Environmental sustainability assessment of farmed striped bass from Mexico produced in marine net pens

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Species:	Striped bass (*Morone saxatilis*)
Location:	Mexico
Gear:	Marine net pens
Type:	Farmed
Author:	Seafood Watch
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Assessed using Seafood Watch Aquaculture Standard V4

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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.

Guiding Principles

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

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

Seafood Watch will:

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

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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

Striped Bass from Mexico, farmed in marine net pens.

Approximate annual production (2023)	**1,349 MT**		
Criterion	**Score**	**Rating**	**Critical?**
C1 Data	7.96	Green	
C2 Effluent	8.00	Green	NO
C3 Habitat	7.60	Green	NO
C4 Chemicals	10.00	Green	NO
C5 Feed	5.35	Yellow	NO
C6 Escapes	4.00	Yellow	NO
C7 Disease	4.00	Yellow	NO
C8X Source of stock	0.00	Green	NO
C9X Wildlife mortalities	0.00	Green	NO
C10X Introduction of secondary species	0.00	Green	
Total	**46.905**		
Final score (0–10)	**6.701**		

OVERALL RATING

Final score	**6.701**
Initial rating	Green
Red criteria	0
Interim rating	Green
Critical criteria?	NO

FINAL RATING
Green

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. White text with a black background indicates a Critical score. Two or more Red criteria, or one Critical criterion result in a Red final result.

Summary

The final numerical score for striped bass farmed in marine net pens in Mexico is 6.701 out of 10, and with no red criteria, the final ranking is green.

Executive Summary

There is currently only one marine striped bass (*Morone saxatilis*) producer in Mexico (in fact, on the entire west coast of the Americas), and the farm (Pacifico Aquaculture) is based in Ensenada in Baja California. The striped bass species produced in Mexico (*Morone saxatilis*) should not be confused with the hybrid striped bass (hybrid of *M. saxatilis* and its congener *M. chrysops*, known as palmetto bass or sunshine bass) that is commonly grown in freshwater in other locations in the Americas.

The grow-out site consists of 3 modules (north, central, and south) with 62 floating net pens on the eastern (lee) side of Isla Todos Santos, a small group of islands approximately 11 miles offshore from Ensenada, in the state of Baja California in northwest Mexico. The company operates a freshwater hatchery on the mainland in Ensenada and supplies all its fry. The production volume of striped bass increased from 545 metric tons (MT) in 2018 to reach its peak at 2,359 MT in 2021, and has subsequently declined, with 1,349 MT in 2023. Roughly 80% of the Mexican striped bass production is designated for export to the United States, while the remaining 20% is consumed domestically.

This Seafood Watch assessment involves several different criteria that cover the impacts associated with effluent, habitat, wildlife and predator interactions, chemical use, feed use, escapes, the introduction of secondary organisms, disease, the source of stock, and general data availability.[2]

Because of the single-producer nature of the industry and the company's commitment to data provision, the data availability on all aspects of the production was good. Information on the broader Mexican regulatory systems for aquaculture and relevant academic studies in the region is somewhat limited, particularly regarding the rapidly expanding production, but overall, there is a currently a good understanding of the site's practices and potential impacts, and the score for Criterion 1—Data is 7.96 out of 10.

The concern regarding effluent impacts from the producer's waste discharges into the environment (i.e., uneaten feed waste and fish excretion) is considered to be low. While acknowledging some limitations in the data, such as inconsistency in the reported param and sampling sites throughout the assessment period (2020–23), the available data, including soluble and benthic nutrient indicators, benthic impact models, and heavy metal concentrations, do enable a fairly comprehensive understanding of the effluent impacts from the striped bass producer. The producer conducts annual comprehensive analyses of water quality and benthic indicators. These analyses entail testing water and sediment samples by an independent laboratory, Asesoria Integral Ambiental Puritec, in adherence to the Best Aquaculture Practices certification standards. This standard also requires predefined sampling locations, based on characteristics identified through a study conducted by a third party; in this case, Anderson Marine Surveys (AMS). Consequently, this assessment considers recommendations derived from AMS's benthic impacts model, evaluates key soluble nutrient indicators and sediment quality indicators, and scrutinizes available literature to better comprehend the potential contribution of the producer to cumulative impacts in Todos Santos Bay.

For soluble nutrients in the water column, the available monitoring data are supported by academic studies on net pen aquaculture in exposed locations, which conclude that significant impacts beyond the immediate farm area are highly unlikely. For benthic impacts, the available monitoring data appear to

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[2] The full Seafood Watch Aquaculture Standard is available at: http://www.seafoodwatch.org/seafood-recommendations/our-standards

support the comprehensive modeling assessment by AMS, which concludes that, although there will be some change and degradation to benthic communities in the immediate farm area, and some param are elevated at 30 m from the net pens compared to the reference sites, it is highly unlikely that there will be significant impacts much beyond this immediate farm area, particularly considering the rapidly increasing depth with increasing distance from the net pens.

There are some indications of excessive seasonal nutrient enrichment along the shoreline from wastewater treatment plants, but there are no studies readily available that the farm is contributing to the poor seasonal water quality along the shoreline. Considering the isolated nature of the striped bass farm, the data show no evidence that effluent discharges cause or contribute to cumulative impacts at the waterbody/regional scale. But there is a need for ongoing monitoring at various locations and distances from shore, to ensure the long-term health and sustainability of this valuable coastal ecosystem.

In conclusion, data show no evidence that effluent discharges cause or contribute to cumulative impacts at the waterbody/regional scale, and the impacts within the immediate vicinity of the farm are considered temporary. The final score is 8 out of 10 for Criterion 2—Effluent.

The striped sea bass industry in Mexico has a single producer utilizing 62 grow-out net pens, operating in about 180 ha, which is a small fraction (< 1%) of the bay's total surface area. Situated near Todos Santos Island, with depths ranging from 30 to 100 m and a substrate of sand/volcanic rock, the habitat type of the net pens can be classified as nearshore and coastal, which is considered a high-value habitat. The evidence emphasizes both the complexity and uncertainty regarding the scale of the impacts and the appropriate level of concern, but the examples cited do not indicate the loss of any critical ecosystem services from the affected habitats. Thus, the habitats are considered to be maintaining functionality with minimal impacts, and the score for Factor 3.1—Habitat conversion and function is 9 out of 10.

The content of habitat management measures is moderate. The company is sited according to ecological principles and environmental considerations. For example, the farm is compliant with all the necessary environmental permits, and it conducted an environmental impact assessment (EIA) in 2004. But the content (i.e., legislation and regulatory implementation) of the habitat management measures is considered limited, and the BAP certification does not address cumulative impacts or area-based principles. As a result, Factor 3.2a—Content of habitat management measures is considered moderate and the score is 3 out of 5. Enforcement of regulations aimed at protecting habitat is evident, with identifiable and accessible institutions such as PROFEPA taking a complaint-driven approach to enforcement (i.e., imposing penalties). In addition, the industry's sole producer demonstrates compliance with legal requirements, which is verified through annual inspections by BAP and SENASICA. Consequently, the score for Factor 3.2b—Enforcement of habitat management measures is 4 out of 5. Combined with the score for Factor 3.2a, the combined Factor 3.2 score for striped bass is 4.80 out of 10. As a result, the final score for Criterion 3—Habitat for striped bass is 7.60 out of 10.

Although there are no Mexican regulations limiting the volume or frequency of antibiotic use, there are requirements addressing the production and quality control of veterinary treatments (NOM-012-ZOO-1993), as well as guidelines for the classification and prescription of the active ingredients used in these treatments (NOM-064-ZOO-2000). In addition, the chemical treatments allowed for aquaculture use are clearly defined in the legislation, as well as the handling and transportation of chemicals of agricultural use (including those for aquaculture). The producer also adheres to the company's Best Management Practices for Drug and Chemical Use (BMP), which is aligned with U.S. Food and Drug Administration aquaculture treatment protocols. Most importantly, the producer has maintained low stocking densities and supplemented feed with immunostimulants (i.e., biomos, eucalyptus, and vitamin C), and there have not been any chemical treatments (i.e., antibiotics or pesticides) during the 5 years of operation from 2019 to 2023. Therefore, the available data (which score 7.5 out 10 under the Data Criterion) demonstrate a low need for chemical use, and the final score for Criterion 4—Chemical Use is 10 out of 10.

Specific data on the composition of striped bass were provided by Pacifico Aquaculture based on input from their feed supplier, EWOS (Cargill Animal Nutrition). The available information indicates that fishmeal and fish oil levels are low, and the feed is dominated by land animal and crop ingredients. The averaged feed conversion ratio (eFCR) was estimated at 2.69. Regarding the use of by-products, the feed manufacturer indicated that no by-products are used for fishmeal and that 100% of their fish oil is sourced from by-products. The forage fish efficiency ratio (FFER) is estimated at 1.25 and 0.05 for FM and FO, respectively. The Feed Criterion uses the higher, 1.25 FFER value to determine the score. This FFER value means that, from first principles, 1.25 MT of wild fish must be caught to supply the fishmeal to grow 1 MT of striped bass. The source fisheries for the marine ingredients used by the feed manufacturer appear to be sustainable (score of 8 out of 10), and the combined (Factor 5.1a and 5.1b) Wild Fish Use score is 7 out of 10. The feed protein content over a production cycle used in this assessment is 43%. With a whole striped bass protein content of 19.55% (and the eFCRs considered in this assessment), there is a substantial net loss of protein of –83.10%, resulting in a score of 1 out of 10. The feed footprint calculated as the embedded climate change impact (kg CO_2-eq) resulted in an estimated kg CO_2-eq per kg of farmed seafood protein of 10.99. This value is equivalent to a score of 7 out of 10. The three scores combine to give a final score for Criterion 5—Feed of 5.35 out of 10 (see the Seafood Watch Aquaculture Standard for further details on all scoring tables and calculations).

The final score for Criterion 6—Escapes is a combination of the escape risk and the potential impacts of escapees. The striped bass producer implements multiple escape-prevention methods, including strategic farm siting, size grading with appropriate mesh size, and a detailed Environmental Best Management Practices (BMPs) manual, which includes details on the containment management system (CMS) that emphasizes net pen design and construction, site maintenance including net management and testing (i.e., periodic diving inspections), moorings and subsurface components, predator control, all fish handling procedures, and escape response and recapture plans. In addition, the CMS includes a Hazard Analysis and Critical Control Point Assessment (HACCP) for the site and an assessment of the fate and potential impacts of a hypothetical striped bass escape from the site. While best management practices are in place for escape prevention and no escapes are reported by the industry's single producer, the net pens used are inherently vulnerable to both large-scale and small-scale escape. The annual counting errors estimated from the producer's fish inventory, averaging negative 11.23% over the past 5 years, suggests potential frequent annual trickle losses, although this has not been directly observed. Therefore, an intermediate score is necessary. Considering the open nature of the production system, the implementation of BMPs, and reporting no major escape events, Factor 6.1 would merit a score of 4 out of 10. But the cumulative discrepancies in fish inventory counts (> 5% cumulatively) over the past decade suggest the possibility of frequent trickle losses, warranting a score of 2 out of 10 under the SFW standard. Therefore, a precautionary intermediate score of 3 out of 10 is deemed appropriate for Factor 6.1—Escape Risk.

The establishment of viable populations of nonnative striped bass at Isla Todos Santos is highly unlikely because of unsuitable habitat conditions for reproduction. In addition, the probability of escaped striped bass migrating around 550 mi to San Francisco Bay, the nearest known breeding ground, is deemed low.

If such migrations were to happen, the potential impact of farm escapees from Mexico is regarded as low when contrasted with the deliberate stocking of millions of striped bass by the California Department of Fish and Wildlife (CDFW) into the estuary. Although striped bass appear to be present in Mexican waters (i.e., based on anecdotal captures), the absence of monitoring makes it challenging to estimate their population level or their impact on local fish populations; any impact would likely depend on the frequency and number of escaped fish. In addition, post-escape mortality is uncertain but may be significant because of potential predation and fishing activities in the area. Overall, escaped fish may have some impact on wild species, but the likelihood of striped bass establishing viable populations in the region is highly unlikely. Consequently, the score for Factor 6.2 is 6 out of 10. Factors 6.1 and 6.2 combine to give a final numerical score of 4 out of 10 for Criterion 6—Escapes.

Despite being recognized as a disease-resistant cultured species, striped bass is susceptible to various infectious and noninfectious diseases. Primary diseases affecting cultured striped bass in the Americas include gram-negative and gram-positive bacteria, fungi, and parasites. Although numerous studies have delved into diseases affecting cultured striped bass, information regarding their impact on wild populations remains scarce. Net pens, deemed “open” to the environment, pose a potential risk of pathogen amplification and subsequent release into waters shared with wild fish. The implementation of biosecurity measures (i.e., Veterinary Plan for Sanitation and Animal Welfare and the Biosecurity Plan) and best practices by the producer, verified through third-party certification (Best Aquaculture Practices), is evident. Despite these efforts, it appears that various bacterial pathogens such as *Tenacibaculum maritimum* and *Vibrio* spp., along with parasites such as *Trichodina* sp., persist in affecting the cultured striped bass, resulting in heightened mortalities, especially during vulnerable stages like the transfer of fingerlings from the hatchery to the marine net pens. As a result, the risk of potential pathogen transmission from the cultured striped bass to wild fish in the surrounding area persists. Limited data, especially on the potential impacts on wild fish, prompt the use of the risk-based assessment (Data Criterion score for the disease section < 7.5 out of 10). Considering the potential pathogen and parasitic transfer risk to wild species, the openness of production systems, the prevalence of parasites, and the documented disease-related mortalities of the grow-out net pens across various cohorts (i.e., an average disease-related mortality rate of 37.43% out of the total reported mortality of 8.94% for the calendar year 2023), as well as the company’s documented implementation of biosecurity protocols, the final score for Criterion 7—Disease is 4 out of 10.

With a purpose-built hatchery and dedicated broodstock facility, striped bass production is fully independent of wild fisheries for broodstock and juveniles. The final score for Criterion 8X—Source of Stock is a deduction of 0 out of –10.

The colonies of seals and sea lions and large numbers of birds are the primary concern for wildlife interactions with the farm, but the company has a comprehensive written policy of exclusion, which was observed in practice with seal and bird nets on all net pens (during the site visit in 2016). Though impossible to verify, there were no documented cases of accidental or deliberate wildlife mortalities reported by the farm under scope from 2019 to 2023, and the company has actively instituted a wildlife interaction mitigation plan. The dedicated efforts of conservation groups in the Pacific islands of Mexico have led to positive ecological enhancements; however, they recognize that the aquaculture operations of the region (including the production under scope for this assessment) as a threat or an industry of concern for the recovery of marine bird species populations. Overall, the farm is in an area of high ecological value and preventive measures appear to be effective, because it appears that no wildlife mortalities have resulted from the assessed operation, and observed disturbances on seabirds appear highly unlikely to affect the health of the wild populations. The final numerical score for Criterion 9X—Wildlife Mortalities is 0 out of –10.

Striped bass is nonnative to the Pacific Ocean, and although there is an established population in the San Francisco Bay with historic active stocking of hatchery-raised fish, Pacifico Aquaculture originally imported juveniles and broodstock from a selective breeding program in Delaware in the United States. The company now has a broodstock unit at the Isla Todos Santos site and a freshwater hatchery established on the mainland in Ensenada. Movements of fish between these two locations on either side of Ensenada Bay are considered to be within the same waterbody, and there are also quarantine facilities at the hatchery. Production is now considered independent of international or trans-waterbody movements of fish, and the final numerical score for Criterion 10X—Introduction of Secondary Species is a deduction of 0 out of –10.

Introduction

Scope of the analysis and ensuing recommendation

Species
Striped bass—*Morone saxatilis*
(Note: this is not hybrid striped bass, the more commonly farmed hybridization of *M. saxatilis* and its congener *M. chrysops*, known as palmetto bass or sunshine ass)

Geographic Coverage
Todos Santos Bay, Ensenada, México.

Production Method(s)
Marine net pens

Species Overview

Brief overview of the species
According to NOAA (2015), striped bass is native to the Atlantic Coast of North America, ranging from the St. Lawrence River in Canada to St. John's River in Florida. It is anadromous, meaning that it lives in the ocean but returns to freshwater to spawn. Larvae and post-larvae drift downstream toward nursery areas located in river deltas and the inland portions of the coastal sounds and estuaries. Juveniles typically remain in estuaries for 2–4 years and then migrate to the ocean. Striped bass spends the majority of its adult life in coastal estuaries or the ocean, migrates north and south seasonally, and ascends rivers to spawn in the spring.

According to the California Department of Fish and Wildlife (formerly "Game") (CDFG, 2001), striped bass was introduced to the Pacific coast of the U.S. in 1879. The only major population is in the San Francisco Bay and delta, approximately 550 mi north of the Pacifico Aquaculture farm site in northern Mexico. This population has been supported by California Department of Fish and Wildlife with active stocking of millions of hatchery-raised fish that continued until the year 2000.

Striped bass demonstrates robust adaptation and high survival rates in both recirculating aquaculture systems (RAS) and floating net pens. Research indicates that striped bass exhibits comparable growth performance across varying water salinities, including freshwater, brackish, and saltwater environments (Andersen et al., 2021). In the late 1800s, efforts to culture striped bass initially aimed to enhance commercial and recreational fisheries of native Atlantic coastal stocks. But commercial aquaculture did not begin until the hybridization of striped bass with white bass, leading to aquaculture for hybrid *Morone* food-fish production in the United States in the 1970s (Andersen et al., 2021). Italy and Israel are also among the main producers of hybrid striped bass. Nonetheless, it appears that the only commercial producer of pure striped bass (*Morone saxatilis*) is Pacifico Aquaculture, operating along the Pacific coast of Mexico in net pen systems (FAO, 2024), and it is the scope of this assessment.

Production system
The single producer, Pacifico Aquaculture, operates a land-based freshwater hatchery in Ensenada, Mexico. Fingerling juveniles, averaging 11.62 g in weight, are transported from the hatchery to circular, plastic-framed net pens situated in seawater at offshore locations near Isla Todos Santos, approximately 11 mi off the Ensenada coast, to commence their grow-out phase. During this transfer, a single cohort of

striped bass is typically segregated by size and stocked into smaller, square-shaped net pens measuring 8 by 8 m and varying in depth from 5 to 10 m. Once the fish in these smaller net pens attain an average weight of 250 g, they are relocated to larger net pens measuring 25 m in diameter, with depths ranging from 15 to 20 m, where they remain until harvest (Figure 1). At this production stage, the reported average stocking density by the producer is 10.3 kg/m^3. Typically, the production cycle spans a period of 60 months. It is worth noting that this timeframe may decrease as the company progressively integrates larger fingerlings into their production methods (pers comm, Pacifico Aquaculture representatives, November 2023).

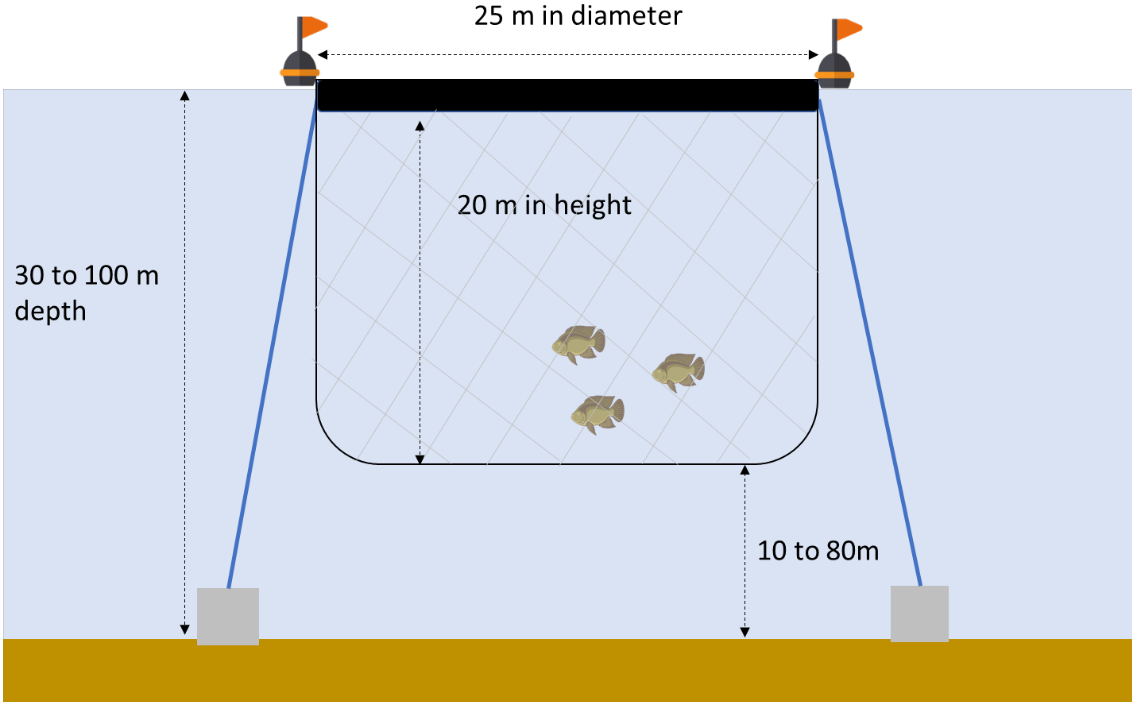

Figure 1: Net pen dimensions and configuration. Pens are 25 m (diameter) by 20 m (height), are in a depth of 30 to 100 m and are positioned between 10 and 80 m from the benthic zone. Each cage is anchored to several anchors (pers comm, Pacifico Aquaculture representatives, November 2023).

The net pens producing striped bass in Mexico are located on the eastern side (the lee side) of the largest island within the Isla Todos Santos group, encompassing three distinct modules of net pens, positioned within a relatively short distance of less than 1.5 m between each module (Figure 2). The central module receives striped bass fry from the hatchery; hence, it is equipped with 27 of the smaller, square-shaped net pens (measuring 8 × 8 × 8 m). One of these smaller net pens holds another species, *Totoaba macdonaldi*, under a temporary collaboration agreement with the Universidad Autónoma de Baja California (UABC). In addition, five of these net pens are utilized to hold striped bass broodstock, and six net pens are of regular size, which eventually are towed to the north and south modules. The remaining 15 net pens are stocked with fingerlings to initiate the grow-out phase of production. Notably, the northern module had been inactive since 2019; however, it was reactivated at the beginning of 2023. The northern module comprises 12 net pens, although only 6 of these were active in 2023. The southern module encompasses 26 net pens, with 23 of them active during the course of 2023. All three modules (north, central, and south) are strategically situated at a water depth ranging approximately between 30 and 100 m (see Figure 2). They are positioned over a steeply sloping seabed, situated on the periphery of a submarine canyon that reaches depths of more than 600 m to the east of the site. The sites are supported by workboats from Ensenada, and by a small shore base on the island. Because the primary environmental impacts are considered to occur at the sea site (as opposed to the land-based hatchery), this assessment focuses on the grow-out phase of production at Isla Todos Santos.

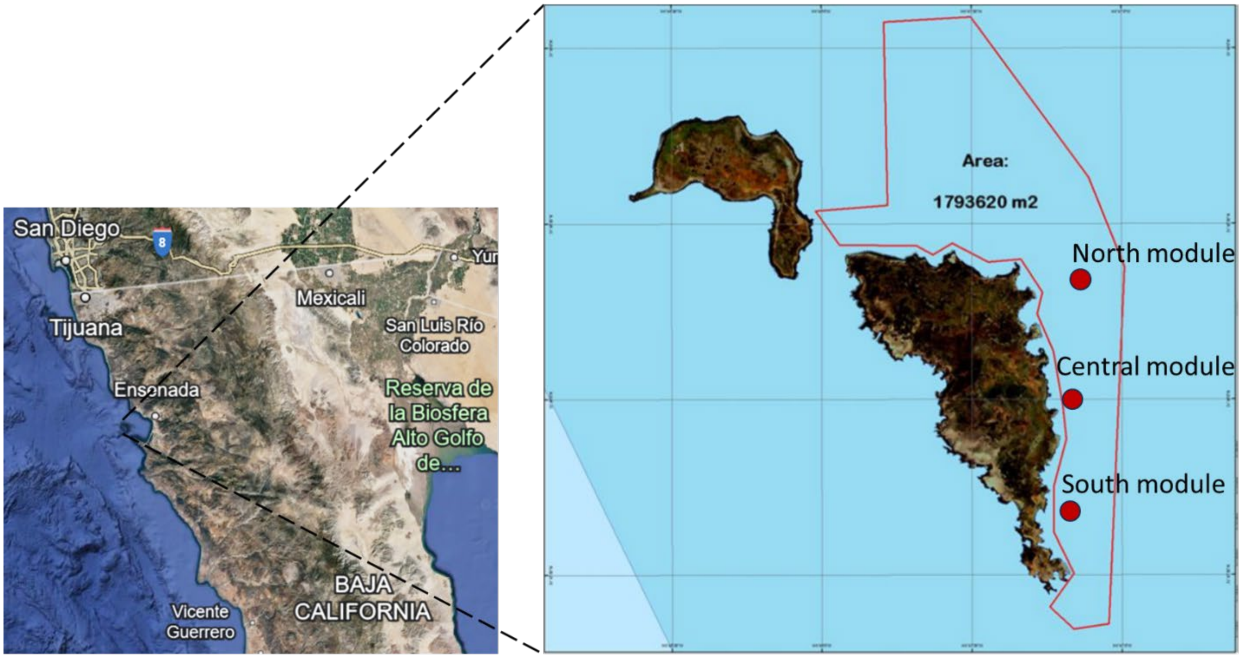

Figure 2: Site location maps. The left image shows where Ensenada Bay and Isla Todos Santos are located in relation to the United States and the Baja California peninsula. The right image shows the islands and the locations of the three net pen modules. Images provided by Google Earth and Pacifico Aquaculture (pers comm, Pacifico Aquaculture representatives, November 2023).

Production Statistics

Pacifico Aquaculture is the only marine-sited striped bass farm in the world. It must be noted that this is not the hybrid variant of striped bass (i.e., *M. saxatilis* X *M. chrysops*, known as palmetto bass and sunshine bass) that is grown in significant volumes in freshwater. Pacifico Aquaculture previously produced white seabass (*Atractoscion nobilis*) at the Isla Todos Santos site until 2016, transitioning to stocking their net pens with striped bass at the beginning of 2015. The production figures obtained from official statistics, provided by the Federal Commission of Fisheries and Aquaculture (CONAPESCA), exhibit slight disparities compared to the volumes reported by Pacifico Aquaculture (as depicted in Figure 3). According to the producer, they provide the same monthly production records to CONAPESCA as they did to Seafood Watch. The slight disparities with CONAPESCA's public data might be attributed to possibly classifying it under a different species, water type, or production method (such as fisheries versus aquaculture). For instance, the name used in official statistics for striped bass is "Lobina" instead of "lobina rayada," which would be the actual translation of the species' common name, with "freshwater" listed as the water type for culturing. Alternatively, striped bass might have been included under the category "Otras" ("Others"), which encompasses all species not specifically classified in CONAPESCA's official statistics (pers comm, Pacifico Aquaculture representatives, November 2023). But the volume reported by the producer is considered the most accurate and complete production data available for the country, because they are the primary source of this information, so these are the data considered in this report. It is worth noting that the volume of striped bass production exhibited significant fluctuations. It increased from 545 MT in 2018 to reach its peak at 2,359 MT in 2021, and has subsequently declined, with 1,349 MT in 2023'.

