principle

- Impact: mortality of predators or other wildlife caused or contributed to by farming operations.
- Sustainability unit: wildlife or predator populations.
- Principle: aquaculture populations pose no substantial risk of deleterious effects to wildlife or predator populations that may interact with farm sites.

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

Criterion 9X Summary

Wildlife and predator mortality parameters	Score	
C9X Wildlife and Predator Mortality Final Score (0–10)	**–4**	
Critical?	NO	YELLOW

Brief Summary

Shrimp ponds attract a variety of predators, particularly birds, but no specific data on predator mortalities in Nicaragua were found. A list of relevant local species in the ASC audit reports included several species of birds, but they were all listed as “Least Concern” by the International Union for the Conservation of Nature (IUCN). This gives some confidence that any mortalities are unlikely to significantly affect the species’ population sizes, and the final score for Criterion 9X—Wildlife and Predator Mortalities is –4 out of –10.

Justification of Rating

No specific data were found on predator mortalities, and efforts to contact INPESCA and shrimp producers were unsuccessful. Nicaragua’s BAP manual (MAGFOR 2008) recommends nonlethal, nontoxic methods (such as flashing lights or noise) to scare birds and other predators away from ponds, in addition to barriers such as netting and screens. The ASC audit report (ASC 2018) notes that, other than crabs, mollusks, shrimp, and fish that are controlled by screens on water inlets, the primary wildlife interactions are with a variety of resident and migratory birds, all of which are listed as “Least Concern” by the IUCN:

- Blue heron, *Ardea Herodias*
- Common heron, *Ardea alba*
- Pink heron, *Platalea ajaja*
- Fisher eagle, *Pandion haliaetus*
- Crab bald eagle, *Buteogallus anthracinus*
- Tiny-tailed hawk, *Buteo barchyrus*
- Piche, *Dendrocygna autumnalis*

- Playerito, *Calidris minutila*
- Peregrine falcon, *Falco peregrinus*

No other wildlife types or species were mentioned in the ASC audit report. Morales et al. (2014) confirm the high importance of the Estero Real wetlands for migratory and resident birds, noting that the area is designated as "important" according to Birdlife International and qualifying as a Shorebird Reserve of hemispheric importance according to the criteria of the Western Hemispheric Network of Shorebird Reserves (WHNSR).[21] Interestingly, the species of greatest importance listed by WHNSR[22]—Wilson's plover (*Charadrius wilsonia*), whimbrel (*Numenius phaeopus*), and semipalmated sandpiper (*Calidris pusilla*)—are not mentioned in the ASC audit list. This may be due to their seasonal occurrence during overwintering. These species are also listed as "Least Concern" by the IUCN.

Morales et al. (2014) state that the areas of greatest concentration for birds are affected by thousands of hectares of shrimp farming activities that directly influence the feeding habitat and refuge of shorebirds. The same study observed that large numbers of birds rested on the pond dykes during high tide periods. The WHNSR states, "We are actively engaging shrimp farmers to implement best management practices to improve shorebird habitat." There is no indication that the interactions between birds and shrimp farms result in substantial direct mortalities due to deterrents, controls, accidental entanglements, or other encounters.

On a precautionary basis without data, it is assumed that some mortalities occur, but the "Least Concern" listing of key species gives some confidence that mortalities do not significantly affect the species' population sizes. Therefore, the final score for Criterion 9X—Wildlife and Predator Mortalities is –4 out of –10.

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[21] https://www.manomet.org/project/western-hemisphere-shorebird-reserve-network-whsrn/

[22] https://www.whsrn.org/delta-del-estero-real

Criterion 10X: Escape of Secondary Species

Impact, unit of sustainability and principle

- Impact: movement of live animals resulting in introduction of unintended species
- Sustainability unit: wild native populations
- Impact: aquaculture operations by design, management or regulation avoid reliance on the movement of live animals, therefore reducing the risk of introduction of unintended species.

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

Criterion 10X Summary

Escape of secondary species parameters	Score	
F10Xa—International or trans-waterbody live animal shipments (%)	0	
F10Xb—Biosecurity of source/destination	n/a	
C10X Escape of secondary species Final Score	**0.00**	GREEN

Brief Summary

No data were available on live shrimp importations, and though it is possible that there is some international exchange of broodstock or postlarvae with neighboring Honduras, these regions share the same waterbody in the Gulf of Fonseca. Therefore, trans-waterbody shipments of live animals that risk the unintentional introduction of nonnative species are not currently considered to be significant. The final score for Criterion 10X—Escape of Secondary Species is a deduction of 0 out of –10.

Justification of Rating

It is clear, historically, that various shrimp pathogens have been introduced into Nicaragua, most likely during movements of live shrimp; for example, the introduction of WSSV in 1999 (Cato et al. 2005). No data could be found on current live animal importations; although it is possible that some broodstock continue to be imported into Nicaragua for breeding programs, these would be considered to come from specialist breeding facilities with high biosecurity.

Although it is also possible that there is some international exchange of broodstock or postlarvae with neighboring Honduras, these regions share the same waterbody in the Gulf of Fonseca. Therefore, trans-waterbody shipments of live animals that risk the unintentional introduction of nonnative species are not currently considered to be significant. Therefore, the score for factor 10Xa is 10 of 10, and Factor 10Xb is not necessary to complete. The final score for Criterion 10X—Escape of Secondary Species is a deduction of 0 out of –10.

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Appendix 1: Example of Recent Dry Forest Conversion

Figure 14: Image taken in 2014, copied from Google Earth.

Figure 15: Image taken in 2016, copied from Google Earth.