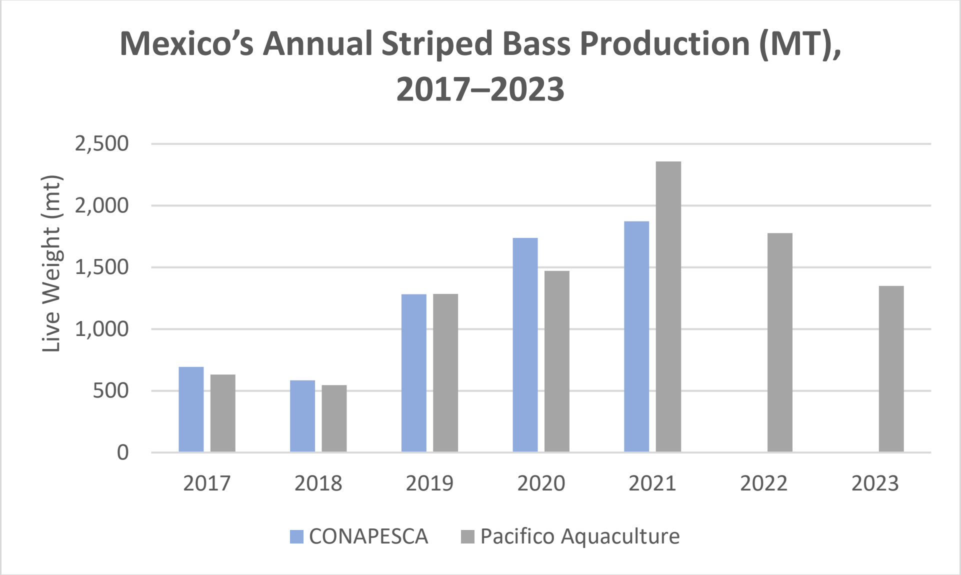

Figure 3: Annual production of striped bass as reported by CONAPESCA and Pacifico Aquaculture, from 2017 to 2023 (note that the latest volume reported by CONAPESCA is for 2021) (pers comm, Pacifico Aquaculture representatives, November 2023) (CONAPESCA, 2023).

Import and Export Sources and Statistics

Roughly 80% of the Mexican striped bass production is designated for export to the United States, while the remaining 20% is consumed domestically (pers comm, Pacifico Aquaculture representatives, November 2023). The entirety of striped bass exports consists of whole gutted fish. But when contrasting the reported annual production volumes with the official trade statistics, significant disparities become evident (refer to Figures 3 and 4 for graphical representation). It is noteworthy to recognize that, within the National Oceanic and Atmospheric Administration (NOAA) database, there is no specific product item corresponding to the item name "striped bass," under which the producer indicates they export their fish. Thus, the products considered for the reported import volumes are limited to "seabass (*Dicentrarchus* Spp.)" and "bass fresh," because these are the only product items available within the NOAA Foreign Trade database that could encompass striped bass. Even after implementing adjustments to the total trade volume (MT) as described in EUMOFA[3] 2019 guidelines (1.17 conversion factor—whole gutted fish), the traded volumes are considerably lower than production volumes reported by Pacifico Aquaculture. For instance, the production volume designated for export in 2023, which constituted 80% of the total, amounted to 1,079 MT (considering the 1.17 conversion factor). This figure significantly surpasses the 289 MT reported by NOAA Foreign Trade for the same year.

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[3] https://www.eumofa.eu/supply-balance-and-other-methodologies

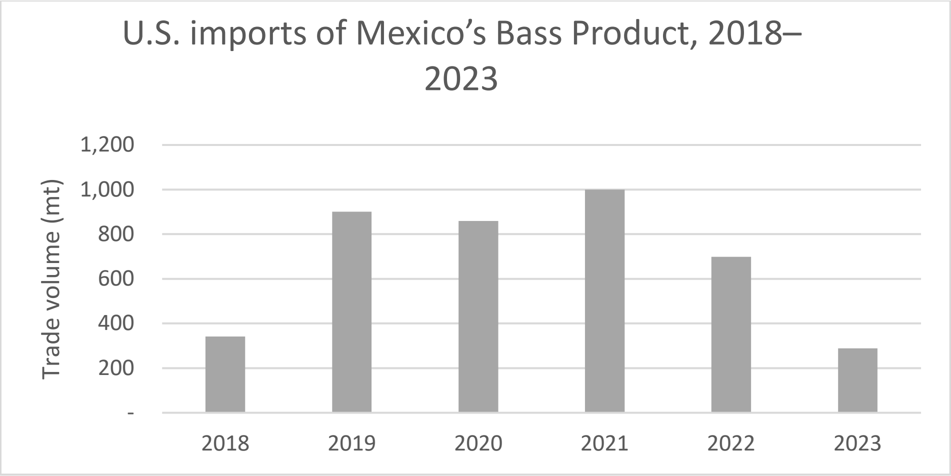

Figure 4. United States imports of Mexico's "seabass (*Dicentrarchus* Spp.)" and "bass fresh" products in volume (MT) (NOAA Foreign Trade, 2023).

Common and Market Names

Scientific Name	*Morone saxatilis*
Common Name	Striped bass
Spanish	Lobina rayada
Sushi	Suzuki

Analysis

Scoring guide

- With the exception of the exceptional factors (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.seafoodwatch.org/-/m/sfw/pdf/standard%20revision%20reference/2015%20standard%20revision/mba_seafoodwatch_aquaculture%20criteria_final.pdf?la=en
- The full data values and scoring calculations are available in Appendix 1

Criterion 1: Data Quality and Availability

Impact, unit of sustainability and principle

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

Criterion 1 Summary

Data Category	Data Quality
Industry or production statistics	10
Management	7.5
Effluent	7.5
Habitat	7.5
Chemical use	7.5
Feed	7.5
Escapes	7.5
Disease	5
Source of stock	10
Wildlife mortalities	10
Introduction of secondary species	10
Total	**87.5**

C1 Data Final Score (0–10)	**7.96**
	Green

Brief Summary

Because of the single-producer nature of the industry and the company's commitment to data provision, the data availability on all aspects of the production was good. Information on the broader Mexican regulatory systems for aquaculture and relevant academic studies in the region are somewhat limited, particularly regarding the rapidly expanding production, but overall, there is a currently a good understanding of the site's practices and potential impacts, so the score for Criterion 1—Data is 7.96 out of 10.

Justification of Rating

The single-producer nature of the industry means that detailed information was provided by Pacifico Aquaculture on all aspects of production. External data sources from the region and more broadly from Mexico were limited, but some useful academic studies and other sources of information are available, as follows. Although no site visit was performed during the reassessment process, the site visit by a SFW representative in May 2016, including the hatchery and offices in Ensenada and the marine site at Isla Todos Santos, was still referenced when relevant. All management and monitoring documents were made available electronically.

Industry and Production Statistics

The industry consists of a single producer company. This company, Pacifico Aquaculture, provided basic information of production volumes, site locations, site characteristics, and the various production characteristics and data considered in the following sections. Other sources of production data include the Mexican Comisión Nacional de Acuacultura y Pesca (CONAPESCA), which publishes an annual yearbook of fisheries and aquaculture statistics by species and region in Mexico (Estadistíca Pesquera y Acuícola de México).[4] Accessed most recently in November 2023, the latest version available has data through 2021, although there is a small discrepancy with the reported harvest data compared to the farm records. In addition, NOAA Foreign Trade (2023) provided some useful trade indicators, but they were not specific to "striped bass." With specific annual and monthly harvest figures from the striped bass producer, the data score for the industry and production statistics is 10 out of 10.

Management and Regulations

Pacifico Aquaculture provided all information requested on the company's production and management practices. The company has four manuals on best management practices, which allowed for a high degree of confidence in understanding the company's risk management or company practices:

- Pacifico Aquaculture Environmental Best Management Practices
- Pacifico Aquaculture Best Management Practices for the Use of Aquaculture Drugs and Chemicals
- Pacifico Aquaculture Best Feed Management Practices for Feeds and Feeding
- Pacifico Aquaculture Veterinary Plan for Health and Animal Welfare.

Detailed information on aquaculture laws, regulations, rules, and decrees are available (in Spanish) from the Federations Official Diary[5] (DOF); particularly:

- Mexican Official Standards Fisheries and Aquaculture (Normas Oficiales Mexicanas Pesqueras y Acuícolas)
- Mexican Official Standards Fisheries—Aquaculture Health (Normas Oficiales Mexicanas Pesqueras [Sanidad Acuícola])
- Mexican Official Standards in Environmental Protection—Ecological (Normas Oficiales Mexicanas en Materia de Protección al Ambiente [Ecológicas])
- Mexican Official Standards for Seafood (Normas Oficiales Mexicanas de Pescados y Mariscos)

A review of Mexican aquaculture legislation is also available from the FAO country overview, with the English version updated more recently (FAO, 2023). The Mexican law on Sustainable Fishing and Aquaculture, with the latest update in 2023 (Ley General de Pesca y Acuacultura Sustentables DOF 04-12-2023) is available on the DOF website.[6] In addition, state-specific regulations apply; for example, the 2008 Law on Fisheries and Aquaculture in the State of Baja California (Ley de Pesca y Acuacultura Sustentables para el Estado de Baja California) is available from Baja California's Secretariat of Fisheries

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[4] Estadistíca Pesquera y Acuícola de México: http://www.gob.mx/conapesca/documentos/estadistica-pesquera-y-acuicola-de-mexico

[5] http://www.ordenjuridico.gob.mx/leyes.php#gsc.tab=0

[6] https://www.diputados.gob.mx/LeyesBiblio/pdf/LGPAS.pdf

and Aquaculture (Secretaria de Pesca y Acuicultura—SEPESCA[7]). Additional information can be sourced from technical documents and academic papers, which compile lists of relevant legislation and often indicate the degree of enforcement. Government websites also provide some useful information and data on enforcement and compliance, though coarse and limited in temporal coverage, and attempts to contact regulators at multiple agencies were mostly unsuccessful. Environmental impact assessments are publicly available and include information on regulation (though the usefulness and integrity of these have been questioned), and there are a number of peer-reviewed publications offering evaluation of Mexico's regulatory effectiveness. Despite these sources, substantial uncertainty remains about the content and particularly the application and enforcement of the various regulations and management practices in Mexican aquaculture farms. In light of the existing Mexican regulations, the difficulty in ascertaining their enforcement, and the access to the company's management plans and records, the available data are considered to give a reliable representation of the management and regulations governing striped bass production in Mexico, resulting in a data score of 7.5 out of 10.

Effluent

Pacifico Aquaculture provided a range of information relating to the fate of soluble and particulate effluent wastes from the Isla Todos Santos site, including monitoring results and a sampling plan. For soluble nutrients and sediment quality indicators (biological oxygen demand, chemical oxygen demand, total suspended solids, sulfur, copper, nitrate, nitrite, ammonia, and phosphate, and the metals: zinc, cadmium, lead, copper, mercury, and iron), the producer facilitated independent reports for each year evaluated from 2020 to 2023. Following the predefined sampling sites (i.e., at the edge of net pens, at 30 m from the edge, and from two reference sites), AIA Puritec collected samples once a year from at least six locations within the south module. Within each of the six locations, three replicated samples were taken from mid-depth in the water column, and from the sediment surface directly below the sampling site. Also, samples were from two transects at the cage edge and 30 m (at the larger south module), and from two reference sites. But it is important to acknowledge the limitations of the analyses, stemming from data constraints. For example, total suspended solids data were absent from the 2022 water quality and sediment report, and both biological and chemical oxygen demand results were omitted from the 2020 and 2022 reports. Furthermore, there was inconsistency in the reported sampling sites throughout the assessment period. These discrepancies in both sampling sites and nutrient indicators posed a challenge in conducting a comprehensive analysis that compares these indicators across sites and years. It is worth noting that records for additional param (such as sulfur, nitrate, nitrite, and chlorophyll b and c) were available. But because of the aforementioned irregularities, they were excluded from this analysis, to maintain clarity.

In addition, the company also provided a comprehensive, independent, benthic-modelling assessment carried out by Anderson Marine Surveys Ltd. for the south module. This provided information on the predicted benthic footprint at different production intensities (in terms of peak biomass).

Further, there is a large volume of scientific literature relating to the fate and potential impact of soluble nutrients in the water column from net pen fish farms broadly (e.g., Braña et al., 2021; Tanahara et al., 2021; Price et al., 2015; Svåsand et al., 2017; Riera et al., 2017; and Keeley et al., 2013; 2015). Although the data were provided by the company and cannot be directly verified, the data—though variable in

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[7] chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.congresobc.gob.mx/Documentos/ProcesoParlamentario/Leyes/TOMO_VII/30112018_LEYPESCA.PDF

sampling location, variables measured, and across time—are considered to give a reliable representation of the operations impacts, so the data score for effluent is 7.5 out of 10.

Habitat

Two environmental impact assessments (EIAs) were reviewed to help define the habitat type and location occupied by the striped bass net pens in Todos Santos Bay. The EIA conducted by the striped bass producer (Bajamichi, 2004) and a publicly available EIA for a multispecies project within the same bay (Acuario Oceanico, 2015) yielded sufficient data indicating that the striped bass production site is characterized as nearshore and coastal, which is recognized as a high-value habitat according to the SFW standard.Detailed information on the infrastructure characteristics, such as the type and dimensions of the production system, as well as current operational details, including the active number of modules and net pens, was provided by the producer (pers comm, Pacifico Aquaculture representatives, November 2023). Relevant studies on the potential impacts of marine net pen aquaculture and associated ecosystem services were sourced from the literature and the forementioned EIAs (Bloecher and Floerl, 2020; Bedolla-Guzman et al., 2019; Callier et al., 2018; and McKindsey, 2011). Regulatory measures (i.e., legislation and enforcement frameworks) aimed at habitat protection were readily available and can be accessed through government websites, while scientific literature provides insights into the efficacy of these regulations. In addition, the sole striped bass producer presented the documents (i.e., EIA and CONAPESCA farm concession permit) showing their up-to-date compliance with Mexico's siting legal requirements. The availability of some publicly accessible data, the information on enforcement efforts and management measures, and the present but noncritical data limitations or gaps hinder a comprehensive enough understanding of habitat impacts, management, and enforcement effectiveness. Overall, the available data provided the assessor with a moderate to high confidence to understand the striped bass operation and its potential impacts, resulting in a score of 7.5 out of 10 for data for habitat.

Chemical Use

The striped bass producer reported abstaining from pharmaceutical treatments during the grow-out stage of production since 2018 (pers comm, Pacifico Aquaculture representatives, November 2023). In addition, treatment records spanning from 2016 to 2018 (the only period when the producer documented the use of therapeutic treatments) for antibiotics and other nontherapeutic measures (e.g., immunostimulants and vitamin supplements) were provided. These records include detailed information such as the date, fish batch number, net pen module and reference number, type of antibiotic administered, dosage and duration, treatment method, and location (i.e., hatchery or offshore site). But these records cannot be independently verified, and no academic studies could be found that robustly defined their use (or nonuse) for the aquaculture industry in Mexico.

The producer has furnished an updated certification from the General Directorate of Agrifood, Aquaculture, and Fisheries Safety, under the National Service of Alimentary Health, Quality, and Innocuity (SENASICA). This certification confirms compliance with legal requirements and best practice standards for residue levels and the handling of chemicals and veterinary medicines for 2021 and 2022. Moreover, Mexican legislation, including the "Especificaciones para la regulación de productos para uso o consumo animal" (Specifications for the regulation of products for animal use consumption) (NOM-012-SAG/ZOO-2020); the "Lineamientos para la clasificación y prescripción de productos farmacéuticos veterinarios por el nivel de riesgo de sus ingredientes activos" (Guidelines for the classification and prescription of veterinary pharmaceuticals based on the risk level of active ingredients) (NOM-064-ZOO-2000); and NOM-005-STPS-1998, which outlines requirements for the safe and proper handling, transportation, and storage of chemicals, contribute to the understanding of chemical use in Mexico.

Overall, the available proof of surveillance (i.e., SENASICA's certification), along with the detailed data on chemical use provided by the producer, provide the assessor with moderate to high confidence in understanding the striped bass operation and its potential impacts, resulting in a data score for chemical use is 7.5 out of 10.

Feed

EWOS Canada (Cargill Animal Nutrition) and Pacifico Aquaculture provided comprehensive data on the characteristics of their feeds, disclosed all ingredients employed and their inclusion levels (or an inclusion range when no average was available), and provided the country of origin for most of their ingredients (i.e., fishmeal [FM], fish oil [FO], soybean meal, peas, dried beans, and sunflower meal). But they did not disclose the country of origin for a few feed components, such as land animal ingredients (i.e., poultry meal, porcine meat meal, feather meal, and poultry oil), wheat bran, corn gluten meal, and vitamins/minerals, which combined account for ≈54% of the diet's ingredients. Although the overall inclusion of FM and FO, along with the country of origin for each species, was disclosed, specific estimates for the inclusion levels of each species were not provided. It is important to note that diet data are sensitive and proprietary information for EWOS, and market dynamics for ingredients make it challenging to specify inclusion levels, including species-specific inclusion levels for FM and FO. In addition, the lack of information regarding the origin of land animal ingredients and vitamins/minerals (which account for 28.5% of the ingredients) does not significantly affect the results of this assessment. This is because the Global Feed LCA Institute (GFLI) database that was used to obtain the embedded climate change impact value considered in Factor 5.3 only provides global values for these ingredients. The inclusion levels of these ingredients were also compared with the data available from control diets for hybrid striped bass found in the existing literature (McCann et al., 2021; Rawles et al., 2013). Additional data points, such as whole-body protein content for striped bass from Karahadian et al. (1995) and marine ingredients sustainability (e.g., FishSource), were obtained through published literature. Therefore, the available feed data are considered to give a reliable representation of the operation, and the data gaps that are present are noncritical, resulting in a data score for the feed criterion of 7.5 out of 10.

Escapes

The producer has records of fish counts, escape events, and fish inventory records across the past 5 years of production (2018–23), along with escape management plans and evidence of best practices for escape prevention, in addition to escape monitoring and recording procedures. Because there have been no reported escapes, there were no specific escape records. Academic studies in other net pen production systems (e.g., Callier et al., 2018; Glover et al., 2017; and Skilbrei et al., 2015) note the potential for escapes because of factors that may be beyond the producer's control, or because of undetected or unreported trickle losses from these systems. The latter undetected risk was informed through the producer fish inventory records available for the past 5 years. In addition, escape risks associated with environmental conditions were informed through the available EIAs for the area (i.e., Bajamachi, 2004; Acuario Oceanico, 2015).

A variety of academic literature was reviewed regarding the fate and potential impact of escaping striped bass at the Isla Todos Santos site. This was supported by reference and monitoring information from the California Department of Fish and Wildlife, and when applicable, by personal communication efforts carried out in 2016 with their striped bass specialist (Marty Gingras). There is considered to be a reliable understanding of the fate of any escapes from open net pen systems, and though there is inevitably some uncertainty regarding trickle loss escapes and their potential impact to wild species through competition and predation, these are considered to be noncritical, resulting in a data score for escapes of 7.5 out of 10.

Disease

Mexico's State Committee on Aquaculture Health and Safety Baja California (Comité Estatal de Sanidad Acuícola e Inocuidad de Baja California, CESAIBC) has a factsheet on striped bass in Mexico specific to the sole producer's site. It provides basic information on diseases of striped bass, and specifically lists the notifiable diseases specified by the World Organisation for Animal Health (OIE). Pacifico Aquaculture provided fish health monitoring data consistent with notifiable diseases, along with estimated mortalities for each cohort still in production (i.e., from 2017 to September 2023) and the causes of these mortalities. Insights into the transmissibility and host specificity of diseases affecting striped bass were gleaned from the literature (Manchanayake et al., 2023; Perez-Pascual et al., 2017; and AbouLaila and Igarashi, 2013). In addition, legislative documents such as the Carta Nacional Acuicola (2022) and the General Law of Fisheries and Aquaculture outline the required sanitary measures for aquaculture sites. The producer furnished their updated certification from the National Health Service for Food Safety and Quality (SENASICA), demonstrating compliance with the sanitary measures mandated by these laws. Furthermore, the producer provided their Veterinary Plan for Sanitation and Animal Welfare, as well as their implemented Biosecurity Plan. But there is limited information available to assess the potential impacts on wild fish in the event of a disease outbreak of farmed fish, which generates uncertainty around key information. Hence, the data score for disease is 5 out of 10.

Source of Stock

The single hatchery in Ensenada was toured as part of the SFW site visit in 2016. The history of the broodstock was provided, including their domestication status (i.e., they were hatchery raised). The data score is 10 out of 10.

Wildlife and Predator Mortalities

Pacifico Aquaculture furnished details of their Environmental Best Management Plan and highlighted regulations concerning predator control. The company also provided records of wildlife interactions spanning 2019 to 2022, indicating no instances of seals or sea lions being unintentionally or intentionally harmed or killed. These records also included rough estimates of wildlife sightings and the frequency of predator interactions with net pens. Furthermore, the Environmental Impact Assessment (EIA) report contains information on species present at the site and those most likely to interact with it. During the site visit in 2016, management measures such as predator nets were observed, along with the presence of various marine mammal and bird species at the Isla Todos Santos site. Academic articles by Bedolla-Guzman et al. (2019), Arrellano-Peralta & Medrano-Gonzalez (2015), and Donlan et al. (2000) provide background information on the species of significance in the region and their status, both at the marine site and on Isla Todos Santos. Given the available records, the recent literature developed by the conservation organization Grupo de Ecología y Conservación de la Isla (GECI), which is reachable and active in the operations area, and the evidence of compliance provided by the producer (i.e., BAP and SENASICA certification), there is a high level of confidence in assessing the impacts of wildlife mortality or lack thereof. Therefore, the data score for wildlife mortalities is 10 out of 10.

Escape of Secondary Species

Pacifico Aquaculture provided information on the initial movement of broodstock from the United States into Mexico and the subsequent development of broodstock units at the marine site and at the hatchery. Full data on movements of fish between these two locations within the same waterbody (the bay of Ensenada) were available. The data score is 10 out of 10.

Conclusions and Final Score

The final numerical score for Criterion 1—Data is 7.96 out of 10.

Criterion 2: Effluent

Impact, unit of sustainability and principle

- *Impact:* Aquaculture species, production systems and management methods vary in the amount of waste produced per unit of production. The combined discharge of farms, groups of farms or industries contribute to local and regional nutrient loads.
- *Unit of sustainability:* The carrying or assimilative capacity of the local and regional receiving waters
- *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 Evidence-Based Assessment

C2 Effluent Final Score (0–10)	**8**	**GREEN**

Brief Summary

The concern regarding effluent impacts from the producer's waste discharges into the environment (i.e., uneaten feed waste and fish excretion) is considered to be low. While acknowledging some limitations in the data, such as inconsistency in the reported param and sampling sites throughout the assessment period (2020–23), the available data, including soluble and benthic nutrient indicators, benthic impact models, and heavy metal concentrations, do enable a fairly comprehensive understanding of the effluent impacts from the striped bass producer. The producer conducts annual comprehensive analyses of water quality and benthic indicators. These analyses entail testing water and sediment samples by an independent laboratory, Asesoria Integral Ambiental Puritec, in adherence to the Best Aquaculture Practices certification standards. This standard also requires predefined sampling locations, based on characteristics identified through a study conducted by a third party; in this case, Anderson Marine Surveys (AMS). Consequently, this assessment considers recommendations derived from AMS's benthic impacts model, evaluates key soluble nutrient indicators and sediment quality indicators, and scrutinizes available literature to better comprehend the potential contribution of the producer to cumulative impacts in Todos Santos Bay.

For soluble nutrients in the water column, the available monitoring data are supported by academic studies on net pen aquaculture in exposed locations, which conclude that significant impacts beyond the immediate farm area are highly unlikely. For benthic impacts, the available monitoring data appear to support the comprehensive modeling assessment by AMS, which concludes that, although there will be some change and degradation to benthic communities in the immediate farm area and though some param are elevated at 30 m from the net pens compared to the reference sites, it is highly unlikely that there will be significant impacts much beyond this immediate farm area, particularly considering the rapidly increasing depth with increasing distance from the net pens.

There are some indications of excessive seasonal nutrient enrichment along the shoreline from wastewater treatment plants, but there are no studies readily available that the farm is contributing to the poor seasonal water quality along the shoreline. Considering the isolated nature of the striped bass farm, the data show no evidence that effluent discharges cause or contribute to cumulative impacts at the waterbody/regional scale. But there is a need for ongoing monitoring at various locations and distances from shore to ensure the long-term health and sustainability of this valuable coastal ecosystem.

In conclusion, data show no evidence that effluent discharges cause or contribute to cumulative impacts at the waterbody/regional scale, and the impacts within the immediate vicinity of the farm are considered temporary. The final score is of 8 out of 10 for Criterion 2—Effluent.

Justification of Rating

Mexico's aquaculture industry (including all species) is experiencing growth, particularly in net pen production, which offers advantages such as utilizing existing waterbodies, lower capital investment, and relatively simple technologies (Romero-Beltran et al., 2021). But net pen production systems are open to the surrounding environment and generally lead to increased nutrient output, primarily nitrogen and phosphorus, because of uneaten feed waste and fish excretion (Romero-Beltran et al., 2021). These nutrient inputs can disrupt the surrounding aquatic ecosystem, increasing the risk of physical, chemical, and biological implications such as eutrophication, algal blooms, reduced oxygen availability, and elevated concentrations of organic matter and metals (Romero-Beltran et al., 2021) (Price et al., 2015). Moreover, when net pens are situated nearshore, particularly in proximity to other waste discharge sources like cities or agricultural fields, these negative effects could be exacerbated; the cumulative impact of these industries may exceed the carrying capacity of the watersheds. Nevertheless, modern operating conditions have significantly minimized the impact of individual fish farms on marine water quality. This includes mitigating the effects on dissolved oxygen and turbidity, with near-field nutrient enrichment to the water column typically undetectable beyond 100 m. These modern operating practices involve carefully selecting farm locations, considering their orientation with respect to prevailing currents and water depth to minimize both near- and far-field impacts; limiting farm size and total production volume; controlling biomass density (kg/m^3); and implementing feeding protocols to minimize feed waste (Braña et al., 2021) (Price et al., 2015).

With sufficient data and information to understand the nutrient dynamics of striped bass aquaculture in net pens in Mexico, the data score for the Effluent category is 7.5 out of 10 in Criterion 1 –Data. Thus, the evidence-based assessment method in the Seafood Watch Aquaculture Standard has been used.

Farm Site

The Mexican striped bass industry is presently narrowed to a single producer company. As mentioned, the producer is adjacent to Isla Todos Santos in Ensenada Bay, approximately 16 km from the coastal area of the city of Ensenada (see Figure 2). The bay's bathymetric configuration is irregular, characterized by notable features including the shoal of San Miguel, with a minimum depth of 5.5 m, and the Todos Santos submarine canyon, with depths reaching more than 600 m. Sediment transport studies reveal that, in the north of the bay, sediment moves toward the southeast, while in the central part, it primarily flows in a northeast to north-northeast direction, with a westward component near the mouth of the Punta Banda coastal lagoon (Sánchez and Carriquiry, 2011). Along the Todos Santos canyon, where the net pens are situated, sediment transport follows a northeast trajectory, and current velocities were found to be moderately high for an open ocean location, with a maximum recorded surface velocity of 0.28 m per second (AMS, 2018) (Sánchez and Carriquiry, 2011). Therefore, the characterization of the hydrodynamics at the operational site and throughout the bay reveals complexity and high levels of tidal and current energy.

The production facilities operate within three modules: north, central, and south, with their locations relative to the east of the bigger and southern island mapped in Figure 2. The central module notably comprises 27 smaller square net pens (measuring approximately 8 × 8 × 8 m). One of these smaller net pens holds another species, *Totoaba macdonaldi*, under a temporary collaboration agreement with the

Universidad Autónoma de Baja California (UABC). In addition, five of these net pens are utilized to hold striped bass broodstock. The remaining 21 net pens are stocked with fingerlings to initiate the grow-out phase of production.

Once the average weight of the fish reaches 250 g, they are transferred to one of the six standard-sized net pens of 25 m in diameter, also located within the central module. These net pens are later towed to either the north or south modules, where they will remain until harvest. Although small harvests totaling 207 MT were reported for this central module during 2023, this was because of a limited number of net pens lingering from previous years' schedules and production logistics that the producer was phasing out. Starting in 2022, this module has been utilized solely for the initial phase of fingerlings, and no further harvests should be expected from this module going forward (pers comm, Pacifico Aquaculture representatives, November 2023). The southern module comprises 23 net pens (all measuring 25 m in diameter), and dominates production with 2,188 MT as of October 2023. In contrast, no production has been reported yet for the northern module, because it became operational in 2023, and currently operates with six net pens of 25 m in diameter (pers comm, Pacifico Aquaculture representatives, November 2023). According to the producer's latest report, the average stocking density stands at 10.3 kg/m^3. Typically, the grow-out phase of the production cycle spans a duration of 60 months, with an additional 4 to 6 months at the hatchery stage, which falls beyond the scope of this assessment. In addition to strategically positioning the net pens to account for bathymetric configuration (i.e., depth) and sediment transport (i.e., prevailing current direction and energy), along with the implementation of best farm practices (i.e., maintaining appropriate biomass density levels and feeding regimes), the producer conducts benthic and water quality monitoring. These practices and farm siting considerations align with the mitigation and effluent-related considerations described in the literature as "modern aquaculture practices" (Braña et al., 2021) (Price et al., 2015).