Appendix 2: Data Points and all Scoring Calculations

Criterion 1: Data Quality and Availability

Data Category	**Data Quality (0–10)**
Industry or production statistics	7.5
Management	2.5
Effluent	2.5
Habitats	5
Chemical use	2.5
Feed	5
Escapes	5
Disease	5
Source of stock	2.5
Predators and wildlife	2.5
Secondary species	2.5
Other (e.g., GHG emissions)	n/a
Total	**42.5**

C1 Data Final Score (0–10)	**3.9**	**YELLOW**

Criterion 2: Effluents

Factor 2.1—Biological waste production and discharge

Factor 2.1a—Biological waste production

Protein content of feed (%)	30
eFCR	1.56
Fertilizer N input (kg N/ton fish)	17.36
Protein content of harvested fish (%)	17.8
N content factor (fixed)	0.16
N input per ton of fish produced (kg)	95.98
N in each ton of fish harvested (kg)	28.48
Waste N produced per ton of fish (kg)	**67.50**

Factor 2.1b—Production System discharge

Basic production system score	0.51
Adjustment 1 (if applicable)	–0.2
Adjustment 2 (if applicable)	0
Adjustment 3 (if applicable)	0
Discharge (Factor 2.1b) score (0-1)	**0.31**

Factor 2.1 Score—Waste discharge score

Waste discharged per ton of production (kg N ton^{-1})	20.93
Waste discharge score (0–10)	**7**

Factor 2.2—Management of farm-level and cumulative effluent impacts

2.2a Content of effluent management measure	2
2.2b Enforcement of effluent management measures	1
2.2 Effluent management effectiveness	**0.8**

C2 Effluent Final Score (0–10)	**4.00**	**YELLOW**
Critical?	NO	

Criterion 3: Habitat

Factor 3.1—Habitat conversion and function

F3.1 Score (0–10)	0

Factor 3.2—Management of farm-level and cumulative habitat impacts

3.2a Content of habitat management measure	2
3.2b Enforcement of habitat management measures	1
3.2 Habitat management effectiveness	**0.8**

C3 Habitat Final Score (0–10)	**0**	**RED**
Critical?	YES	

Criterion 4: Evidence or Risk of Chemical Use

Chemical Use parameters	**Score**	
C4 Chemical Use Score (0–10)	**0**	
C4 Chemical Use Final Score (0–10)	**0**	**RED**
Critical?	NO	

Criterion 5: Feed

5.1—Wild Fish Use

Feed parameters	**Score**
5.1a Fish In:Fish Out (FIFO)	
Fishmeal inclusion level (%)	14.5
Fishmeal from by-products (%)	31
% FM	10.005
Fish oil inclusion level (%)	1.5
Fish oil from by-products (%)	100
% FO	0
Fishmeal yield (%)	22.5
Fish oil yield (%)	5
eFCR	1.56
FIFO fishmeal	0.69
FIFO fish oil	0.00
FIFO Score (0–10)	8.27
Critical?	NO
5.1b Sustainability of Source fisheries	
Sustainability score	–10
Calculated sustainability adjustment	–1.39
Critical?	NO
F5.1 Wild Fish Use Score (0–10)	**6.88**
Critical?	NO

5.2—Net protein Gain or Loss

Protein INPUTS	
Protein content of feed (%)	30
eFCR	1.56
Feed protein from fishmeal (%)	32.14
Feed protein from EDIBLE sources (%)	90.04
Feed protein from NON-EDIBLE sources (%)	9.96
Protein OUTPUTS	
Protein content of whole harvested fish (%)	17.8
Edible yield of harvested fish (%)	45
Use of non-edible by-products from harvested fish (%)	50
Total protein input kg/100 kg fish	46.8
Edible protein IN kg/100 kg fish	42.14
Utilized protein OUT kg/100 kg fish	18.64
Net protein gain or loss (%)	–55.76

Critical?	NO
F5.2 Net protein Score (0–10)	**4**

5.3. Feed Footprint

5.3a Ocean Area appropriated per ton of seafood	
Inclusion level of aquatic feed ingredients (%)	16
eFCR	1.56
Carbon required for aquatic feed ingredients (ton C/ton fish)	*69.7*
Ocean productivity (C) for continental shelf areas (ton C/ha)	*2.68*
Ocean area appropriated (ha/ton fish)	6.49
5.3b Land area appropriated per ton of seafood	
Inclusion level of crop feed ingredients (%)	84
Inclusion level of land animal products (%)	0
Conversion ratio of crop ingredients to land animal products	*2.88*
eFCR	1.56
Average yield of major feed ingredient crops (t/ha)	*2.64*
Land area appropriated (ha per ton of fish)	0.50
Total area (Ocean + Land Area) (ha)	6.99
F5.3 Feed Footprint Score (0–10)	7

Feed Final Score

C5 Feed Final Score (0–10)	**6.19**	**YELLOW**
Critical?	**NO**	

Criterion 6: Escapes

6.1a System escape Risk (0–10)	2	
6.1a Adjustment for recaptures (0–10)	0	
6.1a Escape Risk Score (0–10)	**2**	
6.2. Competitive and genetic interactions score (0–10)	**4**	
C6 Escapes Final Score (0–10)	**3**	**RED**
Critical?	**NO**	

Criterion 7: Diseases

Disease Evidence-based assessment (0–10)	4	
Disease Risk-based assessment (0–10)		
C7 Disease Final Score (0–10)	**4**	**YELLOW**
Critical?	NO	

Criterion 8X: Source of Stock

C8X Source of stock score (0–10)	–2	
C8 Source of stock Final Score (0–10)	**–2**	**GREEN**
Critical?	NO	

Criterion 9X: Wildlife and Predator Mortalities

C9X Wildlife and Predator Score (0–10)	–4	
C9X Wildlife and Predator Final Score (0–10)	**–4**	**YELLOW**
Critical?	NO	

Criterion 10X: Escape of Secondary Species

F10Xa live animal shipments score (0–10)	0.00	
F10Xb Biosecurity of source/destination score (0–10)	10.00	
C10X Escape of secondary species Final Score (0–10)	**0.00**	**GREEN**
Critical?	n/a	

Appendix 3: Interim Update

This assessment report was originally published in November 2018. An Interim Update of this assessment was conducted in August 2023 and is detailed here. Interim Updates focus on an assessment's limiting (i.e., Critical or Red) criteria, and include a review of the availability and quality of the data relevant to those criteria. This review evaluates the Data, Habitat, Chemical Use, and Escapes criteria. The following text summarizes the findings of the review for these four criteria and a brief update of industry statistics. Overall, no new information was found or received that would suggest that the final rating in the 2018 assessment is no longer accurate. No substantive edits were made to the original (2018) text of the report (except an update note in the Executive Summary).