Benthic and Water Quality Monitoring

The producer conducts an annual comprehensive analysis of water quality and sediment to monitor grow-out production on both the water column and the benthic environment. As illustrated in Figure 5, the sampling locations at the larger south module are determined based on characteristics identified in the Anderson Marine Surveys (AMS) analysis. While the BAP guideline suggests taking seabed samples at least once per production cycle and during periods of maximum feeding activity, the producer currently does not operate discrete production sites. Instead, they mix cohorts from various years in the north and south modules, making it challenging to distinguish production cycles at each module. Therefore, it was recommended during the AMS analysis that sampling be conducted annually and during the summer to coincide with warm water temperatures and, consequently, maximum appetite.

The AMS study found that any nutrient plume is expected to travel northeastward from the net pens, at 55 degrees from the main axis of the seabed. This orientation indicates the direction of the predominant water currents near the seafloor. Based on these findings, samples were collected along two SW-NE transects (T1 and T2), each with two sampling locations at the cage edge (S1 and S3) and at 30 m horizontally (S2 and S4). These samples can be compared to reference locations R1 and R2 located "upstream" of the anticipated effluent plume. Given the scale of production at each module, it is deemed appropriate to consider the large south module as representative for this report, with reference to the other modules only when relevant.

As mentioned, the producer conducted annual water quality and sediment monitoring through a third party, Asesoria Integral Ambiental Puritec (AIA Puritec), during the summer months. This monitoring generated independent reports for each year evaluated from 2020 to 2023. Following the predefined sampling sites established by the AMS study conducted in 2018, AIA Puritec collected samples once a year from at least six locations within the south module (see Figure 5). At each location, three replicated samples were taken from mid-depth in the water column, along with three replicates from the sediment surface directly below the sampling site. Limited data were available from the newly positioned north module, which started operating in 2023, and from the central module, because this is a temporary step of the production cycle. In addition, the precise locations of the sampling sites at the north module have not been specified.

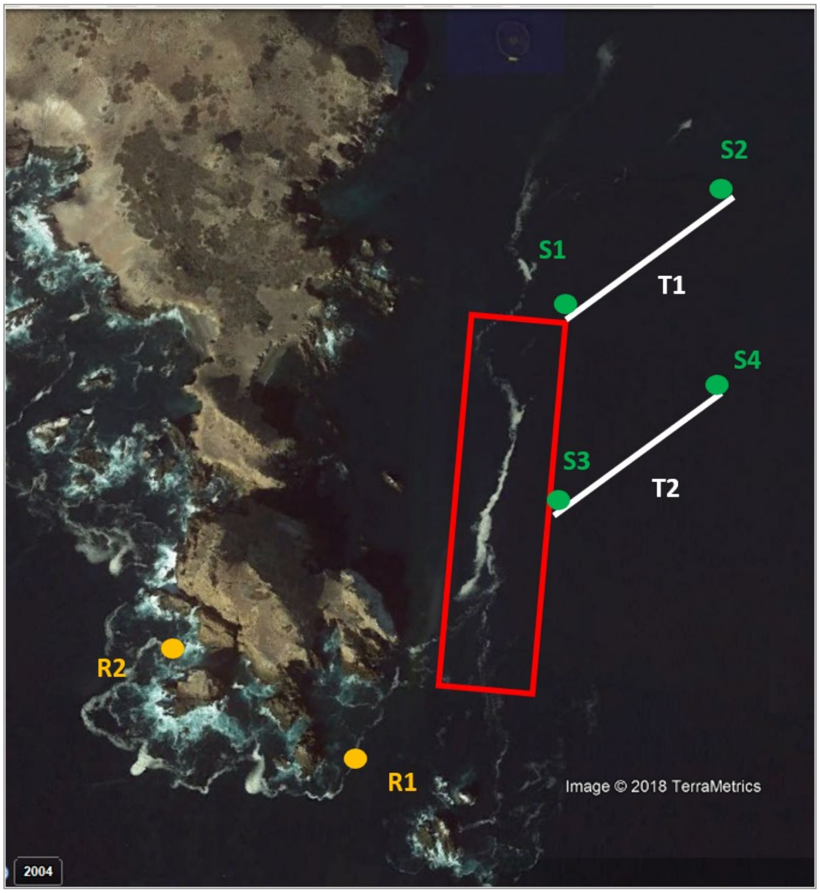

Figure 5: Sampling locations for the south module. The red box shows the approximate location where the net pen array is operating. The green S1-S4 dots are sampling locations used during production, and the orange R1-R2 dots are the reference locations. Image provided by Pacifico Aquaculture from the Anderson Marine report (AMS, 2018).

Management measures: maximum permissible

Mexico's Official Standard, NOM-001-SEMARNAT-2021, establishes the maximum permissible limits for the discharge of effluents from various industries. The norm includes comprehensive lists of limits for key pollutants and heavy metals, which are outlined in Tables 1 and 2. To ensure compliance with these limits, the National Water Commission (CONAGUA) is responsible for administering permits related to effluent discharge (Aguilar-Manjarrez et al., 2017) (Garcia-Ortega and Calvario-Martinez, 2008) (NOM-001-SEMARNAT-2021). It is important to note that, while the 2021 regulation addresses water discharges from various industries, including in-land aquaculture operations (i.e., those considered a point-source of effluents), specific requirements dedicated to wastewater discharges from aquaculture are currently lacking (Hermoso, 2016). In addition, this norm does not apply to effluents from net pens, because these are not classified as wastewater discharges. Nonetheless, the striped bass producer still uses this norm as a reference to ensure the protection of the production area (pers comm, Pacifico Aquaculture representatives, July 2024) (Hermoso, 2016).

The assessment of the producer's data considers the permissible limits for marine zones set by SEMARNAT, as referenced in the subsequent section when applicable. It is worth noting that the producer does not provide results for every water parameter outlined in this norm within their annual independent studies. But the studies do encompass certain key indicators that contribute to the understanding of water quality in the operational area.

Table 1: Monthly and daily averages, and instant value of maximum permissible limits for basic pollutants as it relates to fresh waterbodies and marine zones (taken from NOM-001-SEMARNAT-2021).

Parameters (mg L-1, except when specified)	Rivers, streams, channels, and drains			Reservoirs, lakes, and lagoons			Marine zones		
	MA	DA	IV	MA	DA	IV	MA	DA	IV
Temperature (°C)	35	35	35	35	35	35	35	35	35
Fats and oils	15	18	21	15	18	21	15	18	21
Total suspended solids	60	72	84	20	24	28	20	24	28
Chemical oxygen demand	150	180	210	100	120	140	85	100	120
Total organic carbon	38	45	53	25	30	35	21	25	30
Total nitrogen	25	30	35	15	25	30	25	30	35
Total phosphorus	15	18	21	5	10	15	15	18	21
Escherichia coli, (MPN/100 ml)	250	500	600	250	500	600	250	500	600
Fecal *enterococcus* (MPN/100 ml)	250	400	500	250	400	500	250	400	500
pH	6–9								

* MA: Monthly average. DA: Daily average. IV: Instant value. MPN: Most probable number.

Table 2: Monthly and daily averages, and instant value of maximum permissible limits for heavy metals as it relates to rivers, and natural and artificial reservoirs (taken from NOM-001-ECOL-1996).

Parameters (mg L-1)	Rivers, streams, channels, and drains			Reservoirs, lakes, and lagoons			Marine zones		
	MA	DA	IV	MA	DA	IV	MA	DA	IV
Arsenic	0.2	0.3	0.4	0.1	0.15	0.2	0.2	0.3	0.4
Cadmium	0.2	0.3	0.4	0.1	0.15	0.2	0.2	0.3	0.4
Cyanide	1	2	3	1	1.5	2	2	2.5	3
Copper	4	5	6	4	5	6	4	5	6
Chromium	1	1.25	1.5	0.5	0.75	1	1	1.25	1.5
Mercury	0.01	0.015	0.02	0.005	0.008	0.01	0.01	0.015	0.02
Nickel	2	3	4	2	3	4	2	3	4
Lead	0.2	0.3	0.4	0.2	0.3	0.4	0.5	0.75	1
Zinc	10	15	20	10	15	20	10	15	20

* MA: Monthly average. DA: Daily average. IV: Instant value. MPN: Most probable number.

Soluble nutrients in the water column

Analyses of key nutrient concentrations and water quality parameters, hereafter referred to as nutrient indicators, were conducted using water samples obtained during the summer months, coinciding with the maximum feeding schedule during the year. The initial analysis encompasses all sampling sites within the farm's vicinity (i.e., excluding reference sample sites) for various soluble nutrient indicators from 2020 to 2023 (Figures 6 and 7). This approach provides insights into the duration of effluent impacts in the water column. Furthermore, the samples taken for 2023 underwent analysis, comparing results from distinct sampling sites, including reference sites, locations directly adjacent to the net pens (0 m), and those situated farther away (30 m from the edge of the net pens). These comparisons are discussed further in this criterion (see Figures 8 and 9). By comparing results across sites, valuable insights are gained regarding the spatial extent of effluent impacts relative to the farm's vicinity.

Before delving into the results, it is important to acknowledge the limitations of the analyses stemming from data constraints. For example, data for total suspended solids (TSS) were absent from the 2022 water quality and sediment report, and both biological and chemical oxygen demand results were omitted from the 2020 and 2022 reports. Furthermore, there was inconsistency in the reported sampling sites throughout the assessment period. These discrepancies in both sampling sites and nutrient indicators posed a challenge in conducting a comprehensive analysis of these indicators across sites and years.

It is worth noting that, as outlined in Criterion 1—Data, records for additional parameters (such as sulfur, nitrate, nitrite, and chlorophyll b and c) were available. But because of the aforementioned irregularities, they were excluded from this analysis, to maintain clarity.

The box plots presented in Figure 6a–b illustrate the annual concentrations (µg/L) of ammonia and phosphate from 2020 to 2023, respectively. Each figure represents the distribution of results obtained from 28 water samples collected over the 4-year period. The analyses presented in Figures 6a–b and 7a–c incorporate reported values from all sampling sites within the farm's vicinity, including 17 samples obtained at the edge of the net pens and 11 samples 30 m at the edge. While no distinct trend is evident for ammonia (see Figure 6a), there was a notable increase observed in 2021, and subsequent decreases in 2022 and 2023, with concentrations falling below those reported for 2020. Conversely, there is an observable increasing trend in phosphate concentration over the 4-year period analyzed in this study (see Figure 6b).

While specific thresholds for these nutrient indicators are not defined by any regulatory body, they can serve as alternative indicators for total nitrogen and total phosphorus, for which SEMARNAT has set permissible limits (see Table 1). Monitoring ammonia is particularly important because of the potential toxicity of high ammonia levels (typically in the tens of thousands µg/L) to marine wildlife. Furthermore, phosphate can influence primary productivity and carbon sequestration in the ocean, thereby contributing to the risk of eutrophication (Australian Government Initiative[8], 2000) (Patey et al., 2008). But upon converting the reported phosphate concentrations to total phosphorus (where phosphate molecules contain three times the concentration of phosphorus atoms), it is observed that even the maximum phosphate value reported from 2020 to 2023 (i.e., 67.7 µg/L phosphate, equivalent to 22.6

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[8] https://www.waterquality.gov.au/anz-guidelines/guideline-values/default/water-quality-toxicants/toxicants/ammonia-2000

µg/L total phosphorus) is well below the permissible limit for total phosphorus (15,000 µg/L) set by SEMARNAT for marine zones (EPA,[9] accessed April 2024).

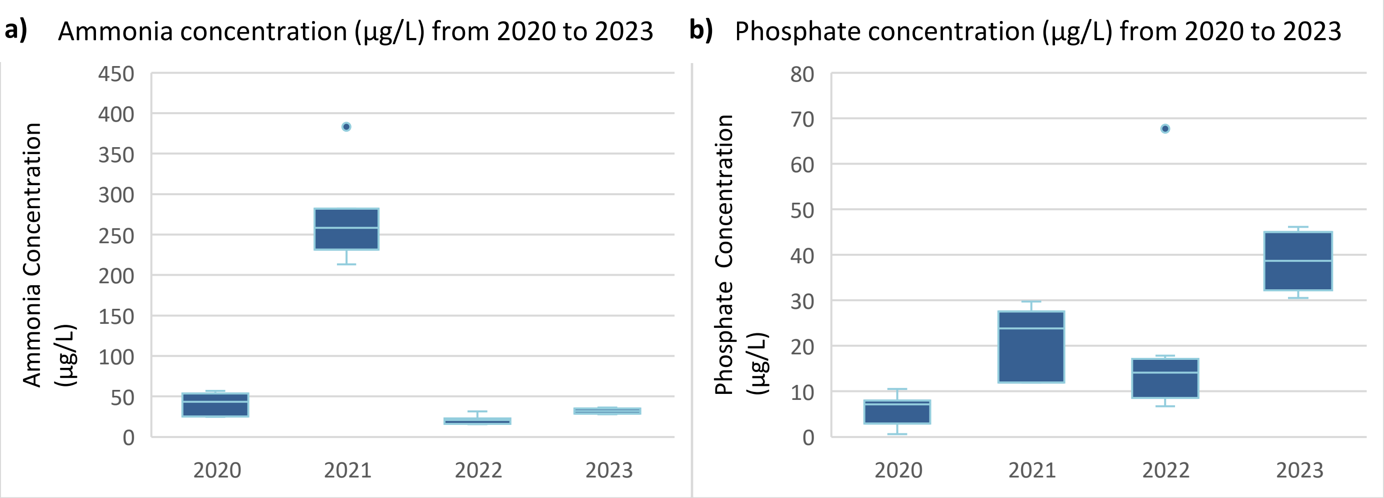

Figure 6: Box plots of (a) ammonia and (b) phosphate concentrations (µg/L) taken from the water column annually from 2020 to 2023. Each box plot shows the 25th and 75th percentiles, and each horizontal line indicates the median. The dots represent outliers. (Data obtained from AIA Puritec 2020–2023 reports.)

In contrast to the ascending trend observed in phosphate concentration (Figure 6b), Figure 7 illustrates a descending trend for the three nutrient indicators (total suspended solids, biological oxygen demand, and chemical oxygen demand) considered in this box plot analysis. The lower levels of total suspended solids and reduced chemical and biological oxygen demands in the most recent years compared to previous years suggest that water quality in the vicinity of the farm is unlikely to be deteriorating.

As previously highlighted, SEMARNAT stipulates daily average permissible limits for TSS (24 mg/L) and COD (100 mg/L) specific to water quality in marine zones (see Table 1). Upon comparing these permissible limits with those presented in Figures 7a and 7b, it is evident that the reported averages for TSS and COD fall well below SEMARNAT's established limits during the assessed period. Further analysis reveals three individual reported values for TSS in 2021 that exceeded the daily average permissible limit (24 mg/L). But none of the reported TSS values surpassed the instant value permissible limit, set by SEMARNAT at 28 mg/L.

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[9] https://archive.epa.gov/water/archive/web/html/vms56.html#:~:text=Since%20the%20PO4%20molecule%20is,to%20PO4%2C%20multiply%20by%203.

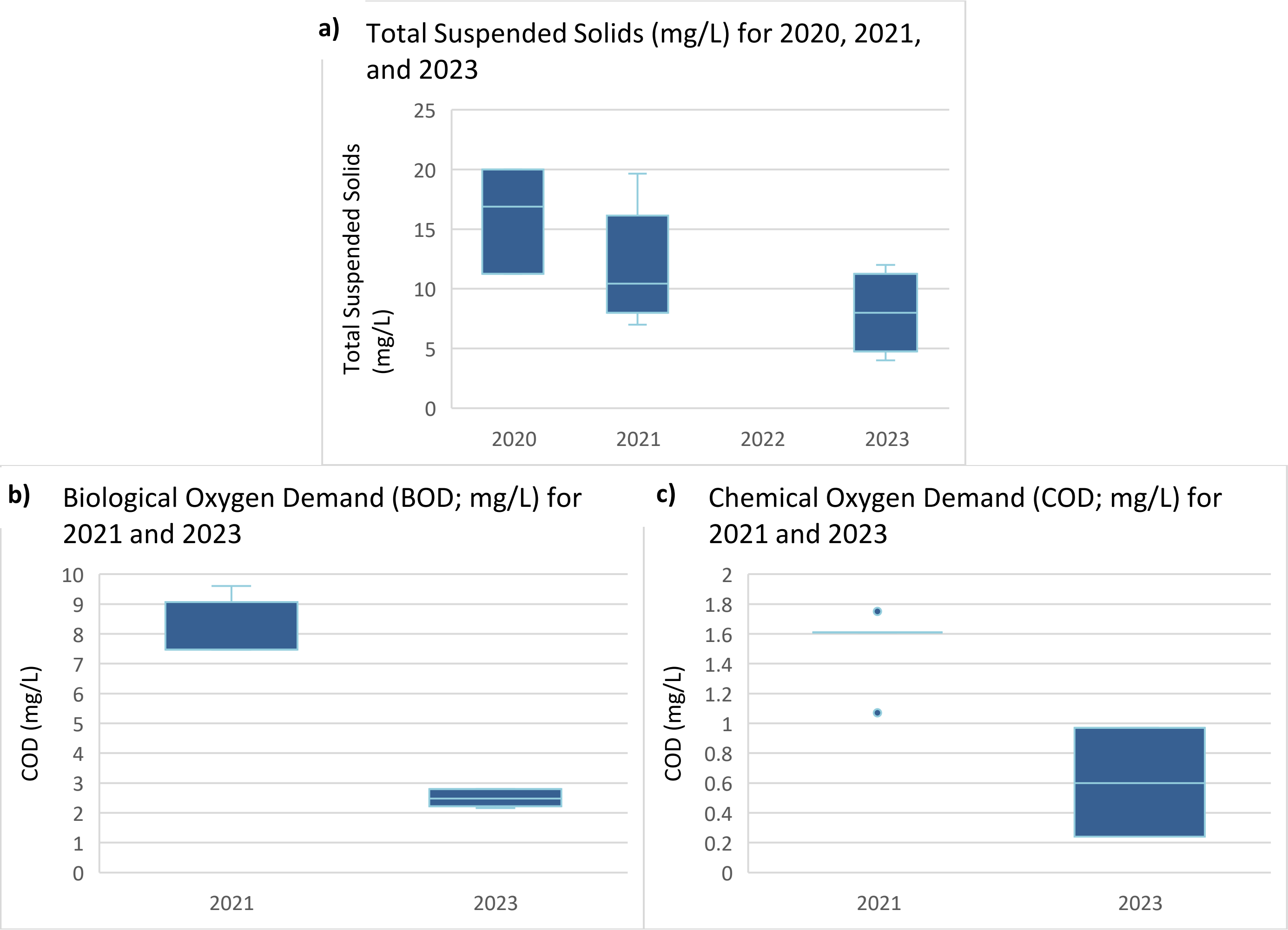

Figure 7: Box plots of (a) total suspended solids, (b) biological oxygen demand, and (c) chemical oxygen demand in milligrams per liter taken from the water column annually from 2020 to 2023. Each box plot shows the 25th and 75th percentiles, and each horizontal line indicates the median. The dots represent outliers. (Data obtained from AIA Puritec 2020–2023 reports.)

Further insights are derived from the AIA Puritec reports by comparing nutrient concentration parameter results obtained at the reference sites with those obtained at the edge of net pens, as well as at a distance of 30 m from the edge of net pens located at the south module. For instance, phosphate and ammonia concentrations at the edge of the net pens demonstrate higher levels compared to the reference site, but also show a decline compared to the concentrations obtained from samples at 30 m from the edge of the net pens (Figure 8). These findings are in line with expectations. Given the dynamic and high-energy characteristics of the Isla Todos Santos site, and the criteria used to position net pens (i.e., upstream from prevailing currents and at the edge of a submarine canyon), it is anticipated that nutrient concentrations would be diluted and detected at lower levels in samples obtained 30 m from the net pens compared to those obtained at the edge of the net pens.

But a contradictory outcome is observed for COD and TSS, with the latter experiencing a significant 172% increase at 30 m compared to the reference site, but a lower 12% increase at the edge of the net pens (see Figure 8). Furthermore, both COD and BOD levels are lower at the edge of the cages compared to the reference site. Nonetheless, the results for BOD, TSS, and ammonia remain above the reported values for the reference site.

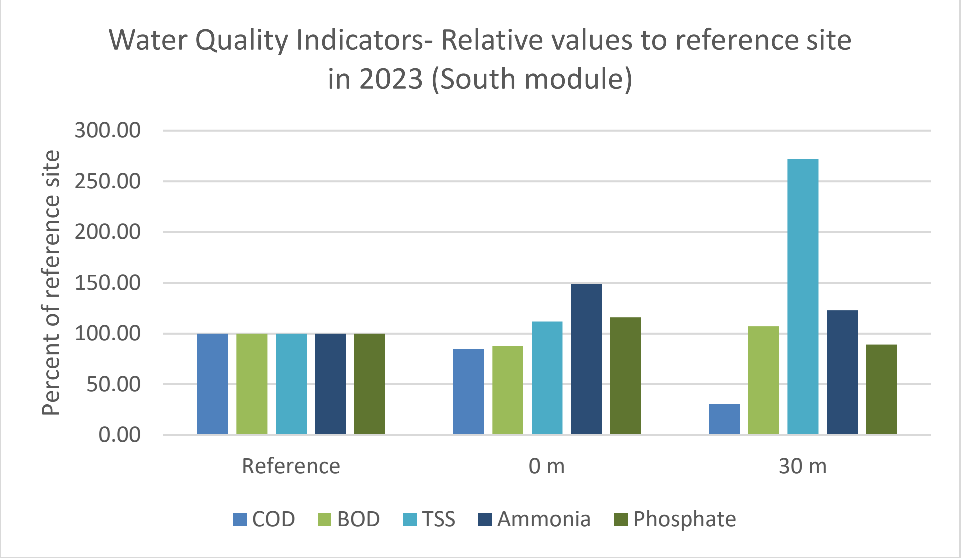

Figure 8: Soluble nutrient monitoring at the south module net pen edge (0 m) and at 30 m, relative to reference sites for key parameters. (Data provided by Pacifico Aquaculture through AIA Puritec reports.) COD: chemical oxygen demand; BOD: biological oxygen demand; TSS: total suspended solids.

Figure 9 presents the same data as depicted in Figure 8, but in absolute values with error bars indicating +/– one standard deviation. Nevertheless, discerning a clear trend proves challenging, because in certain instances, nutrient indicators at the reference sites surpass those located near the net pens (e.g., COD and BOD), and in other instances, nutrient indicators at 30 m from the edge of the net pens remain higher than those at the edge of the net pens (e.g., COD and TSS).

Despite these variations, there does not appear to be any evidence of excessive nutrient loading from the aquaculture facility. But, a more frequent sampling regime, along with measurements taken at varying distances from the cage, and additional reference locations and parameters (i.e., total nitrogen) would provide a clearer understanding of water quality conditions and any potential changes or impacts resulting from aquaculture farming.

Heavy metals were also measured in the water column. In 2021 and 2023, AIA Puritec conducted tests for heavy metal concentrations including lead (Pb), copper (Cu), zinc (Zn), and cadmium (Cd). Notably, lead and zinc concentrations in 2021 exceeded the permissible levels for marine zones established by SEMARNAT, set at 1 and 20 µg/L (instant values), respectively (see Table 2). The average concentration for lead at the southernmost station, obtained from a sample taken at the edge of the cage, was 4.87 µg/L, and the average concentration for zinc was 30.20 µg/L. But the average concentrations for lead and zinc, derived from samples at two reference sites, were 4.18 and 31.44 µg/L, respectively, also surpassing the permissible limits set by SEMARNAT. Consequently, it appears that the elevated levels of heavy metals during AIA Puritec's monitoring cannot be solely attributed to the producer's activities, because even the reference sites exceeded the permissible limits. Instead, these levels might be a

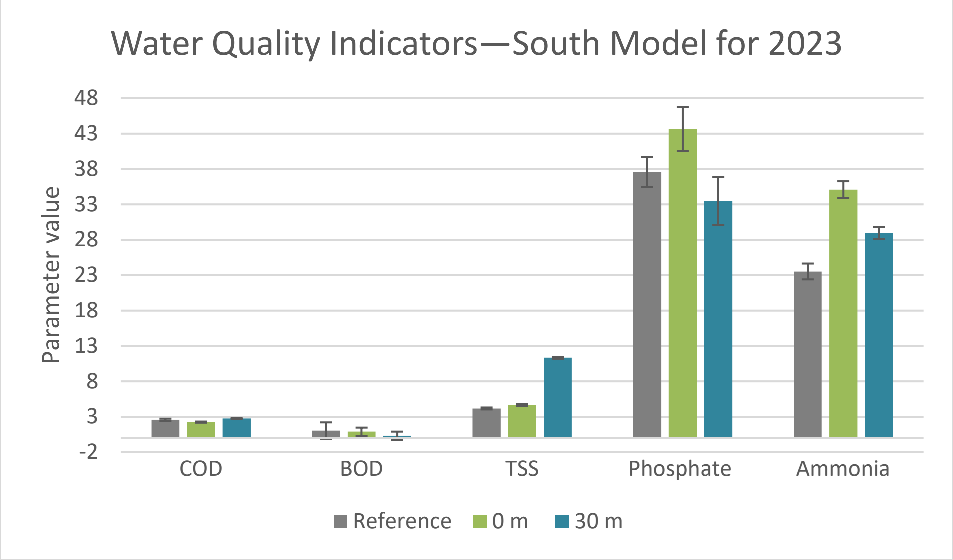

Figure 9: Soluble nutrient monitoring absolute data values at the south module net pen edge (0 m), 30 m, and at the reference sites for key parameters with +/– one standard deviation bars. COD, BOD, and TSS values are in mg/L, and phosphate and ammonia are in µg/L. (Data provided by Pacifico Aquaculture through AIA Puritec reports.)

consequence of the various anthropogenic activities taking place in the Todos Santos Bay. For 2023, no average values for these four heavy metals (Pb, Cu, Zn, and Cd) exceeded the maximum permissible limits established by SEMARNAT.

Overall, the soluble nutrient data from the largest production module suggests several trends. During the 4-year period analysis (2020–23), which included all samples taken within the farm vicinity (i.e., at 0 and 30 m from the edge of the net pens), most water nutrient indicators (e.g., ammonia, TSS, BOD, and COD) show a decreasing trend over time (see Figures 6a and 7a–c), except for phosphate concentration (Figure 6b). In addition, for sample results in 2023, there are elevated water quality measurements at 30 m compared to samples taken at 0 m and/or at the reference site, including total suspended solids (TSS), biological oxygen demand (BOD), and ammonia. All other water quality parameters (COD and phosphate) are at lower levels at 30 m compared to the reference site. The elevated measures for TSS, BOD, and ammonia suggest that there may be increased loading beyond the immediate vicinity of the farm (note: 30 m is considered within the farm footprint for this assessment). Given the current dynamics of the site, it is expected for there to be significant dispersal (AMS, 2018). Additional monitoring results farther from the net pen array (> 30 m) would help to characterize the dispersal mechanics of the surrounding currents and if they remain significant. Also, an improved sampling strategy (i.e., consistent water quality samples through time and location) is needed. But because these samples are taken in the water column, benthic samples and modeling can be helpful to characterize the dispersal mechanics of the site and if loading rates are significant within the farm footprint or if they are effectively dispersed to the surroundings.

Benthic impacts—modeling

Two aspects are presented in the following: the first is the result of an independent benthic footprint modeling assessment for the south module (the central and north modules were not modeled), followed by the monitoring data from Pacifico Aquaculture for the south module.

A comprehensive "Biomass and benthic footprint" assessment was conducted by AMS for the site at Isla Todos Santos. The bathymetric analysis shows that the south module is located over a steeply sloping seabed; Figure 10 shows the depth contours relative to the farm location and the impact modelling area (red box) studied by AMS. The contours in Figure 10 are difficult to read, but the net pen array is situated in water depth of approximately 30–100 m on the edge of a submarine canyon descending to 120 m to the east of the site.

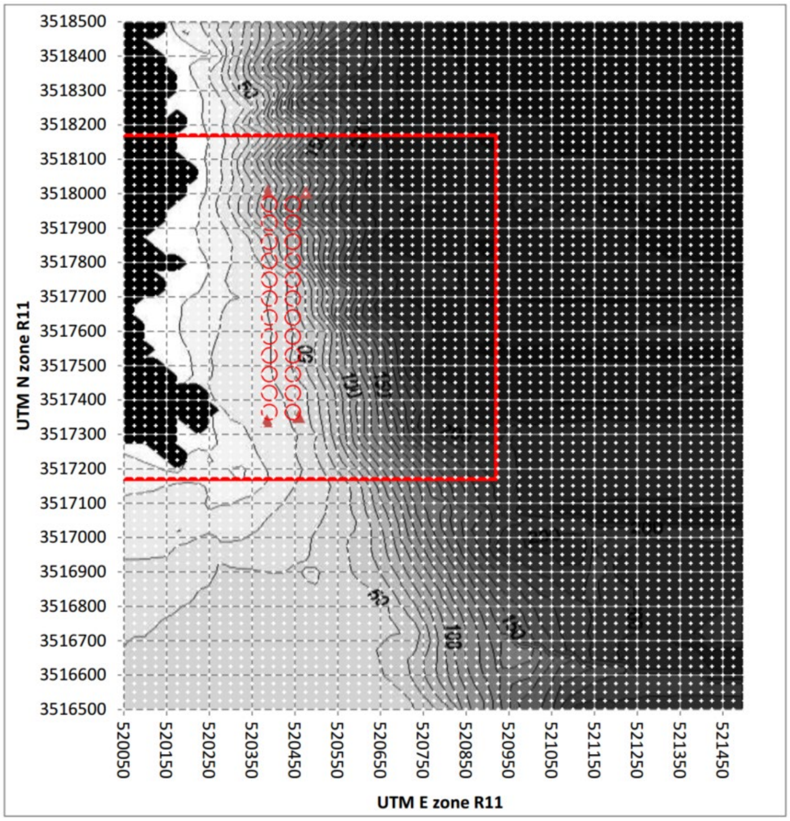

Figure 10: Depth contours at the southern module with net pen locations (red circles) in the location boxed in Figure 2. In this image, the red box is the boundary of the modeling area used by Anderson Marine for predicting benthic impacts. Image copied from AMS (2018).

Given the challenge in predicting the potential area of impact, AMS modeled the fate of particulate wastes (feces and uneaten feed) based on two measures of impact: the first is based on the Scottish Environmental Protection Agency's (SEPA) Infaunal Trophic Index (ITI) and the threshold at which there would or would not be expected to be any change or degradation of benthic fauna.[10] This analysis employs an enhanced version of the aquaculture particulate waste dispersal models coupled with benthic impact estimation (AUTODEPOMOD model v2.0.52), recognized for its widespread application, such as establishing discharge consents, grounded on maximum farmed biomass, for salmon farms throughout Scotland (Riera et al., 2017).

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[10] The thresholds applied by SEPA are considered by Anderson Marine (AMS, 2018) to be a reasonable measure of an acceptable level of environmental effect in Mexico compared to Scotland, because macrofaunal community structure is broadly comparable in continental shelf habitats from the sub-Arctic to sub-tropical areas.

In the AMS model, the ITI is equivalent to a solids flux of 191.8 g/m^2/year. To give a robust comparison, AMS also included a boundary based on Riera et al. (2017), who concluded that a much higher flux threshold of 12,000 g/m^2/year was predicted as a boundary from which ecological degradation occurs in similar habitats (i.e., there would not be ecological degradation below this depositional rate). AMS predicted that, at a realistic stocking density of 20 kg/m^3 (compared to the latest stocking density reported at 10.3 kg/m^3), the SEPA threshold for "change or degradation" is reached in the immediate area of under the net pens (i.e., the gray area in Figure 11), but the higher Riera deposition rate would not be reached (i.e., there is no blue color showing in Figure 11). AMS also ran the model[11] at an unrealistic stocking density of 40 kg/m^3, and because of the current characteristics at the site, the model predicted a solids flux of a little over 1,500 g/m^2/year, which is still well below the much higher flux threshold of 12,000 g/m^2/year established by Riera et. Al. (2017).

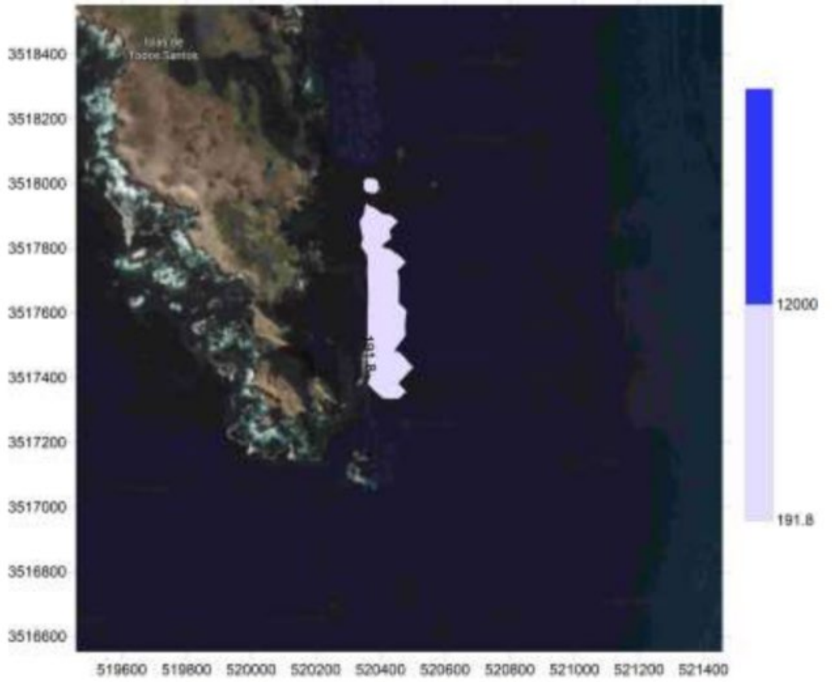

Figure 11: Modeling of area receiving > 191.8g/m^2/year at a realistic stocking density of 20 kg/m^3, therefore exceeding SEPA's threshold of "change or degradation" of benthic communities. The blue threshold of 12,000 g/m^2/year was not reached.

Figure 11 therefore shows that, at a realistic stocking density of 20 kg/m^3, the area potentially "changed or degraded" according to the SEPA threshold is closely related to the net pen array, so there are not likely to be any significant impacts beyond the immediate farm area. In support of this, AMS concluded: "[A]t realistic stocking densities and peak biomass, the predicted spatial area of ecological effect at the seabed is limited to the immediate vicinity of the site (area < 0.06 km^2). The site is predicted to be

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[11] AMS modeled two stocking densities of 15 and 25 kg/m^3 for the north module, giving a peak biomass of 994–1,657 MT. For the dispersive south module, the model was run at a realistic stocking density of 20 kg/m^3 and at an unrealistic stocking density of 40 kg/m^3 with a peak biomass of 7,068 MT.

dispersive and significant effects of material re-suspended and exported from the depositional footprint are considered very unlikely."

Benthic Impacts—Site Monitoring Data

Similar to the analyses of soluble nutrient indicators, the key sediment quality indicators were derived from water samples collected during the summer months, coordinated with the maximum feeding schedule, using the methodology described previously. Two sets of sediment quality indicators are presented, starting with the data for 2023, which analyze and compare results from reference sites with those from sample sites located within the farm's vicinity (sampling site locations indicated in Figure 5; for analysis results, see Figures 12 and 13). The second set of data examines the same spatial comparison of impacts but in relation to heavy metal concentrations in sediments (see Figures 14 and 15). These analyses between results obtained from distinct sampling sites (i.e., reference site, 0 m from net pens, and 30 m from the edge of the net pens) provide insights into spatial effluent characteristics in the benthos relative to the farm's location.

For example, Figure 12 presents data for key benthic parameter indicators (pH, redox potential [ROP], sulfur concentration, total organic carbon [TOC], biochemical oxygen demand [BOD], and organic matter [OM]) measured on the seabed beneath the larger south net pen array's edge and at 30 m horizontally from the net pen's edge for the year 2023. Except for pH, a notable increase (compared to the average results at reference sites) is evident at the net pen's edge for the rest of the sediment indicators (sulfur, TOC, BOD, and OM), with a subsequent decrease observed at 30 m. ROP, BOD, and OM still register elevated levels at 30 m compared to reference site values. While the declining trend of these nutrient indicators from the edge of net pens to 30 m suggests that nutrient impacts may not extend far from the

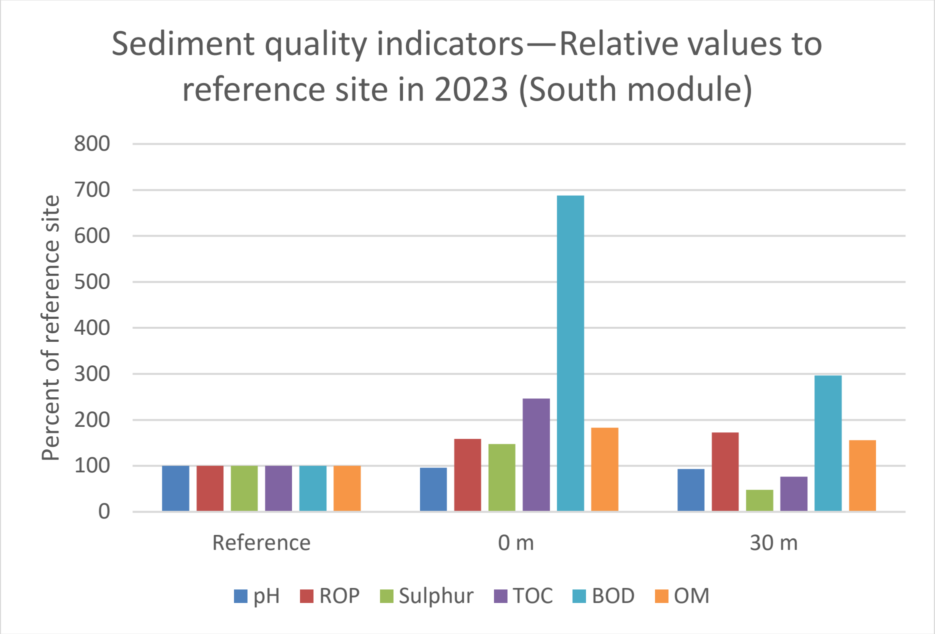

Figure 12: Sediment nutrient monitoring at the south module net pen edge (0 m) and at 30 m, relative to reference sites for key parameters. (Data provided by Pacifico Aquaculture through AIA Puritec reports.) ROP: redox potential; TOC: total organic carbon; BOD: biochemical oxygen demand; OM: organic matter.

immediate net pen vicinity, the percentages remaining above reference site levels (ROP, BOD, and OM) suggest otherwise. The 688% increase in BOD at 0 m compared to the reference sites, and the fact that BOD remained 297% higher than the reference site at 30 m, imply that the operation's footprint can persist on the seabed beyond the immediate farm vicinity.

Figure 13 compares the same seven sediment quality indicators (as those included in Figure 12). Instead of comparing relative values to reference sites, it compares the average of the absolute values reported for 2023 across sampling sites. Therefore, similar results are observed, with increased levels for the samples obtained at the edge of the net pens followed by a decrease for the samples obtained at 30 m from the edge of the net pens compared to the reference sites. This trend was observed for sulfur, BOD, and OM; however, except for sulfur and pH, the results for these indicators remained higher at 30 m from the edge of the net pens than those reported for the reference sites.

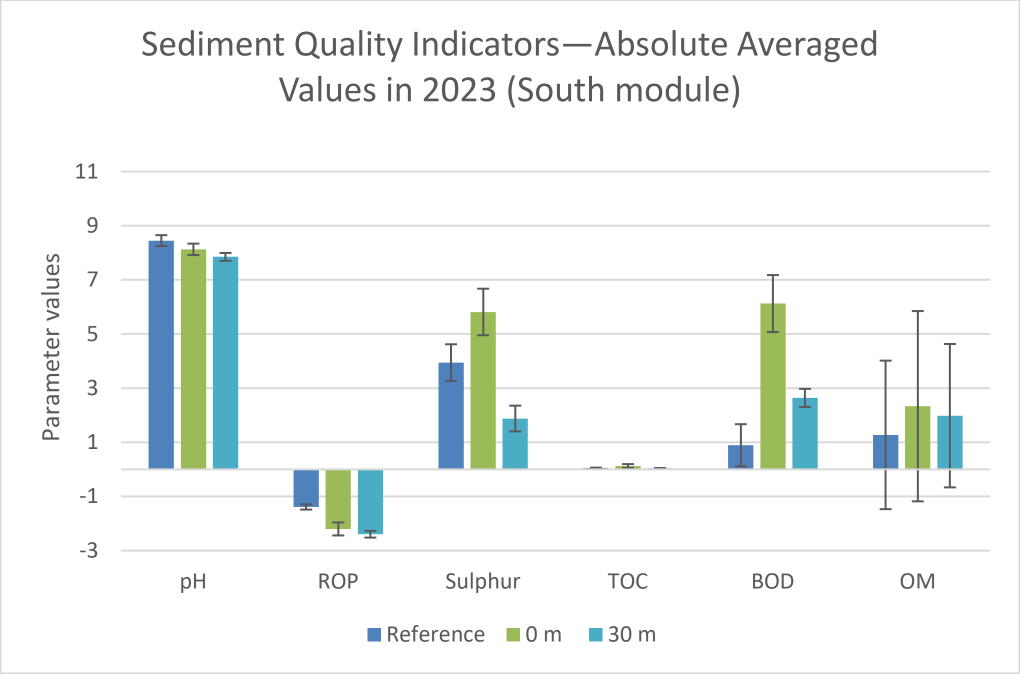

Figure 13: Sediment nutrient monitoring absolute data values at the south module net pen edge (0 m), 30 m, and at the reference sites for key parameters with +/– one standard deviation bars. Redox potential values (ROP) are in millivolts; sulfur is in µg/L; total organic carbon (TOC) and biochemical oxygen demand (BOD) values are in mg/L; and organic matter (OM) is in percentage. (Data provided by Pacifico Aquaculture through AIA Puritec reports.)

Similar results are observed when looking into the concentrations of heavy metals on the seabed beneath the larger south net pen array and at 30 m from their edge. Among the four metals illustrated in Figures 14 and 15, lead exhibited a 1,208% increase at the net pen's edge compared to the reference site, while zinc was 346% higher. At the reference site, the average concentrations of lead and zinc were 0.0127 µg/g and 0.1167 µg/g, respectively. In contrast, at the net pen's edge, the average concentrations rose to 0.1530 µg/g for lead and 0.4033 µg/g for zinc (see Figure 15). The notable increase in lead and zinc concentrations at the net pen's edge, in addition to the sustained higher concentrations observed at 30 m from the edge, imply that the producer's heavy metal contributions, potentially through feed, feces, and anti-fouling agents, may remain in the seabed beyond the immediate vicinity of the farm (Sutherland and Yeats, 2011).

While several sediment quality indicators (pH, sulfur, TOC) and concentrations of heavy metals (Cd and Cu), as well as certain soluble nutrient indicators (BOD and phosphate), suggest that detectable impacts

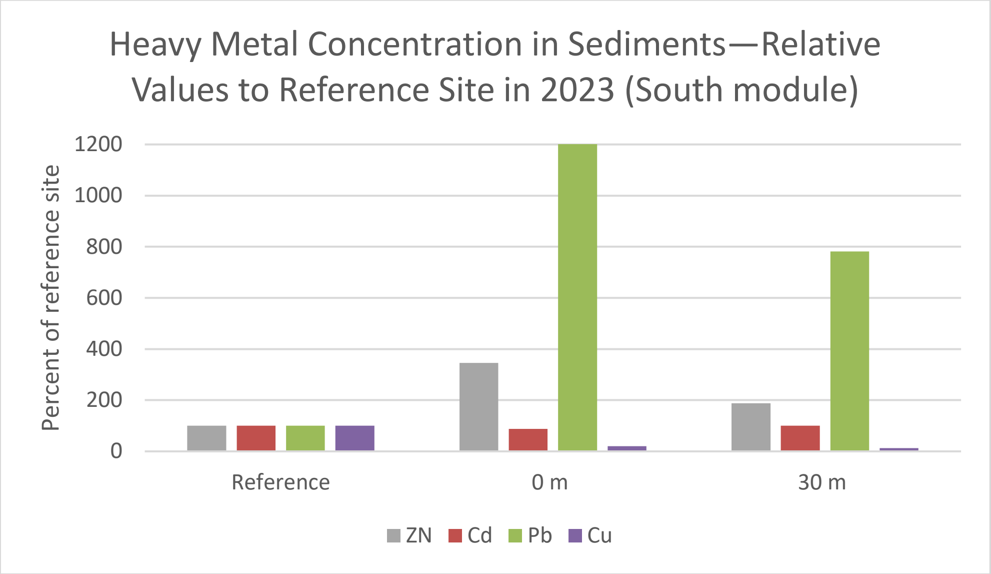

Figure 14: Percentage of heavy metal (zinc, cadmium, lead, and copper) concentrations relative to reference sites, obtained through sediment monitoring at the south module net pen edge (0 m) and at 30 m. (Data provided by Pacifico Aquaculture through AIA Puritec reports.)

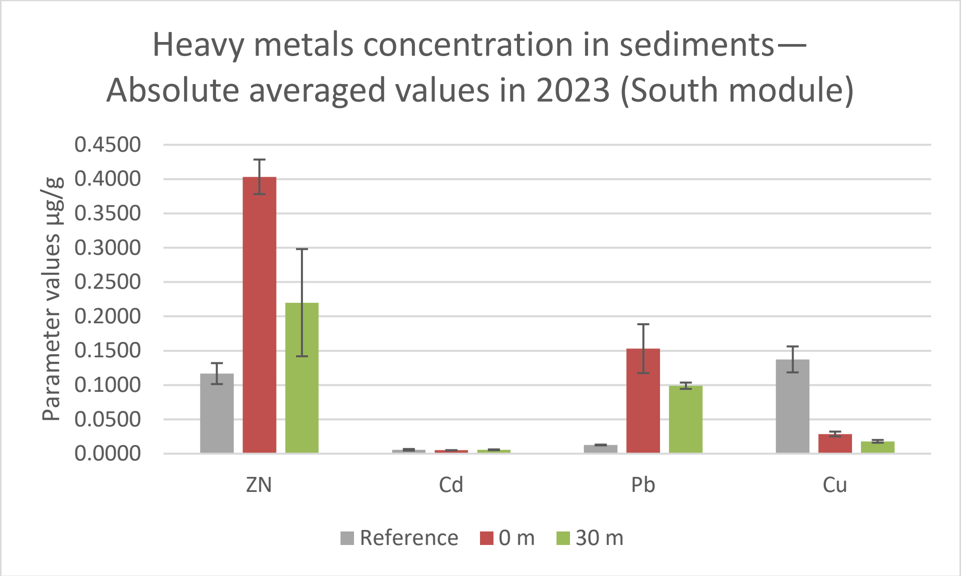

Figure 15: Heavy metal (zinc, cadmium, lead, and copper) concentrations in absolute values in µg/g, obtained through sediment monitoring at the south module net pen edge (0 m), at 30 m, and at reference sites. (Data provided by Pacifico Aquaculture through AIA Puritec reports.)

are quickly diluted and confined to the vicinity of the farm, others such as ROP, BOD, and OM, as well as soluble nutrient indicators (COD, TSS, ammonia) and concentrations of heavy metals (Zn and Pb) indicate otherwise. These parameters show persistently higher levels at 30 m from the edge of the net pens compared to those levels reported for the reference sites.

Overall, benthic monitoring results indicate that the sites' current dynamics are effective at diluting and dispersing most water column soluble nutrients, as evident by the benthic monitoring results. Although there are elevated levels of sulphur, BOD, OM, Zn, and Pb at 0 m compared to the reference site, all show a downward trend moving away from the net pen array (up to 30 m). These monitoring results are not easy to directly correlate with specific impacts to benthic faunal communities, but using examples taken from net pen salmon farming (the most-studied net pen aquaculture industry), even severe benthic impacts are considered to be relatively rapidly reversed with the cessation of production or fallowing. For example, although the time taken for recovery of this area is highly variable, it is frequently substantial in 2 to 3 years (Black et al. 2008). Although Pacifico Aquaculture operates continuously at the three modules (i.e., there is not a formal fallow period between cycles), production volumes are currently lower than the figures used in the AMS "Biomass and benthic footprint" model assessment. The assessment suggests that there will be elevated levels of some parameters within the immediate farm vicinity, but beyond the farm vicinity (defined as < 0.06 km^2), elevated water quality levels are highly unlikely to occur. This suggests there may be impacts within the immediate vicinity of the farm, but they are temporary.

Cumulative Impacts

As previously mentioned, Pacifico Aquaculture is the sole marine striped bass farm in the Americas. While it is crucial to assess the direct effluent impacts of the producer, understanding how the farm may contribute to cumulative impacts in its operating area is equally important. To gain insight into these cumulative impacts, this report will first provide an overview of other aquaculture producers operating along Todos Santos Bay. Then, it will delve into the literature regarding other sources of anthropogenic waste inputs and their relationship to the bay's nutrient hydrodynamics and environmental conditions. In addition, it will assess the health status of the benthos and water column using various biological indicators reported in the literature.

The National Commission on Aquaculture and Fisheries (CONAPESCA) indicates that there are a total of 23 aquaculture concessions within and just outside Todos Santos Bay (Figure 16). Among these, 2 are designated for macroalgae cultivation, 14 for mollusk production, and 7 for finfish farming. Apart from Pacifico Aquaculture's striped bass, other production of finfish species in Baja California includes rainbow trout, bluefin tuna, yellowtail, and striped corvina. Specifically, one small rainbow trout site and two tuna operations are situated at the southern and northern extremities of Todos Santos Bay (where Isla Todos Santos is offshore). But these sites are more than 6 mi from Pacifico Aquaculture. The rest of the concessions within the bay predominantly focus on mollusk production. While the information is somewhat dated, the AMS study in 2018, concludes: "The available receiving area (Todos Santos Bay) is extensive, and significant ecological effects from production operations at the envisaged scale are considered very unlikely." Furthermore, the AMS assessment indicates that the south module can exceed the lower (i.e., more conservative) SEPA definition of degradation at high levels of production in the immediate area under the net pen module, but these high production levels have not been met as of 2023.

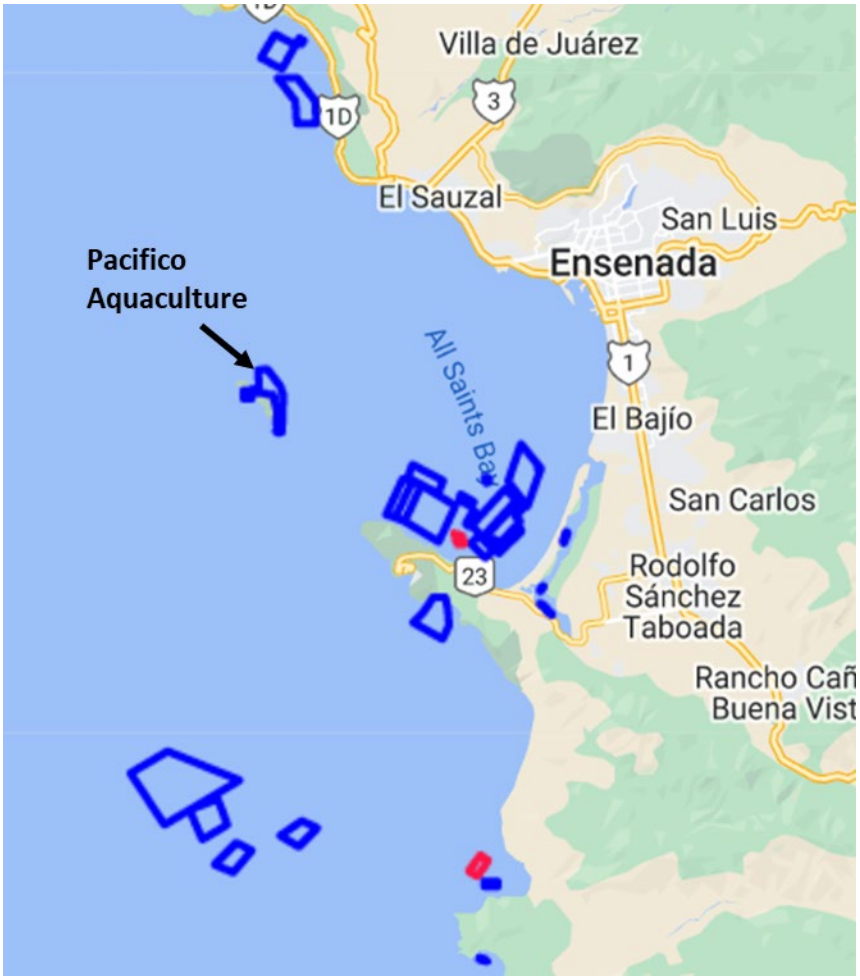

Figure 16: Approved aquaculture concessions around All Saints Bay (blue polygons). The red polygons are concessions pending for approval as of December 2023. (CONAPESCA, accessed in December 2023.)

Considering anthropogenic waste inputs beyond aquaculture production is crucial for understanding the extent of the cumulative environmental impacts from these inputs in Todos Santos Bay. Tanahara et al. (2021) reported significant increases from February 2012 to January 2013 (two-tailed Mann-Whitney, $p < 0.05$) in nutrient concentrations, such as ammonium, nitrate, nitrite, phosphate, silicate, total coliforms, and parasite eggs, linked to localized sewage inputs along the bay's coast. All samples were taken along the entirety of the coast of Todos Santos Bay for a total of 29 sample stations, and water samples were collected within the immediate shoreline. The study emphasizes Ensenada City's contribution (the largest urban development on the bay), with three wastewater treatment plants (WWTPs) discharging treated effluents into local streams, ultimately reaching the coastal waters of the bay. Despite undergoing secondary treatment, these discharges play a role in altering the bay's surface water chemistry, but samples were only taken along the shore, and current dynamics appear to move surface water along the shoreline—compounding the issue (Tanahara et al., 2021). It is noteworthy that official COFEPRIS reports for 2012 and 2013 ranked Playa Hermosa beach, at the southern end of Ensenada within the bay, as a "clean beach," despite Tanahara et al.'s (2021) documented pollution signs. But in the summer of 2021, COFEPRIS declared Playa Hermosa the most polluted beach on the entire Mexican coastline, because of *E. faecalis* values reaching 786 CFU/100 mL (Tanahara et al., 2021).

The study concludes by noting the importance of improved wastewater treatment and water quality monitoring of the bay.

Despite the acknowledged influence of upwelling on surface water chemistry in Todos Santos Bay (Delgadillo-Hinoejosa et al., 2020), the increased levels of nitrate detected during the winter-spring season suggest the presence of additional nutrient inputs along the coastal area, such as treated wastewater discharges and runoff from rivers (Tanahara et al., 2021). Studies indicate that sewage discharge contributes a comparable amount of nitrogen (N) to that of upwelling in certain locations within the Southern California Bight, which is also influenced by the California Current System (Howard et al., 2014). The seasonal trend in ammonium concentrations mirrors that of nitrate, with peak levels occurring during the upwelling season and rainy periods (Tanahara et al., 2021). In addition, ammonium variability is influenced by anthropogenic inputs and the dynamics of the California Current System, with substantial ammonia entering Todos Santos Bay via municipal effluent discharges and agricultural runoff, posing potential harm to marine ecosystems (Smith et al., 1999) (Sutula et al., 2021). Silicate concentrations also exhibit a distinct pattern, reaching maximum levels during the rainy period, upwelling period, and tourism summer peak.

Furthermore, given that benthic polychaete communities constitute the predominant macrobenthic taxon in soft bottom sediments, as observed in Todos Santos Bay, and are influenced by many physical, chemical, and biological factors, the study conducted by Araujo-Leyva et al. (2020) provides a significant perspective on the ecosystem's health as it relates to anthropogenic inputs. This study employed sediment samples collected from 70 sites spanning the years 1998, 2003, 2013, and 2018. The analysis results indicated a moderate to low correlation (i.e., 0.392 to 0.573 correlation coefficient) among environmental variables that are key in explaining the shifts in polychaete family distribution, which was likely influenced by hydrographic conditions, including El Niño events and droughts. Sediment grain size and organic carbon significantly influenced community patterns in 1998, while lead (Pb) showed medium-high correlation in 2013, likely influenced by atmospheric exchange and urban wastewater discharges. The increased number of organisms observed in 2013 may reflect the impact of severe droughts, reducing continental contributions to the coastal area. Aguilar et al. (2017) suggested that drought conditions led to less hydrodynamic perturbation, favoring greater abundance and diversity of polychaetes.