Criterion 1—Data

Updated industry statistics showing the recent scale of production, total pond area, and the types of production system used were available from the government agency INPESCA (see the following sections for all references and/or links used in this Interim Update). Regarding data for Criterion 3—Habitat, the most relevant new information is the Coastal Habitat Mapping project from Clark Labs, which provides data from 1999 to 2022 on land use changes associated with brackishwater aquaculture. The updated information on the total shrimp pond area from INPESCA was also relevant to Criterion 3, and the literature evaluating farm siting regulations and management from INPESCA and the Food and Agriculture Organization were also reviewed. Data availability for Criterion 4—Chemical Use continues to be low, with no significant new information readily available. Minor new information was available from peer-reviewed literature in addition to recent audit reports from a small number of farms certified to the Aquaculture Stewardship Council (ASC); but overall, chemical use remains largely unknown. Lastly, data on shrimp escapes continue to be unavailable, and information describing biosecurity and farm practices to mitigate escape risk continues to be limited. Evidence from recent flooding events associated with tropical storms was available to inform the ongoing escape risk. Overall, the availability and quality of information for each criterion in this interim update (i.e., Habitat, Chemical Use, and Escapes) continues to be low to moderate.

Review of Industry Status

To help extend industry trends through time since the completion of the last assessment in 2018, updated production statistics, which describe production by weight (pounds), area (hectares), and production system type (e.g., artisanal, extensive, semi-intensive, and intensive), are summarized. Production statistics (i.e., total annual shrimp harvest) from 1991 to 2021 in Nicaragua are shown in Figure 14. Data from 1991 to 2006 are from the Food and Agriculture Organization (FAO 2023), while data from 2007 to 2021 are from annual fisheries and aquaculture statistics published by INPESCA.[23] Since the previous assessment in 2018, annual production has been relatively stable at about 25,000 mt. Despite the increase in overall production, total shrimp pond area has also been relatively stable since 2017, except for a dip in 2019 (Figure 15). Note that the types of habitats converted into shrimp farms are discussed further in Criterion 3—Habitat.

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[23] http://inpesca.gob.ni/images/Anuarios%20Pesqueros/Anuario%20pesquero%20y%20acuicola%202021-011222%20BCN-FINAL%202A.pdf

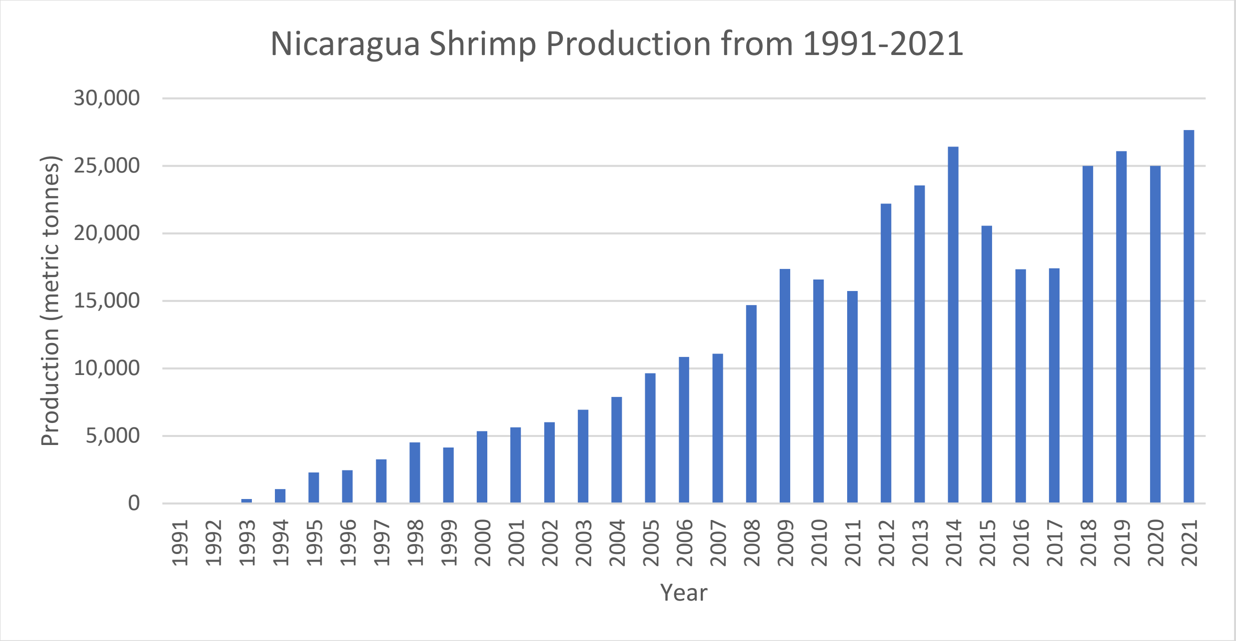

Figure 14: Nicaragua shrimp production from 1991 to 2021. Data from 1991 to 2005 are from FAO FishStat database. Data from 2006 to 2021 are from INPESCA.

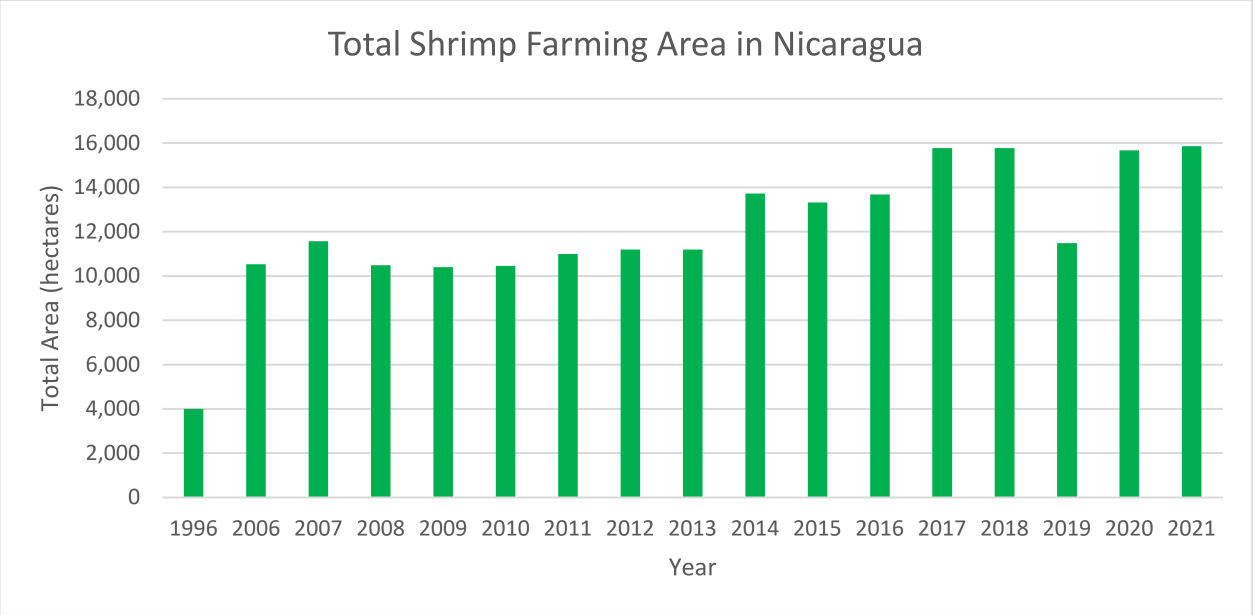

Figure 15: Nicaragua shrimp farming area in hectares. Data from 1996 are from Tobey et al. 1998 citing Rosenberry 1994, 1996, and data from 1996 to 2021 are from INPESCA.