Araujo-Leyva et al. (2020) show an increasing trend in both the abundance (individuals per 0.1 m^2) and biodiversity richness of polychaetes over the two-decade period considered in their study, exhibiting a slight decline in 2018 while persisting at levels surpassing those recorded in 1998. In addition, univariate metrics reveal that the lowest diversity index values were documented in 1998, when the presence of uniform communities and a significant proportion of polychaetes families (Spionidae, Ampharetidae, and Cirratulidae) that are characterized as being indicators of environmental stress linked to high organic matter, were prevalent in the bay (Araujo-Leyva et al., 2020). It is noteworthy that Rodriguez-Villanueva et al. (2000) had previously reported similarly low diversity values in Todos Santos Bay for 1994. Conversely, in 2018, the highest proportion of stations exhibited elevated diversity values, signifying heterogeneous communities thriving in a habitat characterized by ecological quality ranging from good to very good (Araujo-Leyva et al., 2020). The observed changes between 1998 and 2018 could be attributed to heightened hydrodynamics in the bay, which result in increased percentages of sands paired with reduced organic matter content over time (Araujo-Leyva et al., 2020). Fisher and Sheaves (2003) proposed that benthic assemblages with more families present are correlated with highly diverse sediments (i.e., greater variety of microhabitats). It is worth noting that Araujo-Leyva et al. (2020) also suggest that the composition of nonpolychaete benthic macrofauna has fluctuated over the assessed period, indicating either the maintenance of or an increase in biodiversity within Todos Santos Bay.

While aquaculture is a nonpoint source of pressure on the marine ecosystem in Todos Santos Bay (Araujo-Leyva et al., 2020), it is one of many listed by Smith et al. (2008). Importantly, the correlation between environmental factors and polychaete families appears to be primarily influenced by the hydrographic characteristics of the region affected by ENSO events and significant drought periods during the four oceanographic surveys.

Consequently, determining the extent to which aquaculture may contribute to observed anthropogenic disturbances in the bay, particularly at the level of a single producer, poses a significant challenge. The numerous studies discussed earlier suggest that the health of the ecosystem is strongly linked to the combined impact of various other anthropogenic activities (such as agricultural runoff, municipal discharges, and tourism) and hydrodynamic cyclic events (including upwelling, rainfall, and drought). There are some indications of excessive seasonal nutrient enrichment along the shoreline stemming from wastewater treatment plant discharge, but there are no studies readily available suggesting that the carrying capacity of the bay as a whole has been exceeded. The bay is dynamic, consisting of strong currents and deep canyons. Considering the relative isolation of the farm site (≈9 mi from Ensenada) there is no information to suggest that the farm is contributing to the poor seasonal water quality along the shoreline. But there is a need for ongoing monitoring at various locations and distances from shore, to ensure the long-term health and sustainability of this valuable coastal ecosystem.

Conclusions and Final Score

Overall, the concern regarding effluent impacts from the producer's waste discharges into the environment (i.e., uneaten feed waste and fish excretion) is considered to be low. While acknowledging some limitations in the data, such as inconsistency in the reported parameters and sampling sites throughout the assessment period (2020–23), the available data, including soluble and benthic nutrient indicators, benthic impact models, and heavy metal concentrations, do enable a fairly comprehensive understanding of the effluent impacts from the striped bass producer. The producer conducts annual comprehensive analyses of water quality and benthic indicators. These analyses entail testing water and sediment samples by an independent laboratory, Asesoria Integral Ambiental Puritec, in adherence to the Best Aquaculture Practices certification standards. This standard also requires predefined sampling locations, based on characteristics identified through a study conducted by a third party; in this case, Anderson Marine Surveys (AMS). Consequently, this assessment considers recommendations derived from AMS's benthic impacts model, evaluates key soluble nutrient indicators and sediment quality indicators, and scrutinizes available literature to better comprehend the potential contribution of the producer to cumulative impacts in Todos Santos Bay.

For soluble nutrients in the water column, the available monitoring data are supported by academic studies on net pen aquaculture in exposed locations, which conclude that significant impacts beyond the immediate farm area are highly unlikely. For benthic impacts, the available monitoring data appear to support the comprehensive modeling assessment by AMS, which concludes that, although there will be some change and degradation to benthic communities in the immediate farm area, and though some parameters are elevated at 30 m from the net pens compared to the reference sites, it is highly unlikely that there will be significant impacts much beyond this immediate farm area, particularly considering the rapidly increasing depth with increasing distance from the net pens.

There are some indications of excessive seasonal nutrient enrichment along the shoreline from wastewater treatment plants, but there are no studies readily available that the farm is contributing to the poor seasonal water quality along the shoreline. Considering the isolated nature of the striped bass farm, the data show no evidence that effluent discharges cause or contribute to cumulative impacts at the waterbody/regional scale. But there is a need for ongoing monitoring at various locations and distances from shore, to ensure the long-term health and sustainability of this valuable coastal ecosystem.

In conclusion, data show no evidence that effluent discharges cause or contribute to cumulative impacts at the waterbody/regional scale, and the impacts within the immediate vicinity of the farm are considered temporary. The final score is 8 out of 10 for Criterion 2—Effluent.

Criterion 3: Habitat

Impact, unit of sustainability and principle

- *Impact:* Aquaculture farms can be located in a wide variety of aquatic and terrestrial habitat types and have greatly varying levels of impact to both pristine and previously modified habitats and to the critical "ecosystem services" they provide.
- *Unit of sustainability:* 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		9.0
F3.2a Content of habitat regulations	3	
F3.2b Enforcement of habitat regulations	4	
F3.2 Regulatory or management effectiveness score		4.8
C3 Habitat Final Score (0–10)		**7.6**
Critical?	NO	GREEN

Brief Summary

The striped sea bass industry in Mexico has a single producer utilizing 62 grow-out net pens, operating in about 180 ha, which is a small fraction (< 1%) of the bay's total surface area. Situated near Todos Santos Island, with depths ranging from 30 to 100 m and a substrate of sand/volcanic rock, the habitat type of the net pens can be classified as nearshore and coastal, which is considered a high-value habitat. The evidence reviewed emphasizes both the complexity and uncertainty regarding the scale of the impacts and the appropriate level of concern, but the examples cited do not indicate the loss of any critical ecosystem services from the affected habitats. Thus, the habitats are considered to be maintaining functionality with minimal impacts, and the score for Factor 3.1—Habitat conversion and function is 9 out of 10.

The content of habitat management measures is moderate. The company is sited according to ecological principles and environmental considerations. For example, the farm is compliant with all the necessary environmental permits and conducted an environmental impact assessment (EIA) in 2004. But the content (i.e., legislation and regulatory implementation) of the habitat management measures is considered limited, and the BAP certification does not address cumulative impacts or area-based principles. As a result, Factor 3.2a—Content of habitat management measures is considered moderate and the score is 3 out of 5. Enforcement of regulations aimed at protecting habitat is evident, with identifiable and accessible institutions such as PROFEPA taking a complaint-driven approach to enforcement (i.e., imposing penalties). In addition, the industry's sole producer demonstrates compliance with legal requirements, verified through annual inspections by BAP and SENASICA. Consequently, the score for Factor 3.2b—Enforcement of habitat regulations is 4 out of 5. Combined with the score for Factor 3.2a, the Factor 3.2 score for striped bass is 4.80 out of 10. The final score for Criterion 3—Habitat for striped bass is 7.60 out of 10.

Justification of Rating
The habitat criterion assesses the impacts of farm construction and operation/presence on the coastal ocean environment where the striped bass farm is located in Todos Santos Bay, Mexico.

Factor 3.1—Habitat Conversion and Function
Todos Santos Bay is located to the northwest of the Pacific coast of Mexico and extends across a surface area of approximately 20,000 ha, which is made mainly of relatively soft ground. Roughly 80% of the bay has depths of less than 50 m, except for the deep abrupt submarine canyon located between Punta Banda and the Todos Santos Islands that reaches more than 600 m in depth (Acuario Oceanico, 2015) (Bajamichi, 2004). As mentioned, there is only one striped bass producer, operating 62 grow-out net pens (35 net pens of 25 m in diameter and 27 net pens of 8 m in diameter) that are grouped in three modules (north, central, and south) along this submarine canyon, and about 60 to 200 m from the east coast of Todos Santos Island (see Figure 2 in the Introduction). Within each module, each net pen is spaced about 40 m apart and approximately 10 to 80 m from the benthic zone, as measured from the bottom of each pen (Figure 17; see also Figure 1 in the Introduction). Each net pen is anchored to steel anchors positioned on the benthic zone (pers comm, Pacifico Aquaculture representatives, November 2023). The benthic habitat where farm production is located appears to consist mainly of a combination of a soft sandy bottom with volcanic rock as it approximates the canyon, and no corals or highly important marine plants, algae, rocky reefs, or other sensitive habitats appear to be in the vicinity of the net pens (pers comm, Pacifico Aquaculture representatives, November 2023) (Bajamichi, 2004).

Furthermore, there are a total of 23 active aquaculture concessions within the bay, authorized to use 3,902 ha (constituting 19.5% of the total bay area) of sea surface water (see Figure 16 in Criterion 2). While the striped bass producer is currently only operating in one of their three authorized concessions, and currently utilizes a total area of about 179.35 ha (constituting 0.9% of the total bay area), their total approved area is 819.12 ha (pers comm, Pacifico Aquaculture representatives, November 2023). The production area coverage seems stable, because the producer has not expanded its operation beyond the 180 ha currently utilized since it commenced striped bass production in 2016.

Considering the location of the farm (60 to 200 m from Todos Santos Island), the depth of the marine environment (30 to 100 m), and the benthic substrate (sand/volcanic rock), the marine habitat type that best describes the area that the striped bass marine net pens occupy is nearshore and coastal (considered a high-value habitat under the SFW standard).

Research conducted in temperate coastal waterbodies has demonstrated that net-pens and their associated structures, such as floats, weights, mooring ropes, buoys, and anchors, contribute substantial physical structures to nearshore habitats. These structures modify light penetration, currents, and wave action, and provide surfaces for the development of diverse biotic assemblages, further enhancing habitat complexity (McKindsey, 2011). In addition, the increased nutrient inputs from aquaculture activities can exacerbate anthropogenic impacts in these waterbodies. See Criterion 2—Effluent for a more comprehensive description of these impacts.

Figure 17: Striped bass south net pen module along the eastern coast of Todos Santos Island.

Furthermore, the Canadian Department of Fisheries and Ocean (DFO) (in a 2017 information webpage on the Alteration of Habitats[12]) notes that the use of underwater lights may influence the behavior of wild fish by attracting them to—or causing them to avoid—farm sites, but also notes that the lights do not penetrate more than a few meters beyond marine nets, suggesting that their use has minimal effect on the surrounding environment. Floerl et al. (2016) note that a large number of fish (and mussel) farms in North America, Europe, and New Zealand support extensive populations of biofouling invasive species, and the in-situ cleaning of fouled net pens may inadvertently support the persistence and distribution of such species within aquaculture regions by the localized dispersal of nonindigenous propagules and fragments, or by the use of farm structures as stepping stones for range expansion (Bloecher and Floerl, 2020).

In addition to biofouling organisms attached directly to the farm infrastructure as substrates, Callier et al. (2018) reported the attraction and repulsion of wild animals to/from marine finfish (and bivalve) farms, and considered the effects related to the farm infrastructure acting as fish aggregating devices or artificial reefs, the provision of food (e.g., farmed animals, waste feed and feces, and fouling organisms associated with farm structures), and some farm activities (e.g., increased boat activity and cleaning). Callier et al. (2018) also noted that the distribution of mobile organisms associated with farm structures varies over various spatial scales (vertical and horizontal) and temporal scales (season, feeding time, day/night period). Moreover, the attraction/repulsion mechanisms have a variety of direct and indirect effects on wild organisms at the level of individuals and populations, and may have implications for the management of fisheries species and the ecosystem in the context of marine spatial planning. Nevertheless, Callier et al. (2018) also noted considerable uncertainties regarding the long-term and ecosystem-wide consequences of these interactions.

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[12] https://www.dfo-mpo.gc.ca/aquaculture/protect-protege/alteration-habitat-eng.html

Therefore, it is important to describe a few key ecosystem services in Todos Santos Bay that could potentially be affected by the enhanced complexity of its habitat, because of the infrastructural effects previously described and in relation to the farm's construction and operation/presence in this coastal marine environment. For instance, modifying light penetration in coastal ecosystems could potentially affect the quantity of phytoplankton biomass, which plays a crucial ecological role. Phytoplankton is responsible for converting carbon dioxide into organic carbon and generating oxygen in the ocean, and its biomass directly influences ocean productivity. Similarly, macroalgae, as primary producers, serve as food for fish and invertebrates and provide substrates and habitat for various marine species. Studies by Aguilar-Rosas (1981; 1982) and Aguilar-Rosas y Bertsch (1983) documented the presence of brown (Phaeohyta), red (Rhodophyta), and green (Chlorophyta) algae in the southern zone of Todos Santos Bay, overlapping with the location of the largest striped bass production module. Although there is no readily available information indicating the extent to which net pens operating in a coastal habitat could affect the health and density of phytoplankton and macroalgae, it is evident that the area near the Baja California Peninsula experiences significant fluctuations in their biomass. These variations are influenced mainly by seasonal and interannual factors, including phenomena such as El Niño-La Niña cycles as well as local mesoscale processes like coastal upwelling, eddies, fronts, and meanders (Acuario Oceanico, 2015). Therefore, the presence of the net pens, which affect light penetration in roughly less than 1% of the bay's surface area, is likely to have minimal, if any, impact on the bay's primary production.

As noted, net pens can affect the behavior of marine fauna because net pens can act as fish aggregating devices (FADs). The Todos Santos Bay is characterized by its biodiverse fauna: about 56 species of polychaetas, 17 species of crustaceans, and 82 fish species have been reported in the bay (Acuario Oceanico, 2015). Some of these species are important for the commercial and recreational fisheries that are carried out in the bay, but none of the species is under any special protection status. For instance, when analyzing fisheries data reported by CONAPESCA, there are a total of 1,581 vessels authorized for small-scale fisheries of fishers' communities located within Todos Santos Bay (CONAPESCA, 2023). While the producer does not provide specific estimates or insights regarding how their net pens might be altering the behavior and abundance of wild fauna at the production site, they do document a total of 188 predator interactions, totaling 119 collective hours of interactions in 2023 (note that mortalities are assessed in Criterion 9X—Wildlife Mortalities). This suggests that the net pens may be influencing wildlife behavior to some extent simply because wildlife are interacting with the farm, although the exact degree of this impact remains unclear (pers comm, Pacifico Aquaculture representatives, October 2023).

In addition, the avifauna reported for the southern area of Todos Santos Bay comprises approximately 16 species (Acuario Oceanico, 2015). Among the most representative species are the brown pelican (*Pelecanus occidentalis*), yellow-footed gull (*Larus livens*), and cormorants (*Phalacrocorax auritus* and *P. penicillatus*). It is noteworthy that these species nest their interactions with the production site (for details on marine bird presence in Todos Santos Bay, see Criterion 9X—Wildlife Mortalities) (Acuario Oceanico, 2015). But disruptions of natural seabird behaviors, particularly gulls, caused by the artificial lights used by the producer during night hours to increase fish appetite and prevent vandalism, have been identified as potential threats to these species (pers comm, Pacifico Aquaculture representatives, July 2024) (pers comm, Anonymous, July 2024). Furthermore, the frequent presence of hikers and other individuals on Todos Santos Island, presumably staff from the striped bass operation, poses an additional threat to wildlife on the island, which is part of the buffer zone of the Todos Santos Archipelago in the Islas del Pacífico de la Península de Baja California Biosphere Reserve (DOF 07-12-2016). Researchers conducting wildlife surveys in the region have raised increasing concerns that these disturbances could lead to population-level impacts on local seabird species (pers comm, Anonymous, July 2024). But seabird studies on the island, using data as recent as 2019, indicate increasing trends for at least four species, with no observed decreasing trends among the assessed species (Bedolla-Guzman et al., 2019). While the extent of the impact of the striped bass operation on marine birds remains uncertain, it appears highly improbable that the physical infrastructure of the farm is adversely affecting these species' population levels. Current data (i.e., 2006–19) indicate no available evidence that the striped bass operation has had a negative impact on seabird populations in the area (Bedolla-Guzman et al., 2019).

Overall, the striped sea bass industry in Mexico had a single producer that operates 35 grow-out net pens with a diameter of 25 m and 27 net pens with a diameter of 8 m. This operation covers approximately 180 ha, which is well below the authorized area of 820 ha and represents less than 1% of the entire bay's surface area of 20,000 ha. The floating net pen farm containment system is unusual among food production systems in that the "construction" of the farm has a relatively low direct habitat impact, yet the addition of the physical infrastructure and the site operations still have a variety of potential impacts on the habitats of the farm site. Given the proximity of the farm to Todos Santos Island (60 to 200 m), the marine environment's depth (30 to 100 m), and the composition of the benthic substrate (sand/volcanic rock), the habitat type where the striped bass marine net pens are situated can be classified as nearshore and coastal (considered a high-value habitat under the SFW standard). The evidence reviewed emphasizes both the complexity and uncertainty regarding the scale of the impacts and the appropriate level of concern, but the examples cited do not indicate the loss of any critical ecosystem services from the affected habitats. Thus, the habitats are considered to be maintaining functionality with minimal impacts, and the score for Factor 3.1—Habitat conversion and function is 9 out of 10.

Factor 3.2—Farm Siting Regulation and Management

Husa et al. (2014) noted that the cumulative effect of numerous impacted areas around multiple fish farms must be considered when further evaluating the total impact from fish farming on ecosystem functioning, and Factor 3.2 assesses the effectiveness of the regulatory and farm management practices in addressing the potential cumulative impacts from multiple farming sites. The isolated nature of the Isla Todos Santos site will be discussed accordingly.

Factor 3.2a: Content of habitat management measures

The following content relates to the current regulatory system in place for aquaculture farms, and it is important to note that many of the relevant regulations and references are dated during or after when the main expansion of the industry occurred in Mexico, which can be traced to the 1980s (Vazquez-Vera y Chavez-Carreño, 2022).

The legislative instruments currently governing the regulation, promotion, and management of the exploitation of fisheries and aquaculture resources are the General Law of Sustainable Aquaculture and Fisheries (LGPAS[13]) of 2007 and the Law of Sustainable Rural Development of 2001, and its respective rulings.[14] These rulings refer to the laws' complementary Mexican official norms (NOM and NMX), which support the implementation of the law by specifying the requirements for the execution of aquaculture activities. Furthermore, aquaculture production is also governed by other federal regulations outlined in the General Law of Ecological Balance and Environmental Protection, National Water Law, Regulations of the National Water Act, and the Federal Law of Rights. These regulations mandate conducting an

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[13] https://www.diputados.gob.mx/LeyesBiblio/pdf/LGPAS.pdf

[14] https://www.dof.gob.mx/nota_detalle.php?codigo=5617393&fecha=03/05/2021#gsc.tab=0

environmental impact assessment before undertaking the project, obtaining permits for water use, and implementing water treatment measures to ensure that discharged water does not contaminate the receiving bodies of water (Sosa-Villalobos et al., 2016).

The LGPAS addresses aquaculture siting by giving federal entities the power to agree upon actions that promote the territorial planning of aquaculture developments in inland waters (Article 81 § IV), as well as to promote the establishment of protected areas and initiatives for the restoration, rehabilitation, and conservation of coastal, lagoon, and inland water ecosystems, in accordance with the provisions set forth in the General Law of Ecological Balance and Environmental Protection (Article 9 § III). In addition, Article 85 of the LGPAS emphasizes the importance of adopting an ecosystem-based management approach in aquaculture through the establishment of aquaculture management units (UMA). The UMA is defined as a delimited zone that integrates multiple production units with shared infrastructure and facilities, operating collectively (LGPAS, 2010). Each UMA would be required to have a comprehensive management plan in place, addressing the following aspects (relevant to habitat impacts):

1. Producer's action plans in the short and long term.
2. The carrying capacity of the waterbodies which the aquaculture production units intend to use for production.
3. The geographic characteristics of the area or region.
4. The existing infrastructure and planned development works, as well as their corresponding administrative program.
5. The description of the physical and biological characteristics of the aquaculture production units.
6. Actions for the protection and sustainable utilization of natural resources, along with a compliance schedule for relevant legal provisions.

Furthermore, the General Law of Ecological Balance and Environmental Protection (LGEEPA) is intended to regulate ecological considerations when addressing the spatial planning of productive activities in the country, such as aquaculture. For instance, it stipulates the need to determine the ecological regionalization of the national territory, as well as the areas falling under the nation's sovereignty and jurisdiction at the federal, regional, and local levels. This determination is based on a comprehensive assessment of various factors, including the characteristics, availability, and demand of natural resources, the productive activities conducted within these areas, and the distribution and status of existing human settlements (Article 20 § I). In addition, it mandates the Federation to establish guidelines and ecological strategies for the preservation, protection, restoration, and sustainable utilization of natural resources, as well as for the location of productive activities and human settlements (Article 20 § I). Within the context of natural protected areas, Article 51 of this law specifies that the authorization, restriction, or prohibition of activities or resource utilization must align with the provisions outlined in the LGEEPA and the General Law of Sustainable Fishing and Aquaculture. Moreover, the law encompasses criteria for the sustainable use of water as a natural resource and aquatic ecosystems, including provisions related to aquaculture water concessions (Article 89 § IX).

Similar to the legislative components shared between the LGPAS and LGEEPA, there must be coordination among the regulatory bodies responsible for implementing these laws. This collaboration is essential for effectively applying regulations to the production and siting of aquaculture operations. In Mexico, aquaculture falls within the regulatory framework of two departments at the ministerial level: the Department of Agriculture and Rural Development (SADER) and the Department of Natural Resources and Environment (SEMARNAT). Under SADER, there are three agencies most concerned with aquaculture:

1. The National Commission of Aquaculture and Fisheries (CONAPESCA) deals primarily with operating permits.
2. The National Service of Alimentary Health, Quality and Innocuity (SENASICA) is in charge of animal health.
3. The National Fisheries Institute (INP) provides research and technical opinions.

Under SEMARNAT, there are four agencies involved:

1. The Directorate of Environmental Impact reviews environmental impact statements, sets operating restrictions, and evaluates environmental permits.
2. The National Water Commission (I) regulates water use and discharges.
3. The Directorate of Federal Zoning regulates uses of the Federal Coastal Zone.
4. The Environmental Protection Attorney's Office (PROFEPA) enforces environmental regulations.

It is worth noting that, in 1996, the LGEEPA established a requirement that an Environmental Impact Assessment (EIA) be generated for all projects and activities in wetlands, mangroves, lagoons, rivers, lakes, and estuaries connected to the ocean and fishing, aquaculture, and agriculture activities that could threaten the preservation of one or more species or cause harm to the ecosystem (SEMARNAT, 2002). The required EIA holds utmost importance as the primary regulatory component when SEMARNAT and CONAPESCA authorize a particular site as a unit of aquaculture production (UPA), as explained in the following.

Environmental impact assessment and management

The EIA process starts with submission of a preventive report, which identifies whether there are Official Mexican Standards (NOMs) or other regulatory provisions governing emissions, discharges, natural resource exploitation, and overall environmental impacts resulting from the relevant works or activities (FAO, 2023). The preventive report should also outline the urban development plan or ecological ordinance applicable to the proposed project. Furthermore, it must incorporate location plans detailing the area where the project is intended to be implemented (Article 30 of the LGEEPA). Following the submission and analysis of the preventive report, SEMARNAT determines, within a period of 20 days, whether an EIA should be conducted or if the preventive report is deemed sufficient.

As mentioned, an EIA is a prerequisite for obtaining a UPA permit through CONAPESCA,[15] enabling the production of finfish in any waterbody. This EIA must be conducted by a specialist in coordination with SEMARNAT, which holds the responsibility for assessing the validity of the EIA.

Typically, EIAs provide a comprehensive assessment of the anticipated impacts of a proposed project and propose mitigation strategies within the technical characterization of the project (Perevochtchikova and André, 2013) (Aguilar-Manjarrez et al., 2017) (SEMARNAT, 2012). These mitigation measures encompass the construction, operational, and decommissioning stages of the project (Aguilar-Manjarrez et al., 2017), which include activities such as infrastructure abandonment, dismantling, and restoration (SEMARNAT, 2012). While the restoration component of proposed projects is mentioned in the laws previously discussed (LGPAS and LGEEPA), there is a lack of specific guidelines or requirements established by these laws, aside from NOM-022-SEMARNAT-2003, which provides some specifications for mangrove restoration. This issue was also raised by Ileana Villalobos in SEMARNAT's (2012) report, highlighting the lack of progress in habitat restoration in relation to EIA implementation.

An EIA must encompass the following information, as outlined by FAO (2023) and SEMARNAT (2002):

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[15] https://www.gob.mx/conapesca/documentos/conapesca-01-027-concesion-para-la-acuacultura-comercial

- Project Details: This section should include particulars about the project, the applicant, and the individual responsible for conducting the EIA.
- Physical Location: It should provide information about the project's physical location, accompanied by location maps. These maps should indicate the presence of protected natural areas or zones significant for their environmental characteristics, such as submerged vegetation areas or nesting sites. In addition, a layout plan specifying the total surface area (land or water) and all infrastructure required (operational, service-related, administrative, and associated works) must be included.
- Infrastructural-Production Components: This part should outline the main infrastructural and production components of the project. It should include detailed descriptions of the type, number, and layout of the production units to be used, such as net pens.
- Environmental Compliance: The EIA should establish the project's linkage to applicable environmental provisions and, if relevant, to land use regulations. This may involve referencing Plans of Ecological Ordinance of the Territory and Programs for the Management of Natural Protected Areas, among others.
- Description of the Environmental System: This section should conduct a comprehensive analysis of the physical, biotic, social, economic, and cultural environment. For marine and coastal environments, it should describe physiography, tides, bathymetry, hydrology, and water quality. It should also assess the fauna present at the project site, including species of conservation concern and those potentially affected by the project's establishment or operation.
- Identification and Assessment of Environmental Impacts: SEMARNAT's specified environmental impact indicators, such as land erosion risk, should be considered. Potential interactions between fauna and vegetation coverage should also be addressed, identifying sensitive areas that could be affected by habitat alterations.
- Preventive and Mitigating Measures: This section should outline precise, objective, and viable measures to prevent and mitigate environmental impacts. It should include clear explanations of their mechanisms and expected success measures based on technical-scientific fundamentals or experiences in natural resource management.
- Methodological Instruments and Technical Elements: The EIA should identify the methodological instruments and technical elements that support the information provided.

In addition, mitigation strategies are enforced as conditions for aquaculture concession holders, as mandated by SAGARPA, to actively contribute to environmental preservation and the conservation and reproduction of species, including the implementation of repopulation programs (FAO, 2023). But in the past, Mexico's aquaculture regulation has been criticized for often putting social or political criteria over environmental emphasis in aquaculture planning (FAO, 2009). Further, other authors suggest that disregard for biodiversity is not unusual for Mexico; interviews with individuals familiar with this industry have made similar suggestions (SFW, 2019).

Moreover, the national development plan[16] of the federal government, spanning 2019 to 2024, emphasizes two priority areas: food self-sufficiency and the restoration of agricultural fields. In line with these priorities, the aquaculture sector in Mexico is undergoing structural reforms aimed at establishing an aquaculture industry capable of generating significant quantities of high-quality food. This industry is envisioned as a fundamental pillar in ensuring food security for the country while simultaneously facilitating job creation and economic benefits (Reyes-Delgadillo et al., 2015). It is considered to be crucial that these objectives are achieved within a sustainable framework that optimizes the utilization

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[16] https://www.dof.gob.mx/nota_detalle.php?codigo=5565599&fecha=12/07/2019#gsc.tab=0

of Mexico's natural resources (Reyes-Delgadillo et al., 2015). Furthermore, the SEMARNAT Sectorial Program, published in 2020, places its primary objective on promoting the conservation, protection, restoration, and sustainable utilization of ecosystems and their biodiversity (DOF,[17] accessed June 2023). These federal initiatives and regulatory agencies appear to be aligned in fostering a management system that incorporates the entire food production sector, with the overarching aim of maintaining functional ecosystems that form the foundation for the well-being of the population. But determining the actual outcomes and impacts of these national goals is challenging because of the short timeline, but the intentions are promising.

Collectively, these regulations establish a management framework mandating that aquaculture farms adhere to ecological principles and environmental considerations during the siting process. For instance, farm siting procedures are guided by provisions outlined in the General Law of Sustainable Aquaculture and Fisheries, the General Law of Ecological Balance and Environmental Protection, and the National Water Law. In addition, farms are required to undergo an Environmental Impact Assessment and obtain siting approval from relevant authorities, primarily SEMARNAT and SADER. With documented evidence, including their registration and water concession permit approved by SAGARPA, as well as authorization for operation by SEMARNAT (predicated on the submitted EIA), it is evident that the striped bass producer is fully compliant with Mexico's siting regulations.

In summary, the content of habitat management measures is moderate. The company is sited according to ecological principles and environmental considerations. For example, the farm is compliant with all of the necessary environmental permits, and it conducted an Environmental Impact Assessment (EIA) in 2004. But the content (i.e., legislation and regulatory implementation) of the habitat management measures is considered limited, and the BAP certification does not address cumulative impacts or area-based principles. As a result, Factor 3.2a—Content of habitat management measures is considered moderate and the score is 3 out of 5.

Factor 3.2b: Enforcement of habitat management measures

The enforcement of habitat management measures is discussed by identifying the agencies, their tasks regarding farm siting, reviewing how active they may be, and evaluating how effectively the regulations described in Factor 3.2a are being enforced.

The regulatory and enforcement agencies responsible for overseeing aquaculture in Mexico, such as PROFEPA, SEMARNAT, and CONAPESCA, are identifiable and accessible. Information regarding enforcement activities can be found on government websites, although it has certain limitations. CONAPESCA, for instance, offers downloadable data on annual enforcement actions, albeit at a general level with limited detail. Table 3 presents the results of their activities in Baja California (i.e., Estate where Todos Santos Bay is located) from 2019 to 2023, providing an overview of the quantity of actions performed on a state level. The reported number of activities by CONAPESCA seem significant, especially when considering the scale of the aquaculture and fisheries industries in this region (both regulated by CONAPESCA), with 105 active aquaculture concessions and 1,295 active fishery permits in Baja California as of June 2024 (CONAPESCA, 2024a) (CONAPESCA, 2024b). Therefore, the total of 8,833 enforcement activities in 2023 indicates that the available resources may be adequate for effectively overseeing these industries. But CONAPESCA does not provide sufficient additional information regarding the enforcement activities related to specific aquaculture operations, particularly in terms of surveillance, nor do they elaborate on the outcomes of these reported activities (CONAPESCA, 2024a).

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[17] https://www.dof.gob.mx/nota_detalle.php?codigo=5596232&fecha=07/07/2020#gsc.tab=0

Table 3: CONAPESCA's number of enforcement activities in the Estate of Baja California from 2019 to May 2023 (CONAPESCA, 2023a).

Activities	**2019**	**2020**	**2021**	**2022**	**2023**
Surveillance	4,018	2,125	3,302	2,203	4,819
Inspections	122	194	269	221	257
Prevention workshops	65	10	219	201	402
Revision sites	525	575	652	445	795
Aquatic patrols	562	665	523	417	373
Terrestrial patrols	1,538	2,096	1,564	1,562	2,187
Total	**6,830**	**5,665**	**6,529**	**5,049**	**8,833**

PROFEPA, the agency responsible for enforcing SEMARNAT's environmental regulations under the LGEEPA (e.g., surveillance of environmental, wildlife, and marine resource impacts), offers access to annual activity data categorized by state, as well as a bit more detailed information in their annual reports. But similar to CONAPESCA, the data provided by PROFEPA lack context and generally specific details. For example, their 2019 data report a total of 23 inspections related to environmental impacts, and 21 inspections and 2 raids related to wildlife, but it does not provide further information on the nature of these impacts or the specifics of the inspections conducted (PROFEPA,[18] 2019). In 2018, PROFEPA[19] published a news release announcing the closure of two aquaculture farms operating without the required permits (specifically, the SEMARNAT-EIA) in the Marismas Nacionales Biosphere Reserve, a Natural Protected Area. One of the farms was involved in shrimp production on a 20-ha site, while the other was engaged in tilapia production on 8 ha of coastal wetlands. The farm owners faced charges that could result in a federal prison sentence ranging from 2 to 10 years, as well as financial penalties ranging from 300 to 3,000 days of income based on their estimated daily earnings.

While the Mexican government has actively promoted aquaculture development, serious questions have been raised about the enactment and enforcement of environmental regulations meant to govern this rapidly growing industry. For example, the pace of growth has often exceeded the government capacity to regulate for environmental protections (FAO, 2009) (Aguilar-Manjarrez et al., 2017), a sentiment also expressed by industry (pers comm, Soledad Delgadillo, FAO, September 2023) (SEMARNAT, 2012). Others have questioned the effectiveness of the Mexican EIA process (Perevochtchikova and André, 2013) (Mellink and Riojas-López, 2017) as well as the specific geographical usefulness of environmental norms (Ortega-Mejia et al., 2023) (FAO, 2009). Valderrama-Landeros et al. (2017) further point out a lack of synchronization and "even antagonism" between regulation at different levels of government that in some cases make environmental regulation even less effective. This concern was recently conveyed by aquaculture industry stakeholders, by underscoring the presence of a bottleneck in information flow and the lack of communication between governmental entities like CONAGUA, CONAPESCA, INAPESCA, SENASICA, academic institutions, and the aquaculture producers (pers comm, Soledad Delgadillo, FAO, September 2023).

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[18] http://www.profepa.gob.mx/innovaportal/v/7635/1/mx.wap/datos_abiertos.html

[19] https://www.gob.mx/profepa/prensa/clausura-profepa-dos-granjas-acuicolas-en-anp-reserva-de-la-biosfera-marismas-nacionales-nayarit

In a Seafood Watch assessment on shrimp production in Mexico from 2019, one stakeholder raised concerns about persistent corruption and alleged instances of fraudulent EIAs. Another interviewee pointed out that EIAs are frequently authored by private consultants in a manner that appears biased toward favoring aquaculture companies (SFW, 2019). Such anecdotal evidence signals poor regulatory effectiveness from the key governmental entities overseeing the planning (i.e., siting of farms and water-use concessions) and development of the aquaculture sector in the country.

Regarding the aquaculture management units (UMAs) initiative, which aimed to implement an ecosystem-based management approach, concerns have been raised about the lack of clarity surrounding its concept, primary objectives, and operational functionality (Reyes-Delgadillo et al., 2015). While UMAs are a mechanism to manage the development of aquaculture in the country and should be promoted, as stipulated in LGPAS, they are not a requirement. This lack of clarity is further reflected in the absence of any mention of UMAs in the National Program of Fisheries and Aquaculture 2020–2024. Moreover, a thorough investigation conducted within relevant governmental agencies like SADER and CONAPESCA yielded no evidence of UMAs being established in the country, indicating a persistent ambiguity surrounding their implementation. Although UMAs appeared to have great potential related to the siting of recent or new aquaculture development through the national territory, the implementation and regulatory design appear to be ineffective.

Therefore, it is evident Mexico has incorporated an area-based management framework with an aim to maintain ecosystem functionality of potentially affected habitats through farm siting and associated EIA (SEMARNAT, 2012). But there are limitations in the area-based frameworks implementation and the EIA effectiveness at the industry level. These limitations seem to be especially concerning when addressing the food productive sector in general (including the aquaculture sector), because the government capacity to regulate environmental protections is exceeded by the thousands of active food producers in the country (FAO, 2009) (Aguilar-Manjarrez et al., 2017).

Despite these broader industry issues, the company that is the sole producer of striped bass in Mexico has taken steps to comply with regulations, and there is active enforcement of its operations. They submitted an Environmental Impact Assessment (EIA) and obtained approval by SEMARNAT in 2004, along with their registration and water concession permits approved by SAGARPA. The producer has also provided an updated certification from SENASICA (Certificado por el Cumplimiento de las Buenas Prácticas Acuícolas), which involves biannual visits from SENASICA, as well as three to four visits per year from SENASICA's state committee representatives to verify compliance with legal requirements like production permits, biosecurity plans, and environmental monitoring (pers comm, Pacifico Aquaculture representatives, November 2023). Currently, the producer operates within its permitted allotment of total area and number of net pens for the grow-out phase (i.e., net pens of 25 m in diameter), which are enforced by CONAPESCA and actively reviewed annually through SENASICA's visits. For example, the producer operates only 180 ha of the approximately 820 ha granted in their CONAPESCA farm concession permit, with 35 net pens of 25 m in diameter, which is less than half the authorized total net pens with this dimension. In addition, the producer also provided proof of their BAP certification from 2020 to 2024, which involves annual audits conducted by a third-party Conformity Assessment Body that include an inventory of active net pens and a visual assessment of the operational area, and auditors must verify compliance with government farm siting and EIA requirements.

Although regulatory and enforcement agencies like PROFEPA, SEMARNAT, and CONAPESCA are identifiable, contactable, and active, and appear to have resources appropriate to the scale of the aquaculture industry in the northern Mexican region of Baja California, there are significant concerns about the overall effectiveness of the regulatory framework governing the sector. Allegations of corruption, fraudulent Environmental Impact Assessments (EIAs), biased assessments favoring companies, and lack of synchronization between government entities call into question the effectiveness of regulatory implementation. Initiatives like the aquaculture management units (UMAs), meant to adopt ecosystem-based management, appear ineffective because of ambiguity surrounding implementation. These conditions suggest that the enforcement of habitat management measures of the aquaculture industry in Mexico as a whole is limited to moderate. But, given the smaller scope of this assessment, there is evidence of enforcing habitat-related regulations of farm siting, because it is verified through inspections carried out at least annually by BAP and SENASICA's representatives. Therefore, considering the smaller scope of habitat enforcement to just the single producer, the score for Factor 3.2b is 4 out of 5. Combined with the score for Factor 3.2a, the combined Factor 3.2 score for striped bass is 6.40 out of 10.

Conclusions and Final Score

The striped sea bass industry in Mexico has a single producer utilizing 62 grow-out net pens, operating in about 180 ha, which is a small fraction (< 1%) of the bay's total surface area. Situated near Todos Santos Island with depths ranging from 30 to 100 m and a substrate of sand/volcanic rock, the habitat type of the net pens can be classified as nearshore and coastal, considered a high-value habitat. The evidence reviewed emphasizes both the complexity and uncertainty regarding the scale of the impacts and the appropriate level of concern, but the examples cited do not indicate the loss of any critical ecosystem services from the affected habitats. Thus, the habitats are considered to be maintaining functionality with minimal impacts, and the score for Factor 3.1—Habitat conversion and function is 9 out of 10.

The content of habitat management measures is moderate. The company is sited according to ecological principles and environmental considerations. For example, the farm is compliant with all the necessary environmental permits and conducted an Environmental Impact Assessment (EIA) in 2004. But the content (i.e., legislation and regulatory implementation) of the habitat management measures is considered limited, and the BAP certification does not address cumulative impacts or area-based principles. As a result, Factor 3.2a—Content of habitat management measures is considered moderate and the score is 3 out of 5. Enforcement of regulations aimed at protecting habitat is evident, with identifiable and accessible institutions such as PROFEPA taking a complaint-driven approach to enforcement (i.e., imposing penalties). In addition, the industry's sole producer demonstrates compliance with legal requirements, verified through annual inspections by BAP and SENASICA. Consequently, the score for Factor 3.2b—Enforcement of habitat management measures is 4 out of 5. Combined with the score for Factor 3.2a, the Factor 3.2 score for striped bass is 4.80 out of 10. The final score for Criterion 3—Habitat for striped bass is 7.60 out of 10.

Criterion 4: Chemical Use

Impact, unit of sustainability and principle

- *Impact:* The use of chemical treatments can impact non-target organisms and lead to ecological and human health concerns due to the acute or chronic toxicity of chemicals and the development of chemical-resistant organisms.
- *Unit of sustainability:* Non-target organisms in the local or regional environment, presence of pathogens or parasites resistant to treatments.
- *Principle:* Limit the type, frequency of use, total use, or discharge of chemicals to levels representing a low risk of impact to non-target organisms.

Criterion 4 Summary

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

Brief Summary

Although there are no Mexican regulations limiting the volume or frequency of antibiotic use, there are requirements addressing the production and quality control of veterinary treatments (NOM-012-SAG/ZOO-2020), as well as guidelines for the classification and prescription of the active ingredients used in these treatments (NOM-064-ZOO-2000). In addition, the chemical treatments allowed for aquaculture use are clearly defined in the legislation, as well as the handling and transportation of chemicals of agricultural use (including those for aquaculture). The producer also adheres to the company's Best Management Practices for Drug and Chemical Use (BMP), which are aligned with U.S. FDA aquaculture treatment protocols. Most importantly, the producer has maintained low stocking densities and supplemented feed with immunostimulants (i.e., biomos, eucalyptus, and vitamin C), and there have not been any chemical treatments (i.e., antibiotics or pesticides) during the 5 years of operation from 2019 to 2023. Therefore, the available data (which score 7.5 out 10 under the Data criterion) demonstrate a low need for chemical use, and the final score for Criterion 4—Chemical Use is 10 out of 10.

Justification of Rating

The growing scale and intensity of the global aquaculture industry have led to diseases becoming a more prevalent and severe global issue, affecting Mexico as well. This rise in disease incidence globally has prompted an increased use of chemicals, primarily antibiotics and pesticides, aimed at mitigating economic losses resulting from heightened fish mortalities (Velasquez, 2022) (El-Sayed, 2019). This Seafood Watch assessment focuses on antibiotics and pesticides as the dominant veterinary chemicals applied to net pen finfish farming. Although other types of chemicals may be used (e.g., antifoulants and anesthetics), the risk of impact to the surrounding ecosystem is widely acknowledged to be less than that for antibiotics and pesticides. See the Seafood Watch Aquaculture Standard for details on all scoring tables and calculations.

During the first year of striped bass production, from 2015 to the summer of 2016, the striped bass producer did not use any antibiotic or pesticide treatments; however, because of a *Flavobacterium* outbreak in June–July 2016, treatment became necessary for young fish in 19 net pens following their transfer from the hatchery to the grow-out site. Between 2016 and 2018, a variable number of pens were treated with Romet®30, oxytetracycline, and florfenicol for *T. maritimum*, vibriosis (*Vibrio* spp.), and flexibacteriosis (*Flexibacter columnaris*). Throughout this period, it was evident that, on average, fish received fewer than one antibiotic treatment per year. For example, considering the proportion of net pens treated (e.g., 10 out of 33 in 2018) and the limited number of pens receiving more than one treatment (e.g., 2 in 2018), it is clear that fish on average were receiving less than one antibiotic treatment per year.

Notably, 2018 marked the last year when antibiotic treatments were employed. The producer has since maintained low stocking densities (i.e., 10.3 kg/m^3, compared to their allowed maximum stocking density of 20 kg/m^3) in their net pens and supplemented striped bass with immunostimulant feeds containing ingredients such as biomos, eucalyptus, and vitamin C. This strategy has proved effective in eliminating the need for antibiotics as a standard production practice.

The producer's records did not include treatments for external parasites, for which formalin (hatchery only) and hydrogen peroxide[20] have been used. In addition, the producer has provided an updated certification from SENASICA's Dirección General de Inocuidad Agroalimentaria, Acuícola y Pesquera (General Directorate of Agrifood, Aquaculture, and Fisheries Safety), "Certificado por el Cumplimiento de las Buenas Prácticas Acuícolas," which is valid for 2 years. Obtaining this certification requires annual testing of seawater for pesticide residues to ensure compliance with SENASICA's permissible limits. The annual test involves collecting two seawater samples inside the net pens at a depth of 5 m at the producer's grow-out sites, which are then analyzed by a third-party laboratory (Agrolab). The producer furnished laboratory test results, including gas and liquid chromatography for 360 pesticide analytes from 2023, indicating the absence of significant pesticide residues in seawater samples (Informe de resultados de análisis, 2023—provided by Pacifico Aquaculture representative). SENASICA's certification not only confirms compliance with legal requirements and best practice standards regarding pesticide residue levels, but also signals adherence to guidelines related to chemical and veterinary medicine handling, hazard identification, sanitation, hygiene, pest control, waste disposal, cleaning procedures, aquatic health, feed handling, harvest procedures, traceability, and training over the past two years (2021 and 2022).

Moreover, if the company needs to utilize antimicrobial treatments (e.g., antibiotics), they adhere to the company's Best Management Practices for Drug and Chemical Use (BMP). The policy is designed to ensure compliance with the requirements of the United States Federal Drug Administration (FDA), restricting the use of antibiotics in aquaculture to Terramycin® (active ingredient oxytetracycline), florfenicol, and Romet®30 (active ingredients sulfadimethoxine and ormetoprim). Notably, all these antibiotics, except ormetoprim, are classified as highly important for human medicine by the World Health Organization (WHO, 2017). The application of these antibiotics for striped bass must align with FDA "extra-label" guidelines, because the FDA's full approvals for antibiotic use in aquaculture do not encompass the use on striped bass. These guidelines, specified in the Federal Food, Drug, and Cosmetic Act and outlined on the FDA website, mandate prescriptions by veterinarians and meticulous record-keeping (FDA,[21] 2023). Because there has been no apparent antibiotic use in at least five years, the striped bass producer is compliant with BMP's and FDA's drug and chemical use requirements.

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[20] Hydrogen peroxide is considered to rapidly dissociate into environmentally benign by-products upon contact with seawater in the immediate farm area, and its use falls outside the scope of this assessment (Lillicrap et al. 2015).

[21] https://www.fda.gov/animal-veterinary/aquaculture/approved-aquaculture-drugs

Regulatory Measures for Veterinary Medicines

The regulatory framework for veterinary treatments in Mexico consists of various laws and norms, including the "Especificaciones para la regulación de productos para uso o consumo animal" (Specifications for the regulation of products for animal use consumption) (NOM-012-SAG/ZOO-2020[22]). This norm sets forth requirements for the production and quality control of products intended for use and consumption in animals and applies to chemical producers, importers, distributors, and retailers that may pose a zoo-sanitary risk. Another important regulation is the "Lineamientos para la clasificación y prescripción de productos farmacéuticos veterinarios por el nivel de riesgo de sus ingredientes activos" (Guidelines for the classification and prescription of veterinary pharmaceuticals based on the risk level of active ingredients) (NOM-064-ZOO-2000[23]). This norm establishes technical and scientific criteria for the classification, prescription, sale, and use of active ingredients used in the formulation of veterinary pharmaceutical products, taking into account their potential risks to animal and public health. It applies to veterinary pharmaceutical producers, manufacturers, importers, distributors, retailers, and any entity involved in the prescription or application of such substances. In addition, Mexican regulation NOM-005-STPS-1998 stipulates the requirements for the safe and proper handling, transportation, and storage of chemicals.

As of March 22, 2023, SENASICA[24] (Mexico's National Service for Agrifood Health, Safety, and Quality) has registered approximately 9,400 veterinary products for use across terrestrial and aquatic species in Mexico. Of these, 359 products are authorized specifically for aquatic species, with 10 products explicitly approved for use in finfish aquaculture (pers comm, SENASICA representatives, August 2024). These authorized products include four antibiotics (oxytetracycline, florfenicol, enrofloxacin, and the sulfadimethoxine-ormetoprim mix), one antiparasitic treatment (ethylenediamine dihydroiodide), four vaccines (for *Streptococcus*), and at least one hormone (17-α-methyl testosterone for sex reversal in fry) (pers comm, SENASICA representatives, May 2022) (SENASICA, 2023) (SENASICA, 2008). SENASICA issues a Certificate of Aquaculture and Fisheries Welfare for the Use and Application of Antibiotics (CSAUA) for each of the authorized chemicals. These certificates specify the correct doses for producers to use. The pharmaceuticals mentioned previously align with those listed by the FDA, except for enrofloxacin, which is classified as a critically important antibiotic for human medicine by the World Health Organization (WHO, 2019).

SENASICA manages aquaculture health through state-level Aquaculture Health Committees. Aquaculture Health Committees seek to ensure compliance with national and international standards, provide diagnostic services and disease response oversight, and offer farmer education and training in antibiotics usage, along with promoting best practices—including using antibiotics as a last resort (COSAES[25]; CESASIN[26]; CESAJ [27]; CESANAY[28]; accessed May 2023; 2014b, 2019a). It is also worth highlighting that most of these Health Committees often do not have veterinary professionals among

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[22] https://www.dof.gob.mx/nota_detalle.php?codigo=5707676&fecha=06/11/2023#gsc.tab=0

[23] https://www.gob.mx/cms/uploads/attachment/file/203504/NOM-064-ZOO-2000_270103.pdf

[24] https://www.gob.mx/senasica/documentos/productos-registrados-autorizados-regulacion-de-productos-veterinarios?state=draft

[25] https://www.cosaes.org/nosotros

[26] https://cesasin.mx/conocenos/

[27] https://osiap.org.mx/senasica/sector-estado/jalisco/Acuicola

[28] https://cesanay.org/cesanay/nosotros/

their staff, and they show deficiencies related to job security and technical-scientific training (Ortega-Mejia et al., 2023).

In terms of pesticide regulation, SEMARNAT has included an initiative in the Sector Program of Environmental and Natural Resources 2020–2024 to evaluate the contribution of pesticides to water pollution. But this program lacks specific actions to oversee and reduce pesticide use across industries (OECD, 2021). Similarly, the Sector Program of Human Health 2020–2024 does not establish priorities for the assessment of pesticides and their effects on human health (OECD, 2021). Nevertheless, it is noteworthy that Mexico is among the few countries, including Denmark, France, Italy, Norway, and Sweden, that have implemented tax measures to reduce pesticide usage. The Federal Administration for Taxes (SAT) is responsible for implementing these taxes on pesticide users, based on the pesticide categories established in NOM-232-SSA1-2009. This norm not only categorizes pesticides according to their toxicity level in case of ingestion, but also sets requirements for the packaging and labeling of pesticides used in various industries. But it is worth noting that no evidence was found indicating regulations in Mexico that restrict the volume or frequency of antibiotics or other veterinary treatments used in aquaculture.

Conclusion and Final Score

Although there are no Mexican regulations limiting the volume or frequency of antibiotic use, there are requirements addressing the production and quality control of veterinary treatments (NOM-012-ZOO-1993), as well as guidelines for the classification and prescription of the active ingredients used in these treatments (NOM-064-ZOO-2000). In addition, the chemical treatments allowed for aquaculture use are clearly defined in the legislation, as well as the handling and transportation of chemicals of agricultural use (including those for aquaculture). The producer also adheres to the company's Best Management Practices for Drug and Chemical Use (BMP), which are aligned with U.S. FDA aquaculture treatment protocols. Most importantly, the producer has maintained low stocking densities and supplemented feed with immunostimulants (i.e., biomos, eucalyptus, and vitamin C), and there have not been any chemical treatments (i.e., antibiotics or pesticides) during the 5 years of operation from 2019 to 2023. Therefore, the available data (which score 7.5 out 10 under the Data criterion) demonstrate a low need for chemical use, and the final score for Criterion 4—Chemical Use is 10 out of 10.

Criterion 5: Feed

Impact, unit of sustainability and principle

- *Impact*: Feed consumption, feed type, ingredients used, and the net nutritional gains or losses vary dramatically between farmed species and production systems. Producing feeds and their ingredients has complex global ecological impacts, and the efficiency of conversion can result in net food gains or dramatic net losses of nutrients.
- *Unit of sustainability*: 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

C5 Feed parameters	Value	Score
F5.1a Forage Fish Efficiency Ratio	1.25	
F5.1b Source fishery sustainability score (0–10)		8.00
F5.1: Wild fish use score (0–10)		7.00
F5.2a Protein INPUT (kg/100 kg fish harvested)	115.67	
F5.2b Protein OUTPUT (kg/100 kg fish harvested)	19.55	
F5.2: Net Protein Gain or Loss (%)	–83.10	1.00
F5.3: Species-specific kg CO_2-eq kg^{-1} farmed seafood protein	10.99	7.00
C5 Feed Final Score (0–10)		**5.35**
Critical?	No	**Yellow**

Brief Summary

Specific data on the composition of striped bass were provided by Pacifico Aquaculture based on input from their feed supplier, EWOS (Cargill Animal Nutrition). The available information indicates that fishmeal and fish oil levels are low, and the feed is dominated by land animal and crop ingredients. The averaged feed conversion ratio (eFCRs) was estimated at 2.69. Regarding the use of by-products, the feed manufacturer indicated that no by-products are used for fishmeal, and 100% of their fish oil is sourced from by-products. The Forage Fish Efficiency Ratio (FFER) is estimated at 1.25 and 0.05 for FM and FO, respectively. The Feed Criterion uses the higher 1.25 FFER value to determine the score. This FFER value means that, from first principles, 1.25 MT of wild fish must be caught to supply the fishmeal to grow 1 MT of striped bass. The source fisheries for the marine ingredients used by the feed manufacturer appear to be sustainable (score of 8 out of 10), and the combined (Factor 5.1a and 5.1b) Wild Fish Use score is 7 out of 10. The feed protein content over a production cycle used in this assessment is 43%. With a whole striped bass protein content of 19.55% (and the eFCRs considered in this assessment), there is a substantial net loss of protein of –83.10%, resulting in a score of 1 out of 10. The feed footprint calculated as the embedded climate change impact (kg CO_2-eq) resulted in an estimated kg CO_2-eq per kg of farmed seafood protein of 10.99. This value is equivalent to a score of 7 out of 10. The three scores combine to give a final score for Criterion 5—Feed of 5.35 out of 10 (see the Seafood Watch Aquaculture Standard for details on all scoring tables and calculations).

Justification of Rating

The Feed criterion includes three factors: wild fish use (including the sustainability of the source), net protein gain or loss, and the feed "footprint," which is an approximation of the embedded Climate Change Impact value (CCI) (kg CO_2-eq including land-use change [LUC]) of the feed ingredients required to grow 1 kg of farmed seafood protein. For a full explanation of the calculations, see the Seafood Watch Aquaculture Standard document.[29]

Feed Ingredients and Inclusion Levels

Prior research conducted by Tacon and Metian in 2008 had forecasted advancements in aquaculture feed, specifically anticipating reductions in the reliance on marine ingredients such as fishmeal (FM) and fish oil (FO) in feed formulations over time. This prediction has indeed materialized in the case of Mexico striped bass, with reductions in the utilization of fishmeal and fish oil observed over time. From the last evaluation in 2020 to the current evaluation, inclusion levels for fishmeal decreased from 34% to 10.8% and for fish oil decreased from 14% to 2.4%.

EWOS Canada (Cargill Animal Nutrition) and Pacifico Aquaculture provided comprehensive data on the characteristics of their feeds, disclosed all ingredients employed, and provided the country of origin for most of their ingredients (i.e., FM, FO, soybean meal, peas, dried beans, and sunflower meal). But they did not disclose the country of origin for a few feed components such as land animal ingredients (i.e., poultry meal, porcine meat meal, feather meal, and poultry oil), wheat bran, corn gluten meal, and vitamins/minerals, which combined account for ≈54% of the diet's ingredients. The inclusion levels of these ingredients were also compared with the data available from control diets for hybrid striped bass found in the existing literature (McCann et al., 2021) (Rawles et al., 2013). Therefore, the available feed data (Table 4) are considered to give a reliable representation of the operation, and the data gaps that

Table 4: Average striped bass feed formulation inclusion levels: data sourced from Cargill and Pacifico Aquaculture, along with estimated inclusion levels derived from two academic studies (McCann et al., 2021) (Rawles et al., 2013).

Ingredient	Inclusion %
Fishmeal	10.80
Fish oil	2.40
Porcine meat meal	9.17
Poultry meal	9.17
Feather meal	9.17
Poultry oil	2.70
Soybean meal	15.69
Wheat bran	21.00
Corn gluten meal	3.00
Vegetable oil	2.40
Peas	4.00
Dried beans	4.00
Sunflower meal	5.00
Vitamins/minerals, etc.	1.50
Total	**100.00**

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[29] https://www.seafoodwatch.org/recommendations/our-standards

are present are noncritical, resulting in a in Criterion 1—Data score for the Feed criterion of 7.5 out of 10. These data were employed in the pertinent calculations.