The dominant production system in Nicaragua is semi-intensive ponds, accounting for approximately 90% of harvests in 2021 (Figure 16). Through time, according to data from INPESCA, production volumes from semi-intensive systems have oscillated with a peak in 2014 followed by a dip to 2017 and a steady increase in production totals to 2021 (which is also reflected in Figure 14). Artisanal (artesenal in Spanish) production systems are also currently increasing production volume since 2017 (see Figure 3).

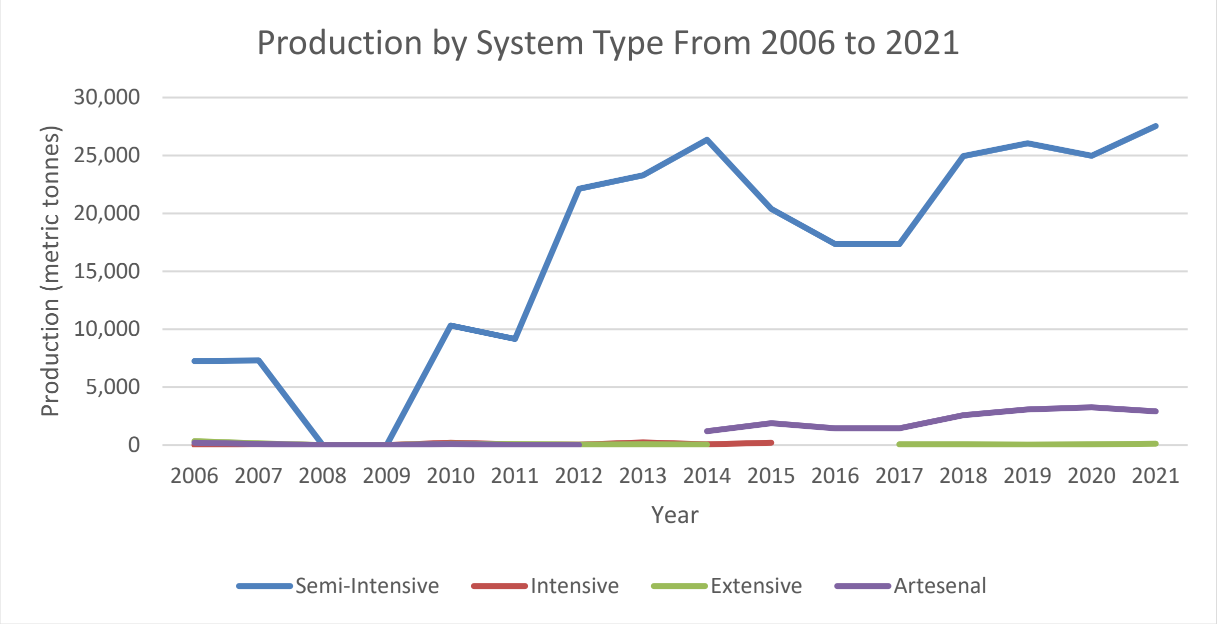

Figure 16: Nicaragua shrimp production by system type from 2006 to 2021. Note: not all years are available from INPESCA, but the general trend clearly shows that semi-intensive production is the dominant production system by volume in Nicaragua. Data source is INPESCA.

Regarding the previous fluctuations seen in annual production (e.g., from 2015 to 2017 in Figures 14 and 16), recent anecdotal evidence indicates that production in 2023 may also have been substantially reduced by the withdrawal of a feed company's sanitary certificate by Nicaragua's Agricultural Protection and Health Institute (IPSA).[24]

Altogether, the most recent production data indicate that both total harvests and total pond area have been generally stable since the previous 2018 assessment, although both appear susceptible to fluctuations. The dominant production system type continues to be semi-intensive ponds with minor increasing production from artisanal systems.

Criterion 3—Habitat

This section seeks to update Criterion 3—Habitat, with new information and/or elaborations on the 2018 assessment.

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[24] The withdrawal in January 2023 suspended Cargill's authorization to produce medicated and nonmedicated shrimp feed in Nicaragua. For example: https://nicaraguainvestiga.com/economia/107092-cargill-nicaragua-ipsa/

Factor 3.1—Habitat Conversion and Function

As stated in the 2018 assessment, the majority of Nicaraguan shrimp is grown in the northwest of the country, primarily along the Estero Real estuary with additional production in Estero Padre Ramos in the Chinandega department (Rivas, 2013)(Benessaiah, 2014 citing MIFIC 2007 and 2013). Because the majority of production occurs in the Estero Real estuary, it is the primary area of interest for this criterion.

The Estero Real is an ecologically important area within the Gulf of Fonseca. Habitat types include mangroves, salt flats, lagoons, and wetlands (Ramsar 2000). This dynamic and biodiverse ecosystem is important regionally for its flora and fauna, particularly shorebirds, which is exemplified by its designation as a Ramsar wetland area (Ramsar 2000) in 2001.

Using satellite imagery, Benessaiah (2008) estimated the total shrimp pond area and land-use change from 1987 to 2006. Although the development of shrimp farms in the estuary began in the late 1970s, they primarily developed in the late 1980s, with a total of 9,788 ha of shrimp ponds constructed by 1999 (Benessaiah 2008). The majority (>75%) of the land converted to shrimp ponds during this period was salt flats and seasonal lagoons, while approximately 20% was from wetlands (Benessaiah 2008).

New information from the Clark Labs project[25] helps to provide quantitative measures of more recent land-use changes by habitat type from 1999 to 2020 in Nicaragua. Because this data source was not available for the previous 2018 assessment, it is considered here in full. Combined with the Benessaiah (2018) studies, a timeline and evaluation of shrimp pond area and land-use change from 1987 to 2022 is now possible.

Clark Labs uses satellite imagery to assess coastal land-use change relating to brackishwater pond production by habitat type from 1999 to 2022 and highlights recent trends within this time period from 2020–22. Because white-leg shrimp is the only species recorded in brackishwater pond production in Nicaragua (FAO FishStat 2023), it appears that the findings by Clark Labs are directly related to the shrimp farming industry.

According to the Clark Labs analysis from 1999 to 2022 in the Chinandega department, 11,702 ha of land were converted to ponds (with an average over this period of 487.6 ha per year), primarily from wetlands (78%), mangroves (14%), and other types of habitat (8%). The total land-use change for wetlands and mangroves is 10,695 ha. The land classification for wetlands includes any "non-mangrove wetland, fresh or brackish, that occurs within the defined coastal zone" (Eastman et al. n.d.), so it would presumably include lagoons (including seasonal lagoons) and salt flats. The "other types of habitat" category includes types of land cover such as cropland, nonmangrove forests, and settlements (Eastman et al. n.d.).

Altogether, the analyses by Benessaiah (2008) and Clark Labs detail the continuous conversion of high-value habitats such as salt flats, lagoons, wetlands, and mangroves to shrimp ponds from 1987 to 2022. The most recent data show that this is ongoing, albeit more slowly, with 167 ha of high-value habitat (e.g., wetlands, mangrove) converted to ponds from 2020 to 2022 (average of 55.7 ha per year). As noted in Figure 15, the total pond area in 2021 was 15,857 ha, but Morales et al. (2019) note that 21,182 ha have been granted under concession in Nicaragua (i.e., an additional 5,325 ha), which do not yet appear to have been used (i.e., they are currently natural habitat).

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[25] https://clarklabs.org/aquaculture/

In summary, the findings of this interim update are consistent with the previous assessment. From 1999 to 2022, it is estimated that 10,695 ha of wetland (e.g., wetlands, lagoons, salt flats) and mangroves have been converted to shrimp farms, which has majorly altered and affected the functionality of the Estero Real ecosystem. It is recognized that the rate of conversion of mangrove and wetland habitats has slowed, with only 167 ha converted between 2020 and 2022, but the large loss of wetlands and mangroves in the last 25 years, in addition to minor ongoing conversion, remains a high concern for Factor 3.1—Habitat Conversion and Function.

Factor 3.2a—Content of habitat management measures
Important legislation and implementing regulations cited in the 2018 assessment were Law 489 and implementing regulation Decree No. 9/05 of 2005 and Law 690 Development of Coastal Zones from 2009, amended in 2015 and implemented by Decreto No. 78/09. The Coastal Law is applicable for all coastal property (i.e., bordering beaches, lagoons, estuaries, and rivers) and helps to define public property as the area between low and high tide and 50 m beyond high tide. Areas outside these defined public coastal areas can be private property.[26] Law 489 has been updated since 2005, but the ecological considerations within the permitting and citing process for shrimp farming do not appear to have changed. In addition, it should be noted that legislation regulating natural resources has existed in Nicaragua in some form since as early as 1976, while the creation of protected areas including the Estero Real estuary was passed in 1983 (Benessaiah 2008, citing Decree no. 1320 1983). Mangrove protections have existed in Nicaragua since as early as 1976, and in 1991 the harvest of mangroves was prohibited (Benessaiah, 2008, citing Nunez-Ferrera, 2003). See Benessaiah (2008) for a detailed summary of historical legislation and regulations regarding environmental protections in Nicaragua and the Estero Real estuary.

For the purposes of supporting and elaborating the findings of the 2018 assessment, and to define the regulatory framework for shrimp farming in Nicaragua in more detail, further information is added here. Many Central American countries participate in The Integrated Central American Fisheries and Aquaculture Registry System (SIRPAC)[27] through Regulation OSP-01-09. This regulation helps to create a directory of aquaculture farms throughout all participating countries, though it does not appear to be publicly available. In addition, the Code of Ethics for responsible fishing and aquaculture in the States of the Central American Isthmus[28] (Regulation OSP 04-11) includes a number of articles and principles that define values, behaviors, and ethical and moral principles for the fisheries and aquaculture industries. This regulation is quite broad and is missing definitions/details, but it sets a framework to promote sustainable aquaculture practices, scientific research and data collection, and labor rights.

At a national level, Nicaragua participated in a number of workshops with the Food and Agriculture Organization (FAO) to develop an Ecosystem Approach to Aquaculture (EAA) in the Estero Real estuary. The purpose of the EAA and workshops was to "address the unsustainable situation of fishing and the need to improve the conditions of aquaculture in the geographic zone [Estero Real estuary]" by creating a sustainable development plan. As discussed in Factor 3.1, the estuary went through considerable development, which has had many direct and indirect social, economic, and environmental effects for the communities and ecosystems in the area (Benessaiah and Sengupta 2014)(Brugere et al. 2019)(FAO 2014). The EAA workshop in 2014 was created to help resolve these issues and included participation from numerous stakeholders, including 53 attendees from state institutions, the private sector, local

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[26] https:/canatur-nicaragua.org/centro-de-documentacion/ley-690-en.pdf
[27] https://www.sica.int/busqueda/secciones.aspx?IdItem=79762&IdCat=48&IdEnt=47
[28] https://www.sica.int/busqueda/secciones.aspx?IdItem=79762&IdCat=48&IdEnt=47

communities, and NGOs (FAO 2014). The following were listed as initial steps to help resolve the issues within the Estero Real Estuary (FAO 2014):

1. Environmental Management and Production program: aims to promote best practices for aquaculture and implement environmental monitoring.
2. Program for the reconversion of artisanal fishers and strengthening of cooperative of small-scale aquaculture farmers: the purpose is to help support small-holder shrimp farmers (i.e., technical support, provide needed resources, and improve governance).
3. Governance and coordination strengthening program institutional: the objective is to improve the governance and coordination of the shrimp farming and fishing activities within the estuary.
4. Communication, extension, and environmental education program: improve communication through "media, activities, events, advice and extension."