Feed Conversion Ratio

The feed conversion ratio is the ratio of feed given to an animal per weight gained, measured in mass (e.g., FCR of 1.4:1 means that 1.4 kg of feed are required to produce 1 kg of fish). It can be reported as either biological FCR, which is the straightforward comparison of feed given to weight gained, or economic FCR (eFCR), which is the amount of feed given per weight harvested (i.e., accounting for mortalities, escapes, and other losses of otherwise harvestable fish). The eFCR is an important component of this assessment and used in the ensuing calculations. Based on the monthly eFCRs provided by Pacifico Aquaculture for net pen grow-out production cycles from 2023, the estimated eFCR of 2.69 is utilized for calculations that follow.

Factor 5.1—Wild Fish Use

Factor 5.1a—Forage fish efficiency ratio (FFER)

As mentioned, striped bass feed formulations considered for this assessment correspond to 10.8% FM and 2.4% FO (Table 5). For fish oil, the average inclusion level is 2.4%, with all (100%) coming from by-product sources, while FM is derived (100%) from whole fish.

Equation 4, derived from the Seafood Watch Aquaculture Standard—Appendix 3 (single feed scenario), is used to calculate the FM and FO forage fish efficiency ratios ($FFER_{FM}$ and $FFER_{FO}$). The FFER is a measure of the dependency on wild fisheries for feed ingredients, using the ratio of the amount of wild fish used in feeds relative to the harvested farmed fish. Each parameter used in these calculations, as detailed in the following, is also summarized in Table 5. To capture the ecological cost of production

Table 5: Parameters used and their calculated values to determine the use of wild fish in feeding Mexico farmed striped bass.

Parameter	Data (%)
Fishmeal inclusion level (total)	**10.80**
Fishmeal inclusion level from whole fish	10.80
Fishmeal inclusion level from by-product[30]	0.00
Fishmeal yield	23.30[31]
Fish oil inclusion level (total)	**2.40**
Fish oil inclusion level from whole fish	0.00
Fish oil inclusion level from by-product[32]	2.40
Fish oil yield	6.20[30]
Economic Feed Conversion Ratio	**2.69**
FFER fishmeal	1.25
FFER fish oil	0.05
Assessed FFER	**1.25**

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[30] Note that 5% of the by-product fishmeal inclusion (i.e., inclusion level × 0.05) is included in the FFER calculations.

[31] The weighted average of processing yields for FM and FO, from whole fish derived from industrial capture fisheries supplied to EWOS Canada (EWOS representative, 2024).

[32] Note that 5% of the by-product fish oil inclusion (i.e., inclusion level x 0.05) is included in the FFER calculations.

associated with by-products, only 5% of the estimated FM and FO by-products inclusion levels are considered when calculating the FFER and are also noted in Table 5. The eFCR and the FM and FO yield values are also identified in Table 5 and used in Equation 4.

The Feed Criterion considers the FFER from both FM and FO and uses the higher of the two to determine the score. As seen in Table 5, the resulting FFER for FM was higher than the FFER for FO. Therefore, the score for Factor 5.1a—FFER is determined as 1.25. Based on first principles, 1.25 MT of wild fish are required to produce the fishmeal required to grow 1 MT of farmed Mexico striped bass.

Factor 5.1b—Sustainability of the source of wild fish

This factor evaluates the sustainability of the fisheries supplying FM and FO for Mexico striped bass grow-out feed. The species and fisheries provided by Pacifico Aquaculture (from EWOS) for fishmeal consist of Gulf menhaden, Pacific sardine, and Pacific thread herring. For fish oil, they rely on North Pacific hake and Alaskan pollock.

Fishmeal Fishery Sources

Gulf menhaden (*Brevoortia patronus*) is obtained from the Gulf of Mexico using purse seines, and all FishSource scores are ≥ 6, including stock health scores ≥ 9 (FishSource,[33] 2023). According to the Gulf States Marine Fisheries Commission's assessment in 2020, which is an update to the 2018 benchmark for the Gulf of Mexico (SEDAR 63), the Gulf of Mexico menhaden fishery is not likely overfished, nor is overfishing occurring (Schueller, 2021). Although fishery managers have raised concerns about the uncertainty regarding the estimated biomass of Gulf menhaden, they have agreed that the stock is likely not undergoing overfishing and is likely not overfished, mainly because of the following factors: the fishery's historical population structure, its accurate and available catch records, a small fleet, only a few landing ports, relatively stable productivity, almost all fish reach maturity and spawn before fishing season starts, and a relatively consistent relationship between measured effort and catch (suggesting that harvests have been well regulated) (Schueller, 2021) (Vanderkooy and Smith, 2002 and 2015). As a result, Factor 5.1b for Gulf menhaden scores 8 out of 10 for this source fishery (Table 6).

All FishSource scores (e.g., Management Quality: management strategy, managers compliance, fishers compliance, and Stock Health: current health and future health) for Pacific sardine (*Sardinops sagax*) fished in the Gulf of California are ≥ 6, including a stock health score of ≥ 8 (FishSource,[34] 2023). In addition, the fishery has been certified (with conditions) by the Marine Stewardship Council since 2011. Fishing mortality rates remain notably lower than the maximum sustainable yield (MSY) threshold, and it is widely acknowledged that adherence to existing regulations is not a source of concern (Bystrom et al., 2023). The management initiatives aimed at achieving sustainability are evident through the implementation of key measures, including the vessel monitoring system (VMS), as well as the deployment of onboard and port observer programs. It is worth noting that, although MSC reports are accessible online, certain inconsistencies have surfaced in the comparisons between stock assessments, thereby introducing a degree of uncertainty into the assessment process. These discrepancies have primarily emerged as a result of methodological errors, which have, in turn, led to an underestimation of fishing mortality estimates (SCS Global Services Report, 2018). As a result, Factor 5.1b for Pacific sardine scores 8 out of 10 for this source fishery (Table 6).

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[33] https://www.fishsource.org/stock_page/887

[34] https://www.fishsource.org/stock_page/2051

Similarly, all Pacific thread herring (*Opisthonema libertate*) FishSource scores are ≥ 6, including a stock health score ≥ 8. Despite being MSC-certified, this fishery operates within a mixed fishery, and MSC certification has been withdrawn for the species, "Gulf of California, Mexico—thread herring fishery." A recent stock assessment reveals that thread herring populations in the central-northern Gulf of California are not experiencing overexploitation or overfishing. Over recent years, the fishery's management measures have shown significant improvement. These enhancements include the approval of a fishery management plan featuring a harvest control rule (DOF 2012), updates to regulations within the Carta Nacional Pesquera (DOF 2022), and the introduction of regulations to the fishery of small pelagic species in 2019 (SADER 2019). But it is worth noting that management has established only one total allowable catch (TAC), which slightly exceeds the scientifically recommended acceptable biological catch (ABC) (FishSource,[35] 2023). As a result, Factor 5.1b for Pacific thread herring scores 8 out of 10 for this source fishery (Table 6).

Fish Oil Fishery Sources

In the case of North Pacific hake (*Merluccius productus*), FishSource scores for management quality are 10, as well as for stock health. Furthermore, this fishery is certified by the MSC, with no conditions (FishSource,[36] 2023). Recent data indicate favorable stock status and sustainable exploitation. Management practices are robust and precautionary, with consistent quota levels set below the advised thresholds since 2004. High compliance with quotas and other management measures further underline the fishery (Stern-Pirlot et al., 2019). Consequently, Factor 5.1b for North Pacific hake scores 10 out of 10 for this source fishery (Table 6).

Lastly, all Alaskan pollock (*Gadus chalcogramma*) FishSource scores are ≥ 8, and the fishery is MSC-certified. Although the precise stock structure of Alaskan pollock in the North Pacific remains a subject of ongoing study, management and assessment practices treat Eastern Bering Sea pollock as a single stock. These assessments undergo regular scrutiny by experts, with their results and methodologies made accessible to the public. According to current reference points, the stock remains neither overfished nor subject to overfishing (Ianelli et al., 2022). Notably, in terms of setting the TAC, historical evidence demonstrates that managers have diligently maintained TACs at or below the recommended ABC. Compliance measures encompass the presence of onboard observers throughout the fishery, enforcement patrols, extensive port sampling, and penalties for vessels found operating in restricted waters or in violation of fishing regulations. As a result, Factor5.1b for Alaskan pollock scores 10 out of 10 for this source fishery (Table 6).

Table 6: Source fisheries and resulting Factor 5.1b scores.

Common Name (*Genus species*)	**Country/fishing region of origin**	**Gear type**	**Relevant certifications/ratings**	**F5.1b Score**
Gulf menhaden (*Brevoortia patronus*)	Gulf of Mexico	Purse Seine	NA	8
Pacific sardine (*Sardinops sagax*)	Gulf of California	Purse Seine	MSC	8
Pacific thread herring (*Opisthonema libertate*)	Gulf of California	Purse Seine	MSC—Withdrawn	8
North Pacific hake (*Merluccius productus*)	West Coast of United States and Canada	Midwater trawls	MSC	10
Alaskan pollock (*Gadus chalcogramma*)	U.S. Pacific East Bering Sea	Midwater trawls	MSC	10

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[35] https://www.fishsource.org/stock_page/1493

[36] https://www.fishsource.org/stock_page/1942

Upon establishing the sustainability scores for each species utilized in feeds and assuming an even distribution of inclusion levels among the reported species, given that a breakdown of each species inclusion level was not facilitated, a single Factor 5.1b—Sustainability of the source of wild fish score for each marine ingredient was determined. This calculation was conducted using Equation 6 from the Seafood Watch Aquaculture Standard—Appendix 3, and the resulting scores for the source fishery sustainability of each marine ingredient are presented in Table 7.

Table 7: Marine ingredients inclusion levels and sustainability scores for Mexico striped bass.

Marine Ingredient	Inclusion %	Sustainability Score
Fishmeal from whole fish	**10.8**	
Gulf menhaden (*Brevoortia patronus*)	3.6	8
Pacific sardine (*Sardinops sagax*)	3.6	8
Pacific thread herring (*Opisthonema libertate*)	3.6	8
Fish oil from by-product	**2.4**	
North Pacific hake (*Merluccius productus*)	1.2	10
Alaskan pollock (*Gadus chalcogramma*)	1.2	10

Equation 7 from the Seafood Watch Aquaculture Standard—Appendix 3 was employed to calculate the weighted overall sustainability scores for total FM and FO. Subsequently, Equation 8 was utilized to adjust the weighted overall sustainability scores of 8 and 10 for fishmeal and fish oil, respectively; and based on their respective Forage Fish Efficiency Ratios (FFER) calculated in Factor 5.1a ($FFER_{FM}$ = 1.25; $FFER_{FO}$ = 0.05). This is done to accurately attribute the sustainability of source fishery scores with the biomass utilized for striped bass feed. As a result, the Final 5.1b—Sustainability of the source of wild fish score is 8 out of 10. Therefore, the farm's FFER Factor 5.1a score of 1.25 combines with the Factor 5.1b score of 8 out of 10 for a Factor 5.1—Wild Fish Use score of 7 out of 10.

Factor 5.2—Net Protein Gain or Loss

Factor 5.2 measures the net protein efficiency of the fish farming process based on the feed protein inputs and the harvested fish protein outputs. The feed protein content was reported at 43.0% (pers. comm., Pacifico Aquaculture representatives, November 2023). A breakdown of the feed ingredients shows the total protein is supplied by fishmeal, land animal and terrestrial crop ingredients (e.g., wheat, corn). The net protein gain or loss is calculated according to equation 1, and the results for each production system are included in Table 8:

$$\text{Net Protein} = \frac{[\text{Harvested fish protein content \%} - (\text{feed protein content \%} \times \text{eFCR})]}{(\text{feed protein content \%} \times \text{eFCR}) \times 100} \tag{Eq. 1}$$

Regarding the protein output in harvested striped bass, the protein content of a whole harvested farmed striped bass is 19.55% (Karahadian et al., 1995), or 195.5 kg protein per MT of striped bass. By considering the inputs and outputs, the net protein loss can be calculated, and with moderately high feed protein contents and relatively low whole-striped bass protein contents, the loss is substantial.

Table 8: The parameters used and their calculated values to determine the protein gain or loss in the production of farmed Mexico striped bass.

Parameter	Net pens and ponds
Protein content of feed	43%
Economic Feed Conversion Ratio	2.69
Total protein INPUT per ton of farmed striped bass	1,156.7 kg
Protein content of whole harvested striped bass	19.55%
Total protein OUTPUT per ton of farmed striped bass	195.5 kg
Net protein loss	**–83.10%**
Seafood Watch Score (0–10)	1

Considering the eFCR of 2.69 (see Factor 5.1a for details), alongside a whole-striped bass protein content of 19.55% (Karahadian et al., 1995), the net protein loss for Mexico striped bass is –83.10%. This results in a score of 1 out of 10 for Factor 5.2—Net Protein Gain or Loss.

Factor 5.3—Feed Footprint

Factor 5.3—Feed Footprint is an approximation of the embedded Climate Change Impact value (CCI) (kg CO_2-eq including land-use change [LUC]) of the feed ingredients required to grow 1 kg of farmed seafood protein. This calculation is performed by mapping the ingredient composition of a typical feed used against the Global Feed Lifecycle Institute (GFLI) database[37] to estimate the CCI of 1 MT of feed, followed by multiplying this value by the eFCR and the protein content of whole harvested seafood. If an ingredient of unknown origin is found in the GFLI database, an average value between the listed global "GLO" value and worst listed value for that ingredient is applied; this approach is intended to encourage data transparency and provision. But in cases where an ingredient is sourced from a known origin but does not have a direct or closely matched entry in the GFLI database, an average value is calculated based on the closest approximate ingredients available in the database. The detailed calculation methodology can be found in Appendix 4 of the Seafood Watch Aquaculture Standard. Because of the licensing agreement, the specific values for each ingredient from the GFLI database are not reproduced here, but the calculated value per MT of feed for each ingredient is shown.

Table 9 shows the CCI items from the GFLI database selected for each feed ingredient. The selection of items of unknown origins or those with no exact match follows the same methodology and are also included in Table 9. For instance, the origins of the marine ingredient Gulf menhaden, soybean meal, peas, dried beans, and vegetable oil (i.e., rapeseed oil) were known and directly matched with CCI values in the database. But the origin of corn gluten meal was unknown. Therefore, for this ingredient, the average of the global value and the worst listed value were used. For wheat bran, the GFLI database provides CCI values for both wet and dry milling. Because neither the milling process nor the origin was specified by the feed manufacturer, the average between the global value and the worst listed value for both wet and dry milling was considered in the calculations (see Table 9). The origins of all land animal ingredients and vitamins/minerals were also unknown. In these cases, where no global or "worst" CCI values were available in the GFLI database, we used the best available match based on the closest approximate ingredients listed in the database.

For the remaining ingredients, the methodology described in the SFW aquaculture standard did not apply directly. Therefore, the most representative CCI values or averages were chosen, as outlined as

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[37] https://globalfeedlca.org/gfli-database/lcia-download/

follows. For instance, Pacific sardine did not have an exact match in the GFLI database, and the CCI averaged value was calculated based on the available data for European pilchard (sardine) and South American pilchard (sardine). These two "sardine" ingredients were the only options present in the database, thus necessitating the use of their average value to approximate the CCI for Pacific sardine. For Alaskan pollock, the average CCI value was derived from "Fishmeal, at processing/US Economic S" and "Fishmeal, from Alaskan pollock, at processing/NO Economic S," because this last item was the only one available for Alaskan pollock. For Pacific thread herring, where the origin was known but no exact match was available, the closest item, Atlantic herring, was used.

Table 9: Estimated embedded climate change impact of one MT of the Mexico striped bass feed.

Feed Ingredients	Species or Ingredient	Climate Change Impact (incl. LUC) item	Ingredient Inclusion %	kg CO_2-eq/ MT feed
Fishmeal from whole fish	Gulf menhaden (*Brevoortia patronus*)	Fishmeal, from Gulf menhaden, at processing/MX Economic S	3.6	100.56
	Pacific sardine (*Sardinops sagax*)	Fishmeal, from European pilchard (sardine), at processing/NO Economic S	3.6	
		Fishmeal, from South American pilchard (sardine), at processing/US Economic S		
	Pacific thread herring (*Opisthonema libertate*)	Fishmeal, from Atlantic Herring, at processing/NO Economic S	3.6	
Fish oil from by-products	North Pacific hake (*Merluccius productus*)	Fish oil, at processing/US Economic S	1.2	14.89
	Alaskan pollock (*Gadus chalcogramma*)	Fish oil, at processing/US Economic S	1.2	
		Fish oil, from Alaskan pollock, at processing/NO Economic S		
Land animal meals	Porcine meat meal	Animal meal, pig, at processing/RER Economic S	9.17	247.30
	Poultry meal	Animal meal, poultry, at processing/RER Economic S	9.17	
	Feather meal	Feather meal, from dry rendering, at processing/RER Economic S	9.17	
	Poultry oil	Fat from animals, poultry, at processing/RER Economic S	2.7	
Total vegetable meals	Wheat bran	Wheat bran, from dry milling, at processing/GLO Economic S	21	422.46
		Wheat bran, from dry milling, at processing/US Economic S		
		Wheat bran, from wet milling, at processing/GLO Economic S		
		Wheat bran, from wet milling, at processing/BR Economic S		
	Soybean meal	Soybean expeller (pressing), at processing/US Economic S	15.69	
	Corn gluten meal	Maize gluten meal dried, at processing/GLO Economic S	3.0	
		Maize gluten meal dried, at processing/BR Economic S		
	Peas	Peas, dry, dried, at storage/CA Economic S	4.0	
		Peas, dry, dried, at storage/US Economic S		
	Sunflower meal	Sunflower seed meal (solvent), at processing/US Economic S	5.0	
	Dried beans	Beans, dry, dried, at storage/CA Economic S	4.0	
		Beans, dry, dried, at storage/US Economic S		
	Vegetable oil	Crude rapeseed oil (pressing), at processing/CA Economic S	2.4	
		Crude rapeseed oil (pressing), at processing/US Economic S		
		Crude rapeseed oil (solvent), at processing/CA Economic S		
		Crude rapeseed oil (solvent), at processing/US Economic S		
Others	Vitamins/minerals, etc.	Total minerals, additives, vitamins, at plant/RER Economic S	2	13.14
Total			**100%**	**798.35**

Based on the available information, the estimated embedded CCI of 1 MT of Pacifico Aquaculture's feed is 798.35 kg CO_2-eq. Considering a whole harvest striped bass protein content of 19.55%, an eFCR of 2.69, and the total inclusion of all ingredients, the estimated kg CO_2-eq per kg of farmed seafood protein is 10.99, which was calculated using Equation 2:

(Eq. 2)

$$Est.\,kg\ CO2-\frac{eq}{kg}\,of\ farmed\ seafood\ protein=\frac{eFCR}{whole\ harvested\ fish\ protein\ content}\times\left(\frac{Total\ CCI}{mt\ of\ Feed}\times\frac{10}{Total\ ingredient\ inclusion}\right)$$

As a result, the feed footprint of Mexico farmed striped bass is considered low to moderate, hence Factor 5.3—Feed Footprint results in a score of 7 out of 10.

Conclusions and Final Score

Specific data on the composition of striped bass were provided by Pacifico Aquaculture based on input from their feed supplier, EWOS (Cargill Animal Nutrition). The available information indicates that fishmeal and fish oil levels are low, and the feed is dominated by land animal and crop ingredients. The averaged feed conversion ratio (eFCRs) was estimated at 2.69. Regarding the use of by-products, the feed manufacturer indicated that no by-products are used for fishmeal, and 100% of their fish oil is sourced from by-products. The Forage Fish Efficiency Ratio (FFER) is estimated at 1.25 and 0.05 for FM and FO, respectively. The Feed Criterion uses the higher 1.25 FFER value to determine the score. This FFER value means that, from first principles, 1.25 MT of wild fish must be caught to supply the fishmeal to grow 1 MT of striped bass. The source fisheries for the marine ingredients used by the feed manufacturer appear to be sustainable (score of 8 out of 10), and the combined (Factors 5.1a and 5.1b) Wild Fish Use score is 7 out of 10. The feed protein content over a production cycle used in this assessment is 43%. With a whole striped bass protein content of 19.55% (and the eFCRs considered in this assessment), there is a substantial net loss of protein of –83.10%, resulting in a score of 1 out of 10. The feed footprint calculated as the embedded climate change impact (kg CO_2-eq) resulted in an estimated kg CO_2-eq per kg of farmed seafood protein of 10.99. This value is equivalent to a score of 7 out of 10. The three scores combine to give a final score for Criterion 5—Feed of 5.35 out of 10 (see the Seafood Watch Aquaculture Standard for further details on all scoring tables and calculations).

Criterion 6: Escapes

Impact, unit of sustainability and principle

- *Impact:* Competition, genetic loss, predation, habitat damage , spawning disruption, and other impacts on wild fish and ecosystems resulting from the escape of native, non-native and/or genetically distinct fish or other unintended species from aquaculture operations
- *Unit of sustainability:* 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	3	
F6.1 Recapture adjustment	0	
F6.1 Final escape risk score		3
F6.2 Competitive and Genetic Interactions		6
C6 Escape Final Score (0–10)		**4**
Critical?	NO	**YELLOW**

Brief Summary

The final score for Criterion 6—Escapes is a combination of the escape risk and the potential impacts of escapees. The striped bass producer implements multiple escape prevention methods, including strategic farm siting, size grading with appropriate mesh size, and a detailed Environmental Best Management Practices (BMPs) manual, which includes details on the containment management system (CMS) emphasizing net pen design and construction, site maintenance including net management and testing (i.e., periodic diving inspections), moorings and subsurface components, predator control, all fish handling procedures, and escape response and recapture plans. In addition, the CMS includes a Hazard Analysis and Critical Control Point Assessment (HACCP) for the site, and an assessment of the fate and potential impacts of a hypothetical striped bass escape from the site. Although best management practices are in place for escape prevention and no escapes are reported by the industry's single producer, the net pens used are inherently vulnerable to both large-scale and small-scale escape. The annual counting errors estimated from the producer's fish inventory, averaging negative 11.23% over the past 5 years, suggest potential frequent annual trickle losses, although this has not been directly observed. Therefore, an intermediate score is necessary. Considering the open nature of the production system, the implementation of BMPs, and reporting no major escape events, Factor 6.1 would merit a score of 4 out of 10. But the cumulative discrepancies in fish inventory counts (> 5% cumulatively) over the past decade suggest the possibility of frequent trickle losses, warranting a score of 2 out of 10 under the SFW standard. Therefore, a precautionary intermediate score of 3 out of 10 is deemed appropriate for Factor 6.1—Escape Risk.

The establishment of viable populations of nonnative striped bass at Isla Todos Santos is highly unlikely because of unsuitable habitat conditions for reproduction. In addition, the probability of escaped striped bass migrating around 550 miles to San Francisco Bay, the nearest known breeding ground, is deemed low. If such migrations were to happen, the potential impact of farm escapees from Mexico is regarded as low when contrasted with the deliberate stocking of millions of striped bass by the California

Department of Fish and Wildlife (CDFW) into the estuary. While striped bass appears to be present in Mexican waters (i.e., based on anecdotal captures), the absence of monitoring makes it challenging to estimate the population level or the impact on local fish populations; any impact would likely depend on the frequency and number of escaped fish. In addition, post-escape mortality is uncertain but may be significant because of potential predation and fishing activities in the area. Overall, escaped fish may have some impacts on wild species, but the likelihood of striped bass establishing viable populations in the region is highly unlikely. Consequently, the score for Factor 6.2 is 6 out of 10. Factors 6.1 and 6.2 combine to give a final numerical score of 4 out of 10 for Criterion 6—Escapes.

Justification of Rating

Aquaculture-related escapes into wild habitats can be of significant concern, given the potential negative impacts associated with the introduction of species, especially because the majority of aquaculture relies on introduced species. These introductions can lead to issues in wild habitats, such as competition with native species for resources, predation on native species, and hybridization, which can result in the loss of genetic attributes in the native species (Gracida-Juarez, 2020) (Sosa-Villalobos et al., 2016).

Factor 6.1—Escape Risk

In Mexico, striped bass is grown in a floating net pen containment system similar in construction to the system used ubiquitously by the salmon farming industry (see Figure 1 in the Introduction). A significant characteristic of striped bass is the much smaller size of fingerlings (e.g., compared to salmon) at transfer to marine sites; the producer moves fish to the Isla Todos Santos site at < 12 g (compared to approximately 70–150 g for salmon smolts). They are moved into smaller floating enclosures with fine mesh net (i.e., the previously mentioned 8 × 8 × 8 m net pens). When the fish are large enough, these smaller net pens are transported to the grow-out modules (i.e., north and south modules). The main net pen structure is then towed over the smaller net pen, and once the main structure and its net are secured in place, the fish are released into the main net pen (pers comm, Pacifico Aquaculture representatives, October, 2023). Any potential fish escapes at this phase would occur directly into Todos Santos Bay, leading directly into the Pacific Ocean.

But the producer has reported no instances of escapes during the last 5 years of production. In addition, it is reasonable to assume that any significant escape events would have been detected by the producer’s staff divers, because they conduct daily inspections of their grow-out modules, weather permitting. This is further supported by the supplied documentation covering January to September 2023, which confirms the absence of reported escapes during the inspections (pers comm, Pacifico Aquaculture representatives, October, 2023).

There are inherent risks associated with net pens that could potentially lead to fish escapes, some of which may be beyond the producer’s control. For instance, cultivating fish in net pens can attract wild animals because of the availability of food from waste feed and feces, and act as fish aggregating devices (Callier et al., 2018). Some of these wild animals can be large enough predators to be capable of causing tears on the net pens, and consequently fish escapes. According to the daily diving inspections conducted by the producer’s personnel, there were a total of 188 predator interactions and 119 collective hours of sea lions attempting to breach the net pens in 2023. Sea lions were able to breach the predator protection mesh and enter the net pen containing the fish during 6.5% of the 92 inspections reported for 2023, resulting in a 23% mortality rate reported for the year (pers comm, Pacifico Aquaculture representatives, October 2023). To reduce predator-related mortalities, the producer began adding additional buoys around the predator protection mesh to pull it farther away from the main net pen. This new measure was implemented in 2023, with initial observations indicating promising results (pers comm, Pacifico Aquaculture representatives, July 2024). In addition, during the diving inspections, any tears in the nets resulting from predator breaches would be promptly repaired and recorded, according to the farm's operations manual.

Given the offshore location of the site, waves pose a substantial risk for escapes, underscoring the critical importance of the protection that the islands provide to the site. The net pens are strategically positioned along the eastern coast of the southern island (see Figure 2 in the Introduction). This location, as previously explained, offers a well-protected environment within Todos Santos Bay, with exposure to winter waves not exceeding 2.5 m. Furthermore, the original environmental impact assessment for the site (Bajamachi, 2004) describes the exposure characteristics: tides are moderate, with a maximum recorded tidal height of 1.5 m, and while the exposed side of the island experiences wave heights up to 10 m (and boasts a big-wave surfing location known as Killers), the sheltered lee (eastern) side is protected. Wave heights in the larger Todos Santos Bay, between the islands and the mainland at Ensenada, range from 0.2 m in the summer to 2.4 m in the winter, with 50- and 100-year wave heights calculated to be in the range 3.4–3.8 m. It is important to emphasize that, in February 1983, unprecedented weather conditions (storms) occurred, leading to waves reaching heights between 6 and 7 m with periods of 20 to 25 seconds in deep waters. In January 1988, wave heights in deep waters even reached up to 10 m, with periods ranging between 15 and 20 seconds (Seymour, 1989). These heights have a return period exceeding 200 years, indicating that a storm of this magnitude is expected to recur at intervals of no less than 100 to 200 years (Acuario Oceanico, 2015). For the island area, waves predominantly approach from the west, typically with a height of 2.0 to 2.5 m and maximums reaching 3 m. Following this, waves from the southwest with heights of 1.5 to 2.0 m are the next most common. Waves from the northwest are the least frequent, ranging from 0.3 to 1 m in height (Acuario Oceanico, 2015).

In the North Pacific region, severe storm events commonly occur in the winter months. Significant occurrences of extreme weather have been noted in the years 1977/78, 1980/81, 1982/83, and 1998/99. The event in 1998/99, linked to the El Niño–Southern Oscillation (ENSO), was particularly devastating. Between 1975 and 1985, a series of storms transpired, with the winter of 1977 and 1978 characterized by enduring storms featuring waves of substantial energy (Acuario Oceanico, 2015).