A follow-up review of the progress of these steps by Brugere et al. (2019) stated that the plan is active yet is challenged by numerous barriers, including competing development objectives, difficulties with interagency cooperation and ecosystem and administrative boundaries, and poor governance and regulation.

The agencies responsible for regulating the permitting process and enforcement within the EAA framework include:

- Institute of Fisheries and Aquaculture (INPESCA)
- Ministry of the Environment and Natural Resources (MARENA)
- Ministry of Development, Industry and Trade (MIFIC)
- Directorate of Fisheries and Aquaculture Management (DOPA)

Despite the more recent efforts to develop a sustainable area-based approach to aquaculture development in the Estero Real estuary through the EAA framework, the main permitting law and regulations for aquaculture siting and development, Law 489[29] and the implementing regulation Decree 9-2005, appear largely unchanged despite the ensuing amendments.[30] The permitting process appears to depend on whether the proposed farm is on private or public lands (as stated above defined by Law 690 Coastal Zones).

Farms may be sited within protected or public areas through a concessions process that includes an application documenting the activity [shrimp farming], area, topography, species and cultivation system type, farm design (i.e., number of ponds, dimensions, area, reservoir pond area, drainage channel design and location, screens utilized, and pumping station specs), and farm practices (i.e., culture process, pond preparation, fertilization, water quality monitoring, and feed management).[31] An application must also include an Environmental Impact Assessment (more details follow), which is reviewed by regional councils, indigenous communities, and municipalities. If the application is approved, concessions are published in newspapers, and any opposition can be submitted to INPESCA for review. All aquaculture

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[29] http://inpesca.gob.ni/index.php/en/direcciones/dopa/reglamento-ley-489

[30] Decree-9 2005 is amended by Decree 30 – 2008, Decree 45-2009, and Decree 28-2012: http://inpesca.gob.ni/index.php/en/direcciones/dopa/reglamento-ley-489

[31] http://www.inpesca.gob.ni/images/Requisitos%20para%20Pesca%20Y%20Acuicultura/acuicultura/Concesi%C3%B3n%20de%20Acuicultura.pdf

concessions must be compliant with a number of conditions as outlined in Article 164, some of which include: comply with MARENA management plan, compliance to regulations (i.e., environmental protection), no mangroves may be cut down, and the granted concession area may not be exceeded. Also, Article 166 states that these conditions are retroactive for all shrimp farms before 2005, and provides a 3-month period for farms to comply to the law and regulations or the State may adjudicate the existing infrastructure on the farm in the courts. Although the mangrove trees are protected, noticeably missing from this legislation is the protection of the broader mangrove ecosystem; i.e., there is no preclusion of pond development within the broader mangrove ecosystems such as hypersaline mud and sand flats (which are classified as "wetlands" in the Clark Labs analysis) nor within seasonal lagoons.

In contrast to the siting of farms within protected or public areas, the permitting process for farms on private lands has fewer barriers.[32] Proposed farms must register by submitting documentation such as the location of the business, capacity, and other business-related information (i.e., address), and must have an approved environmental impact assessment (EIA).

All farms are monitored for regulatory compliance—although the frequency is unknown—but the task is given to "INPESCA and the Mayor's Offices of coastal Municipalities along with help from the police, MARENA and other State institutions" (Article 208). Presumably, the monitoring pertinent for habitat protections is inclusive of assuring that farms are registered, have not cut down any mangroves, and, if on public land, are within the concession allotment. Articles 234 to 238 define the penalties for offenses, which include fines and potentially losing the concession area.

The Environmental Impact Assessment (EIA) process is defined in Decree 20-2017 System of Environmental Assessment For Permits And Authorization For The Sustainable Use Of Natural Resources. Given the date of the Decree, 2017, it is assumed that it was informed by the 2014 EAA workshop and the resulting implementation plan, and it is unclear whether it is retroactive. The rigor of environmental assessment depends on the categorization of the proposed activity. All semi-intensive and intensive farms (Article 15) are considered Category 2 (of 5) projects and by definition have a "High potential [for] environmental impact." The categorization and resulting environmental impact evaluation for other farming types (e.g., artisanal, extensive) was not readily available in the text reviewed for this assessment, but according to data from INPESCA, semi-intensive farming accounts for about 99% of shrimp farming production in Nicaragua, so the details of the EIA process for Category 2 projects are the focus of this update.

According to Annex 3 of System of Environmental Assessment for permits and authorization for the sustainable use of natural resources Decree 20-2017, all semi-intensive and intensive shrimp farm applications must document all environments within 1000 m of the farm (i.e., any protected areas and the river, springs, estuaries, and coasts).[33] [34] Environmental review includes an evaluation of the flooding risk, potential impacts of the project to environmental quality (i.e., water, air, soil, flora, fauna, and landscape). All mitigation and prevention measures for each identified impact along the project timeline must be defined, along with the responsible actors, and when the actions will be implemented.

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[32] http:/inpesca.gob.ni/images/Requisitos%20para%20Pesca%20Y%20Acuicultura/acuicultura/Inscripci%C3%B3n%20de%20Acuicultura%20en%20Terrenos%20Privados.pdf

[33] https:/faolex.fao.org/docs/pdf/nic177024.pdf

[34] https://www.fao.org/faolex/results/details/en/c/LEX-FAOC177024

All EIA applications are reviewed by the “inter-institutional commission” and the results of the review are documented.[35] The EIA application approval is determined by MARENA.[36] The proposed monitoring established by the EIA is carried out by MARENA, SERENA, and the municipal and sector environmental management units.[37] All approved projects with an EIA are within a database but it is not accessible to the public.[38]

Factor 3.2a—Conclusion

The regulatory processes for shrimp farm siting in the Estero Real estuary of Nicaragua appears to consider ecological principles during farm siting. There is a regional approach to managing aquaculture development within the Estero Real estuary, based on the ecosystem approach to aquaculture (EAA), which seeks to develop sustainably by improving governance of the estuary. Despite these efforts, new farms or expanding farms have continued to develop within the estuary and are enabled by the permitted siting of farms in the public and private domains. Law 690 on Coastal Zones defines the area between low tide and 50 m above high tide as public property (in addition to protected areas), which under Law 489 allows for public concessions of this land for development such as shrimp farms. If proposed farms in these areas are semi-intensive or intensive shrimp farms, they must go through an environmental impact assessment and review, and if approved by the Ministry of the Environment and Natural Resources and local municipalities, the pending concession is made public, allowing for public comment/dispute. Although this process has important components of a cumulative management system, and specifically appears to protect mangrove trees, it does not appear to maintain ecosystem functionality because it allows for the development of shrimp ponds in the mud flats, salt flats, and seasonal lagoons of the broader mangrove/wetland ecosystem (i.e., “wetlands,” as defined by Clark Labs, within which 78% of the pond construction from 1999 to 2022 took place). Therefore, the regulations and management measures do not appear to robustly protect these high-value habitats. As discussed in Factor 3.1 and the following Factor 3.2b, the rate of conversion of high-value habitats to shrimp ponds has slowed considerably, but it is not clear if this is due to the content of the regulations and management measures discussed here or to some other reason. Therefore, the findings from the previous assessment are consistent with the findings for this interim update, and the Content of Habitat Management Measures (Factor 3.2a) continues to be considered limited.

Factor 3.2b—Enforcement of habitat management measures

There continues to be limited evidence of enforcement of habitat management measures. On the INPESCA website, there are several mentions of auctions of fishery and aquaculture products confiscated for violations of the Fisheries Legislation[39] from 2016, 2018, and 2019. There is also evidence of a few oppositions to aquaculture concessions in 2022.[40] This may be the result of improved enforcement, but there is no readily available evidence to support this notion. Practical aspects limiting the effectiveness of management enforcement are also apparent; for example, the division of seasonal lagoons into multiple management zones, which complicates their oversight (pers. comm., K. Benessaiah, November 2023). Besides these examples, this update was not able to provide any

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[35] https://www.eia.nl/en/countries/nicaragua/esia-profile

[36] https://www.eia.nl/en/countries/nicaragua/esia-profile

[37] https://www.eia.nl/en/countries/nicaragua/esia-profile

[38] https://www.eia.nl/en/countries/nicaragua/esia-profile

[39] http://inpesca.gob.ni/index.php/en/direcciones/dopa/resoluciones-ejecutivas

[40] https://inpesca-gob-ni.translate.goog/index.php/en/direcciones/dopa/comunicados?_x_tr_sch=http&_x_tr_sl=id&_x_tr_tl=en&_x_tr_hl=en&_x_tr_pto=wapp

substantial new information regarding the enforcement of habitat management measures, and according to the information available, it is concluded that enforcement appears limited.

Criterion 3—Habitat: Conclusion

Nicaraguan shrimp is primarily grown in the northwest of the country, along the Estero Real estuary in the Chinandega department. The Estero Real ecosystem is an ecologically important area that includes the country's largest extension of mangrove forests. The majority of shrimp farms have been built on hypersaline mud flats, salt flats, and seasonal lagoons within broader wetland areas. Overall, the wetlands (i.e., including the salt flat areas and seasonal lagoons) in the Estero Real region have been greatly reduced, especially toward the mouth of the river, where they have been converted into shrimp ponds. From 1999 to 2022, it is estimated that 10,695 ha of wetland and mangrove habitat have been converted to shrimp farms, which has majorly altered and affected the functionality of the Estero Real ecosystem. More than 5,000 ha have also been granted by concession but have not yet been utilized for shrimp production. It is recognized that the rate of conversion has slowed, with only 167 ha converted between 2020 and 2022, but the large loss of wetlands and mangroves in the last 25 years, in addition to minor ongoing conversion, remains a high concern for Factor 3.1—Habitat Conversion and Function.

Shrimp farm siting regulations appear to consider ecological principles, and there is a regional approach to managing aquaculture development within the Estero Real, based on the ecosystem approach to aquaculture (EAA), which seeks to develop sustainably by improving governance of the estuary. Despite these efforts, new farms or expanding farms have continued to develop within the estuary, which is enabled by the permitted siting of farms in the public and private domains. As noted, although no mangrove trees may be cut down, there do not appear to be specific regulatory requirements relating to the mud flat, salt flat, or seasonal lagoon components of the broader mangrove/wetland ecosystem (i.e., "wetlands," as defined by Clark Labs , within which 78% of the pond construction from 1999 to 2022 took place). Therefore, the regulations and management measures do not appear to robustly protect these high-value habitats. Although the rate of conversion of high-value habitats to shrimp ponds has slowed considerably, it is not clear if this is due to the content of the regulations and management measures discussed here or to some other reason. Therefore, the findings from the previous assessment are consistent with the findings for this interim update, and the Content of Habitat Management Measures (Factor 3.2a) continues to be considered limited. There is limited information readily available to suggest any changes from the previous assessment of enforcement of the habitat management measures, and enforcement is considered to be limited. As a result, Criterion 3—Habitat remains a Red rating and is a high concern.

Criterion 4—Chemical Use

Information describing the type, frequency, and governance of Nicaraguan shrimp farming chemical usage or aquaculture in general continues to be limited, with little new information since the previous assessment was concluded in 2018. What is readily available and relevant (e.g., literature, ASC audits) is summarized in the following text.

A recent study by José et al. (2022) surveyed two farms (e.g., Bolívar Marine Farm and the Cidaco Farm) in the Chinandega Department, which were considered noncompliant to Nicaragua's Best Aquaculture Practices. According to the results of the survey, some of the respondents indicated the use of antimicrobials and awareness of a withdrawal time. Neither the respondents nor the authors of the paper provided any insight into the frequency, type, or dosage amount of antimicrobial usage, though a respondent indicated that the precision of dosage amount was not actively followed. From what little information could be gleaned from this study, it appears that antimicrobials are used, but with little qualifying metrics or context.

Dominguez et al. (2021) performed a literature review for 23 Latin American countries (including Nicaragua) that focused on antimicrobial resistance in aquatic environments. Their review found that just one aquatic-focused study had taken place in Nicaragua from 2000 to 2020. The paper referenced, Amaya et al. (2012), assessed *E. coli* in aquatic environments in León, Nicaragua, and is not particularly informative for this assessment. Dominguez et al. (2021) demonstrated a strong correlation between gross domestic product (GDP) and the number of publications, indicating the possible impact of resources on the number of publications or research conducted (i.e., more resources, more publications). As noted in the study, Latin American governments (e.g., Nicaragua) need to improve antimicrobial governance (e.g., antimicrobial stewardship programs, improvement of prescription quality, public health awareness and enforcement).

Flores et al. (2022) sampled 62 fish from 4 fishing communities along the Pacific coastline near Chinandega (but south of Estero Real estuary) in 2019. The study tested antimicrobial resistance from bacterial isolates of two of the wild fish species caught, *S. costicola* and *V. metschnikovii*, and found all samples were resistant to amoxicillin and clavulanic acid and sensitive to ciprofloxacin and chloramphenicol. There were no determined causes of resistance, but the authors speculate that the sample locations are close to estuary river mouths downstream of urban areas (i.e., Leon) and cite a generalized narrative of resistance linked to aquaculture and shrimp farming from around the world.

Audits from ASC certified farms[41] (4 farms are certified, for a total of 16 sites) detail no antimicrobial use. The verified evidence is stated by the auditor as documents provided and reviewed, inspection of the farms, and interviews with farm employees. Some chemicals listed include lime, fertilizer, salt, garlic powder, and calcium hypochlorite, are typically applied for pond water amendments, and do not pose any significant risk of ecological impact to surrounding waterbodies. According to the Seafood Watch production dashboard, 4.4% of Nicaragua's shrimp production is certified to the ASC standard,[42] so these results cannot be extrapolated to shrimp farming more broadly in Nicaragua.

Nicaragua does have a National Plan for Biological Residues of Aquaculture Products (see Law 489, Article 164), which appears to be effective because there have been no United States FDA import refusals of shrimp from Nicaragua since 2011.[43] But the text of the Plan and more information about regulations of chemicals for the aquaculture industry were not readily available.

Globally, the use of antimicrobials in shrimp aquaculture continues to be a concern, with a wide range of antibiotics and other antimicrobials, including heavy metals, fungicides, and antiparasitics, being used (Thomber et al. 2020). Those authors also note the challenge of collating robust data on antimicrobial sales and usage, which is exemplified in the general literature with little information readily available from the Nicaragua shrimp farming industry.

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[41] Sahlman Seafoods, Seafood International Company, Aquacultura Torrecillas, and Camanica Zona Franca: https://asc-aqua.org/find-a-farm/

[42] https://www.seafoodwatch.org/recommendations/environmental-sustainability-dashboard

[43] https://datadashboard.fda.gov/ora/cd/imprefusals.htm

Therefore, despite the exceptions of the data from the certified farms, without specific data from the broader shrimp farming industry in Nicaragua, it cannot be assumed that antimicrobials are not used.

Conclusion

There is little new information readily available describing chemical use governance, use, type, and/or frequency for Nicaraguan shrimp farming or aquaculture in general. Therefore, for the purposes of this assessment, the use of antimicrobials or other chemicals continues to be largely unknown. The global concern regarding the use of antimicrobials in shrimp aquaculture continues, and without new information, the findings of the previous assessment remain warranted, and chemical use remains a high concern on a precautionary basis.

Criterion 6—Escapes

Although white-leg shrimp (*L. vannamei*) is native to the Nicaraguan coast, the increasing domestication and genetic distinction of farmed strains from wild conspecifics create a possible risk of competitive and genetic interactions following large escape events. As stated in the 2018 assessment, any escaping shrimp (other than the 25% of stocks sourced from wild juveniles) are considered to be domesticated, probably for multiple generations, and therefore to some extent genetically differentiated from the wild stocks.

But there continues to be no readily available information regarding the reporting of escape events or the monitoring of escaped farmed white-leg shrimp in the wild. The previous assessment evaluated the risk of escapes based upon the location of farms (in estuaries), and the frequency and severity of storms, hurricanes, and flooding, combined with the potential invasiveness of the escaping stock. There is no new information readily available to suggest that the previous conclusions are incorrect, but what information is available, gathered from recent ASC audits and literature, is summarized as follows.

Heavy storm systems have continued to cause significant flooding throughout Nicaragua and Central America. Two Hurricanes, Eta and Iota, occurred just 2 weeks apart in late October/early November of 2020, which caused significant rainfall, wind, flooding, and river flooding, among other impacts,[44] to Nicaragua and neighboring countries. In 2022, two hurricanes, Bonnie[45] and Julia,[46] also caused severe flooding among other impacts.

The severity of these storms and the impacts to Nicaraguan shrimp farmers (i.e., escapes) are not readily defined in literature, though one comment by a farmer in an ASC report stated "none of the tropical storms that have hit the area have caused flooding, only one in 1998 with Hurricane Mitch, which did cause flooding in the farm which is why high levels of borders are maintained[47]…." Yet, just across the border in the Choluteca department of Honduras (which is a part of the Gulf of Fonseca and connected to the Estero Real Estuary system), 96% of shrimp farming production was lost due to the storms.[48]

Other evidence of impacts or farm practices to mitigate escapes during flooding events is not readily described in literature. According to all ASC audits in Nicaragua, it is common practice for certified farms

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[44] https://www.nhc.noaa.gov/data/tcr/AL312020_Iota.pdf
https://www.nhc.noaa.gov/data/tcr/AL292020_Eta.pdf

[45] https://en.wikipedia.org/wiki/Hurricane_Bonnie_(2022)

[46] https://en.wikipedia.org/wiki/Hurricane_Julia_(2022)

[47] ASC audit of Aquacultura Torrecillas, 2022

[48] https://repositorio.cepal.org/bitstream/handle/11362/46853/3/S2100044_es.pdf

to place screens at the inlets and outlets, along with trapping devices for sampling/monitoring to recover any potential escapes. For these same farms,[49] the average daily water exchange rate is roughly between 5 and 10%, indicating a moderate openness to the surrounding watershed. According to Seafood Watch production statistics, certified ASC farms account for 4.4% of Nicaragua's annual shrimp production.[50]

Conclusion

There continues to be limited information on the escape of shrimp from farms in Nicaragua and/or on the potential impacts to wild shrimp. Recent information appears to confirm the escape risk of shrimp farms due to flooding during tropical storms, but no further information was found on the potential risks to wild shrimp as a result of potential genetic interactions. More information is needed to better inform the ecological risk of white-leg shrimp potential escapes and impacts to surrounding environments. Because farms are sited within the flood plains of estuaries, the findings of the previous assessment remain warranted, and the Escape criterion remains a high concern on a precautionary basis.

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[49] Sahlman Seafoods, Seafood International Company, Aquacultura Torrecillas, and Camanica Zona Franca: https://asc-aqua.org/find-a-farm/

[50] https://www.seafoodwatch.org/recommendations/environmental-sustainability-dashboard

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