While the majority of hurricanes and tropical storms that affect Mexico's Pacific coast typically make landfall to the south of the country, it is noteworthy that northern Baja California, encompassing Todos Santos Bay, is not entirely immune to potential impacts from these weather events. Historical records dating to 1948 reveal that four hurricanes, classified as Category 1 (the lowest wind speed category for hurricanes), and six tropical storms have affected northern Baja California. This includes the two most recent hurricanes, initially reaching Category 4 strength in the southern Pacific coast of Mexico but subsequently weakening to tropical storm status upon reaching the northern region of the Baja Peninsula (Masters and Henson,[38] 2023) (Juvera,[39] 2022) (Anonymous, 2016).

Pacifico Aquaculture provided their Environmental Best Management Practices manual, which includes details on the containment management system (CMS), and evidence of these measures was seen for all

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[38] https://yaleclimateconnections.org/2023/08/californias-first-tropical-storm-watch-on-record-as-hurricane-hilary-heads-for-baja/

[39] https://www.lavozdelafrontera.com.mx/local/estos-son-los-huracanes-que-han-tocado-el-norte-de-bc-8858659.html

sizes of fish present during the site visit in 2016 (performed during the elaboration of the last SFW report for striped bass). The manual includes sections on net pen design and construction, site maintenance including net management and testing, moorings and subsurface components, predator control, all fish handling procedures, and escape response and recapture plans. The CMS includes a Hazard Analysis and Critical Control Point Assessment (HACCP) for the site, and an assessment of the fate and potential impacts of a hypothetical striped bass escape from the site.

While official reports (e.g., CONAPESCA, 2023) indicate no captures of striped bass in local commercial or recreational fisheries, the producer indicates that there have been a few anecdotal reports of striped bass being caught in or near Todos Santos Bay during the past 5 years; however, the origin of these fish remains unknown (pers comm, Pacifico Aquaculture representatives, November 2023). Furthermore, captures by recreational anglers in the United States are often shared on social media platforms and blogs, but no local information regarding striped bass captures was identified in the Ensenada, Mexico area. Likewise, a search on a publicly available citizen science database (i.e., iNaturalist[40]) yielded only a single reported striped bass (*Morone saxatilis*) in Massachusetts, which aligns with its natural distribution along the East Coast of the United States.[41] Notably, no iNaturalist reports for striped bass in Mexico were available.

Despite the escape management measures in place, net pen systems are considered to be inherently vulnerable to escapes (as is well-documented in the salmon farming industry), primarily because of weather, human error of various forms, or damage by predators (e.g., net damage by seals). Although a secondary net is in place as a predator deterrent, the mesh size is too large to act as a secondary containment for any escapes from the main fish containment nets.

Because of technological limitations in the counting process throughout the production stages, achieving an accurate escape inventory is typically unattainable. For instance, during the sorting of fish in net pens based on size, the producer employs Faivre counters for fish weighing up to 100 g. Manual counting is employed for mortalities of fish weighing around 100 g, and for fish with an average weight of less than 100 g, a combination of manual counting and weighing is utilized. Harvest procedures also involve manual fish counts (pers comm, Pacifico Aquaculture representatives, November 2023). The reported counting error by the producer ranges from 1% to 5%—a significant margin, considering that the net pens are stocked with millions of fish. Examining the producer's annual fish-count differences for the past 5 years reveals discrepancies in fish counts greater than the estimated 1% to 5% counting error range (Table 10). The annual percentage of discrepancies, when comparing the final count of fish in the net pens to the discrepancies reported by the producer, shows an overall average of negative 11.23%. From 2019 to 2023, over 3 million fish remain unaccounted for by the producer. But it is unclear whether these discrepancies are because of fish escaping through trickle loss or if the counting error is larger than previously estimated.

Nevertheless, research on similar facilities, particularly net pens used for salmon, suggests the possibility that fish, such as striped bass, can escape undetected by the farm, thus going unreported. Consequently, the actual number of escapes may be substantial, even if there are no escapes reported by the producer (Glover et al., 2017) (Skilbrei et al., 2015).

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[40] https://www.gbif.org/occurrence/map?country=MX&country=US&issue=CONTINENT_DERIVED_FROM_COORDINATES&taxon_key=2394615&occurrence_status=present

[41] https://www.fishbase.se/summary/Morone-saxatilis.html

Table 10: Striped bass inventory discrepancies for the past 5 years of production. (Data provided by Pacifico Aquaculture, July 2024.)

Year	Annual Final Fish Count in Net Pens (# Fish)	Annual Inventory Discrepancies (# Fish)	Annual Percentage of Inventory Discrepancies
2019	5,906,446	–348,044	–5.89
2020	4,805,751	–812,345	–16.90
2021	5,483,763	–1,844,682	–33.64
2022	4,761,689	82,838	1.74
2023	7,711,131	–111,649	–1.45
Total/Average	**28,668,780**	**–3,033,883**	**–11.23 (Average)**

The escape mitigation measures applied by the striped bass producer, such as a containment management system in place according to BMP guidelines and periodic diving net pen inspections, demonstrate best management practices in design, construction, and operation of the production system. In addition, documentation provided signals that there have been no serious physical issues with the nets (e.g., tears) that could result in large numbers of escaped fish in the past 5 years. But there is a notable risk associated with counting errors estimated from the producer’s fish counts, averaging –11.23% over the past 5 years, suggesting the potential of frequent annual trickle losses, although this has not been directly observed. Considering the open nature of the production system, implementing BMPs, and reporting no major escape events, Factor 6.1 would merit a score of 4 out of 10. Nevertheless, the cumulative discrepancies in fish inventory counts (> 5% cumulatively) over the past decade suggest the possibility of frequent trickle losses, warranting a score of 2 out of 10 under the SFW standard. Therefore, a precautionary intermediate score of 3 out of 10 is deemed appropriate for Factor 6.1—Escape Risk.

Escape response measures in the CMS and the presence of an active commercial and sport fishery in the Ensenada region indicate that recaptures at the site and immediately beyond it may be significant; however, with no reported escapes, there is no evidence with which to specify an appropriate adjustment for recaptures. Therefore, the final score for Factor 6.1 is 3 out of 10.

Factor 6.2—Competitive and Genetic Interactions

CONABIO (2017) classifies striped bass as highly invasive, citing its aggressive competition and predation characteristics and its high risk of establishment. But this classification is based on a literature review rather than a dedicated invasiveness study in the specific region where the striped bass producer operates. It is important to note that the literature review draws primarily from studies conducted on the U.S. East Coast, certain locations in California (i.e., Colorado River and along the U.S. West Coast), and invasiveness studies of freshwater bodies in Baja California. These studies observe invasive behaviors in environments with significant deltas conducive to species establishment. In addition, CONABIO considers striped bass an exotic species present in Mexico exclusively in freshwater bodies, such as the water reservoirs (i.e., Falcon Internacional, Tamaulipas; and Venustiano Carranza, Coahuila), rivers (i.e., Rio Colorado and Rio Grande), and an agricultural water channel (Cerro Prieto, Baja California). But this is determined by CONABIO based on dated reports and not on current studies (i.e., Arredondo-Figueroa, 1983; Barges, 1980; Ruiz-Campos et al., 2012). The agricultural channel, where the presence of striped bass in Baja California was reported, is close to Mexicali, about 150 km inland from Todos Santos Bay and without possible water connection to Todos Santos Bay (Ruizcampos et al., 2012).

Also, its presence in this channel is associated with intentional transplantation of the striped bass in waters of the lower Rio Colorado of California (USA), which occurred in 1959 (Ruizcampos et al., 2012).

Conversely, the environmental conditions at the producer's location in Mexico do not support the reproductive requirements for this species' establishment. Reports of striped bass captures in the Todos Santos Bay region and along the coast of Baja California are sporadic and lack continuous documentation, indicating a failure to establish a sustainable population in this region (CONABIO, 2017) (Ruizcampos et al., 2012 and 2014).

Striped bass, originally introduced to the Pacific coast of the Americas from the U.S. East Coast in 1879 and 1882, has not been reported as stocked in Mexican waters. But considering its historical presence in California and the proximity of its production in Todos Santos Bay in Ensenada, Mexico to the California border, there is potential for interaction between escaped individuals from Mexican operations and established populations in California. By 1900, there was a substantial fishery of over 1 million lb (454 MT) annually in the San Francisco area, peaking at over 2 million lb (> 900 MT) in 1903, according to the California Department of Fish and Game (CDFG, 2016).

The population continued to thrive through the 1960s but has faced major declines more recently (Ostrach et al., 2008); the first significant decline occurred in the 1970s, followed by additional declines in the mid-1980s and mid-1990s. As part of conservation plans for striped bass, California Department of Fish and Game (CDFG) began a hatchery program for supplemental stocking in 1981, with the number of fish stocked increasing from about 63,000 in 1980 to almost 3.4 million in 1990 (CDFG, 2001). All stocking was suspended in 1992 because of concern over potential predation by striped bass on threatened and endangered species (such as Sacramento River winter-run Chinook salmon and Sacramento Delta smelt), but was resumed as part of a Striped Bass Management Conservation Plan designed to maintain the striped bass population and sport fishery and to be consistent with recovery of other listed species (CDFG, 2001). This stocking stopped in 2000, and there has been no stocking since then (pers comm, Marty Gingras, California Department of Fish and Wildlife, May 2016). The likelihood of additional striped bass stocking in California is minimal, given a recent study that revealed that a significant portion of striped bass prey consists of native species. This finding poses a challenge to federal and state laws and policies, particularly the federal and California Endangered Species Acts (Brandl et al., 2021) (Weiland, 2022[42]).

According to the reviewed literature and data described in the following sections, if an escape event were to occur at Pacifico Aquaculture, the potential impacts of nonnative striped bass appear to be governed by three key aspects:

1. The potential for the species to establish new populations in the escape area or elsewhere.
2. Potential migration and potential impact (i.e., predation) to the nearest suitable breeding area (San Francisco Bay).
3. Direct predation by striped bass on fish and other marine life.

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[42] https://calwatercenter.org/petition-aimed-at-protecting-non-native-striped-bass-will-only-worsen-the-plight-of-californias-imperiled-native-fishes/

These three aspects are reviewed as follows:

1. Potential population establishment in the escape area or elsewhere

In addition to the San Francisco area, striped bass has been introduced into many other places on the Pacific coast, including the lower Colorado River, several reservoirs, and the Pacific Ocean in southern California (CDFG, 2001). Although the primary California population of striped bass is in the San Francisco Bay estuary, the species has been documented up and down the Pacific coast from 40 km south of the California/Mexico border to British Columbia (Stevens, 1980); however, at this southern limit, the numbers of fish reported are quite small. For example, two individuals were caught at Redondo Beach in 1894 (Stevens, 1980), three at La Jolla in 1931 (CDFG, 1931), and a single fish 25 km south of the California border in Mexico in 1959 (CDFG, 1961). More recent anecdotal angling reports show that individuals are occasionally caught in southern California (e.g., one each in the San Diego area in 2014 and 2017,[43] and one in the Los Angeles area in 2013[44]). There is also an anecdotal mention of an "unusual invasion of southern California beaches by stripers in the warm-water year of 1998"[45] (which was well before any striped bass aquaculture facility was established in Mexico). In a recent review of striped bass along the California coast, the last four reported recreational catches in southern California occurred in 2005, 2011, 2012, and 2017 in Newport Bay, Mission Bay, Alamitos Bay, and San Diego Bay, respectively (Boughton, 2020). As mentioned, there have been no reports of striped bass sightings or captures in Mexico, according to the citizen science database iNaturalist, nor could any records of captured striped bass in Mexico be found online.

Relevant to the industry's operation in Ensenada (80 mi south of the California border and approximately 550 mi south of San Francisco Bay), CDFW (2016) shows that the only striped bass fisheries of consequence have remained within the San Francisco Delta, with occasional fish caught up to 90 mi to the south. Raddovich et al. (1961) concluded that striped bass did not establish off southern California or northern Baja California because there was insufficient freshwater in which to spawn, and CDFG (2001) concluded that conditions are generally not suitable for striped bass spawning in marine waters off southern California. Therefore, the establishment of new populations south of San Francisco by escaping fish from the striped bass producer in Todos Santos Bay, Ensenada, Mexico is considered highly unlikely, if not impossible. This conclusion is considered reasonable by the California Department of Fish and Wildlife's West Coast striped bass expert (pers comm, Marty Gingras, May 2016). Ultimately, the failed historic attempts to stock striped bass in locations throughout California—except for the discrete San Francisco Bay population—demonstrate that the likelihood of striped bass escapees establishing new populations in the greater Ensenada area of northern Baja California or beyond is low.

2. Potential migration and potential impact (i.e., predation) to the nearest suitable breeding area (San Francisco Bay)

On the East Coast of the United States in the native habitat of striped bass, recent research has shown that large fish (> 90 cm total length) can migrate more than 600 miles from their natal rivers on annual migrations (Callihan et al., 2015); these large fish can travel 36 mi per day. Considering the hatchery- and farm-raised nature of the farmed fish in Mexico, their smaller (pre-sexual maturity) size, and their lack of a natal river, it seems unlikely—but not impossible—that significant numbers of escapees would make the migration of 550 mi from the Todos Santos site in Baja California north to San Francisco Bay—the nearest site where reproduction with wild (though still nonnative) stocks would be possible.

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[43] SD Fish—San Diego fishing forum. September 10, 2017.

[44] www.stripersonline.com, April 12, 2013.

[45] http://kenjonesfishing.com/2016/09/striped-bass/

In the scenario that escaped fish from Mexico did migrate to San Francisco Bay, striped bass is known to prey on a number of species in the Sacramento Delta, including some that are listed under the Endangered Species Act (e.g., spring-run Chinook, Central Valley steelhead, Delta smelt, Sacramento splittail). For instance, Brandl et al. (2021) reported that native prey composed 60% of the detections in striped bass gut contents, based on a study carried in the northern Sacramento–San Joaquin Delta. In addition, the variety of species detected in striped bass gut (total of 13 species) suggests that striped bass is not highly selective in its prey, and it has been shown to exhibit considerable trophic adaptability (Brandl et al., 2021). Similarly, Sabala et al. (2015) estimated the mortality of emigrating juvenile Chinook salmon in a "predation hotspot" to be 8–29% per year because of striped bass. In contrast, in research conducted by California DFG, the anticipated predation by the current striped bass population was low (steelhead: 0.8% of the population; Chinook: 1.1%; Delta smelt: 0.9%; splittail: 0.9%), and insignificant or negligible regarding population levels of the preyed-upon species (CDFG, 1999). In addition, Nobriga et al. (2013) reported a growing concern that predation by juvenile striped bass (ages 1–3) may negatively affect the population dynamics of Delta smelt, but they found no evidence for a correlation between juvenile striped bass abundance and Delta smelt survival.

The factors that facilitated the establishment of striped bass populations in the San Francisco Bay in the late 1800s seem to be changing, as evidenced by the persistent low numbers of juvenile fish since the early 2000s (Figure 18). A noticeable decline in these numbers is particularly evident after the last significant fish stocking in the region in 1990 (Weiland, 2022). More importantly, the potential impact of farm escapees arriving from Mexico is considered to be low compared to the historical active stocking of millions of striped bass, deliberately released into the estuary by the CDFG/CDFW. This conclusion is considered reasonable by the California Department of Fish and Wildlife's West Coast striped bass expert (pers comm, Marty Gingras, May 2016).

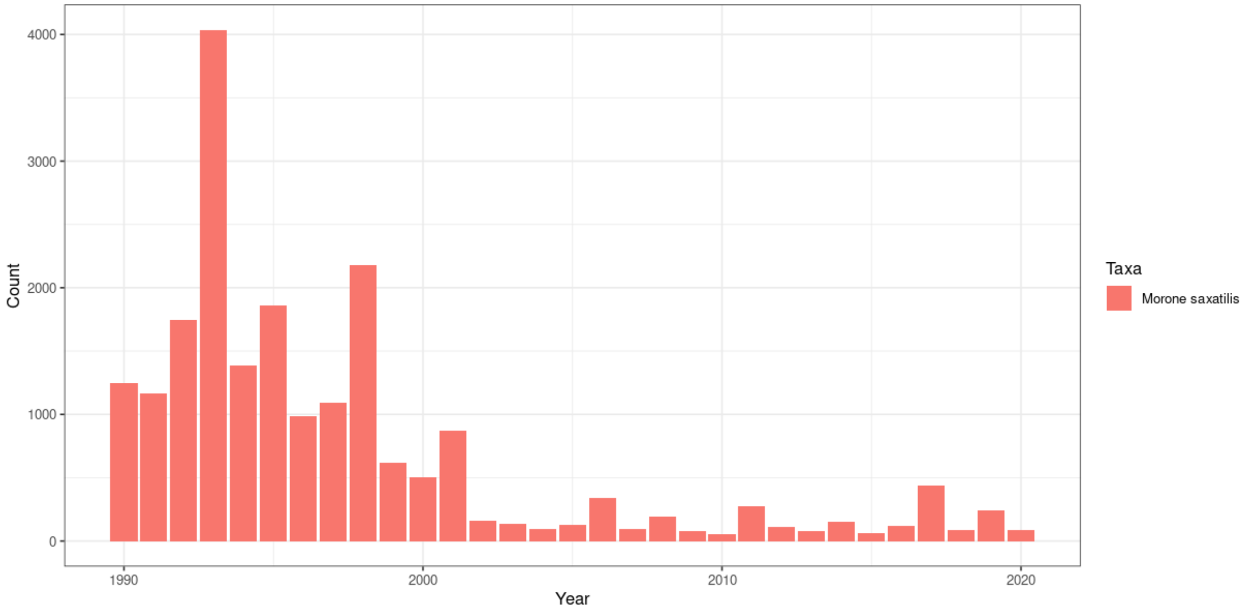

Figure 18: Number of juvenile striped bass in the San Francisco Bay from 1990 to 2020, showing the marked decline in abundance. (Obtained from Delta fish database,[46] accessed in January 2023.)

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[46] https://deltascience.shinyapps.io/deltafish/

3. Direct predation by striped bass on species

Loboschefsky et al. (2013) showed that wild striped bass, in the second and third year, switch to a dominant diet of fish. In the United States, it has been observed that once this species becomes established, it tends to outcompete and prey on other species, leading to their displacement (CONABIO, 2017). Therefore, escaping striped bass would likely be active piscivores; however, it is uncertain how a hatchery- and farm-raised striped bass, accustomed to a constant diet of pelleted feeds, would behave following a potential escape. Although some well-studied species, such as farmed Atlantic salmon, have been shown to have low success at feeding on live prey (i.e., hunting) after escape (e.g., Arismendi, 2012), Atlantic salmon has also been shown to be an unsuccessful colonizer in general—unlike striped bass in the San Francisco Bay. The escape inspections conducted at the farm in 2023 revealed the presence of 188 sea lions in the farm's vicinity (pers comm, Pacifico Aquaculture representatives, November 2023). These predators would be expected to have an immediate impact on escape numbers via predation, but the scale is unknown. Given the offshore location of the site, it is also likely that some escapees would disperse into open waters around the islands, and given the inability of striped bass to reproduce in the region, any predatory impacts on native local fauna by escapees would be considered temporary as the fish disperse. But the lack of comprehensive studies confirming the survival rates of escaped striped bass in natural environments, as well as their potential dispersal, adds to the uncertainty surrounding this matter.

In addition, there are active sports and commercial fisheries in the Ensenada area that would likely reduce escape numbers to some extent. It must also be noted that, despite the known predation of striped bass on endangered species in the San Francisco Bay and Delta, these impacts were considered appropriately managed during a period of intense stocking of millions of hatchery-raised striped bass. Therefore, while some predation on local wild fish populations is possible, if not likely, following a large escape event, population-level impacts to native species are considered unlikely. This conclusion is also considered reasonable by the California Department of Fish and Wildlife's West Coast striped bass expert (pers comm, Marty Gingras, May 2016).

Overall, the establishment of viable populations of the nonnative striped bass species at Isla Todos Santos is considered highly unlikely. This is primarily because of the unsuitability of the escape location, which lacks suitable habitat conditions, such as insufficient freshwater from deltas, that are necessary for the species' reproduction. In addition, the likelihood of escaped striped bass migrating approximately 550 mi to the closest known breeding ground, San Francisco Bay, is considered low. Even if such migrations were to occur, the potential impact of farm escapees from Mexico is considered minimal compared to the historical deliberate stocking of millions of striped bass by the CDFW into the estuary. While striped bass appear to be present in Mexican waters (i.e., based on anecdotal captures), potentially as a result of undetected escapes, there is no monitoring in place to estimate their population levels or the extent of striped bass predation on local fish populations. Any impact would likely depend on the frequency and number of escaped fish. In addition, the post-escape mortality of these fish is uncertain but may be significant because of potential predation by sea lion colonies and active fishing activities in the area. Collectively, these factors suggest that, while escaped fish may have some impact on wild species through direct predation or competition for food resources, it is highly unlikely for striped bass to establish viable populations in the region. Therefore, the score for Factor 6.2 is 6 out of 10.

Conclusions and Final Score

The final score for Criterion 6—Escapes is a combination of the escape risk and the potential impacts of escapees. The striped bass producer implements multiple escape prevention methods including strategic farm siting, size grading with appropriate mesh size, and a detailed Environmental Best Management Practices (BMPs) manual, which includes details on the containment management system (CMS) emphasizing net pen design and construction, site maintenance including net management and testing (i.e., periodic diving inspections), moorings and subsurface components, predator control, all fish handling procedures, and escape response and recapture plans. In addition, the CMS includes a Hazard Analysis and Critical Control Point Assessment (HACCP) for the site, and an assessment of the fate and potential impacts of a hypothetical striped bass escape from the site. Although best management practices are in place for escape prevention and no escapes are reported by the industry's single producer, the net pens used are inherently vulnerable to both large-scale and small-scale escape. The annual counting errors estimated from the producer's fish inventory, averaging negative 11.23% over the past 5 years, suggest potential frequent annual trickle losses, although this has not been directly observed. Therefore, an intermediate score is necessary. Considering the open nature of the production system, the implementation of BMPs, and reporting no major escape events, Factor 6.1 would merit a score of 4 out of 10. But the cumulative discrepancies in fish inventory counts (> 5% cumulatively) over the past decade suggest the possibility of frequent trickle losses, warranting a score of 2 out of 10 under the SFW standard. Therefore, a precautionary intermediate score of 3 out of 10 is deemed appropriate for Factor 6.1—Escape Risk.

The establishment of viable populations of nonnative striped bass at Isla Todos Santos is highly unlikely because of unsuitable habitat conditions for reproduction. In addition, the probability of escaped striped bass migrating around 550 mi to San Francisco Bay, the nearest known breeding ground, is deemed low. If such migrations were to happen, the potential impact of farm escapees from Mexico is regarded as low when contrasted with the deliberate stocking of millions of striped bass by the California Department of Fish and Wildlife (CDFW) into the estuary. While striped bass appear to be present in Mexican waters (i.e., based on anecdotal captures), the absence of monitoring makes it challenging to estimate their population level or their impact on local fish populations; any impact would likely depend on the frequency and number of escaped fish. In addition, post-escape mortality is uncertain but may be significant because of potential predation and fishing activities in the area. Overall, escaped fish may have some impact on wild species, but the likelihood of striped bass establishing viable populations in the region is highly unlikely. Consequently, the score for Factor 6.2 is 6 out of 10. Factors 6.1 and 6.2 combine to give a final numerical score of 4 out of 10 for Criterion 6—Escapes.

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
- *Unit of sustainability:* 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

Despite being recognized as a disease-resistant cultured species, striped bass is susceptible to various infectious and noninfectious diseases. Primary diseases affecting cultured striped bass in the Americas include gram-negative and gram-positive bacteria, fungi, and parasites. Although numerous studies have delved into diseases affecting cultured striped bass, information regarding their impact on wild populations remains scarce. Net pens, deemed “open” to the environment, pose a potential risk of pathogen amplification and subsequent release into waters shared with wild fish. The implementation of biosecurity measures (i.e., Veterinary Plan for Sanitation and Animal Welfare and the Biosecurity Plan) and best practices by the producer, verified through third-party certification (Best Aquaculture Practices), is evident. Despite these efforts, it appears that various bacterial pathogens like *Tenacibaculum maritimum* and *Vibrio* spp., along with parasites such as *Trichodina* sp., persist in affecting the cultured striped bass, resulting in heightened mortalities, especially during vulnerable stages like the transfer of fingerlings from the hatchery to the marine net pens. As a result, the risk of potential pathogen transmission from the cultured striped bass to wild fish in the surrounding area persists. Limited data, especially on the potential impacts on wild fish, prompt the use of a risk-based assessment (Data criterion score for the Disease section < 7.5 out of 10). Considering the potential pathogen and parasitic transfer risk to wild species, the openness of production systems, the prevalence of parasites, and the documented disease-related mortalities of the grow-out net pens across various cohorts (i.e., an average disease-related mortality rate of 37.43% out of the total reported mortality of 8.94% for the calendar year 2023), as well as the company’s documented implementation of biosecurity protocols, the final score for Criterion 7—Disease is 4 out of 10.

Justification of Rating

The amplification of pathogens on fish farms and their potential retransmission to wild fish is of primary concern for ecological impact. Although farmed fish are commonly infected by environmental pathogens, they can also be vectors of pathogen discharge into the marine environment before any disease-related mortality (e.g., Shea et al., 2020).

Although useful farm-level data on parasites and pathogens were provided for the industry under scope, there are no data with which to robustly understand the impact of on-farm diseases to wild fish in the area. As a result, the Data score for Disease is 5 out of 10 (in Criterion 1—Data); therefore, the Risk-Based Assessment option in the Seafood Watch Aquaculture Standard was used.

Striped bass in good health typically possess resistance against various viral, bacterial, fungal, and parasitic pathogens. But their susceptibility to disease agents increases when they experience immunocompromised conditions because of stress (Smith, 2020). The diseases of particular concern for cultured striped bass include:

- Gram-negative bacteria: *Aeromonas* sp., *Edwarsiella tarda*, *Pseudomonas* sp., and *Vibrio* sp. (pers comm, Pacifico Aquaculture representatives, November 2023) (Smith, 2020) (Lemus, n.d.).
- Gram-positive bacteria: *Streptococcus* sp., *Mycobacterium* sp., *Tenacibaculm maritimum* (*Flexibactyer maritimus*), *Flavobacterium columnaris*, and *Staphylococcus* sp. (pers comm, Pacifico Aquaculture representatives, November 2023) (Smith, 2020) (Lemus, n.d.).
- Fungi: *Saprolegnias*, *Aphanomyces*, and *Branchiomyces* sp. (Smith, 2020).
- Parasites: *Trichodines* (i.e., *Trichodina*, *Trichodinella*, and *Tripartiella*), *Benedenia* sp., *Cymothoa* sp., *Ichthyobodo necator*, *Epistylis* sp., *Lernea* sp., *Microcotyle* sp., *Cryptocaryon irritans*, *Vorticella* sp., and *Neascus* sp. (pers comm, Pacifico Aquaculture representatives, November 2023) (Smith, 2020) (Lemus, n.d.).

The State Committee on Health and Safety of Baja California (Comité Estatal de Sanidad e Inocuidad De Baja California A.C.; CESAIBC), is especially concerned about red sea bream iridovirus (RSIV) and viral hemorrhagic septicemia (VHS), which have been listed by the World Organisation for Animal Health (OIE) as pathogens that should be notified to local authorities, and striped bass have demonstrated to be susceptible to both of these pathogens. If outbreaks of these pathogens were to occur, any aquaculture operation in the state would be required to report them to CESAIBC; to date, annual independent PCR screenings for VHS have returned “undetected” results (records provided by Pacifico Aquaculture for 2019–23 annual screenings). The latest PCR screening for RSIV performed by the producer was for 2019, also returning “undetected” results.

The producer provided their mortality report for 2023, detailing estimated mortalities for each cohort still in production, spanning 2017 to September 2023, along with the causes of these mortalities. An average mortality rate of 8.94% was calculated for 2023, considering all stocked cohorts and all causes. But it is important to recognize significant variation in mortality rates and causes among different cohorts. While cohorts stocked between 2017 and 2021 averaged approximately 1% mortality, those stocked in 2022 and 2023 exhibited rates between 17% and 41%, likely influenced by factors affecting fish at the beginning of the grow-out stage of production, such as fingerling vulnerability and stress during transfer to net pens. Despite these variations, the producer’s mortality report attributes fish mortalities to various factors throughout the production cycle. Figure 19 illustrates the average percentage breakdown of these causes for the calendar year 2023, offering a comprehensive overview of mortality factors affecting the grow-out stage of striped bass across six cohorts (2017–23) (pers comm, Pacifico Aquaculture representatives, November 2023).

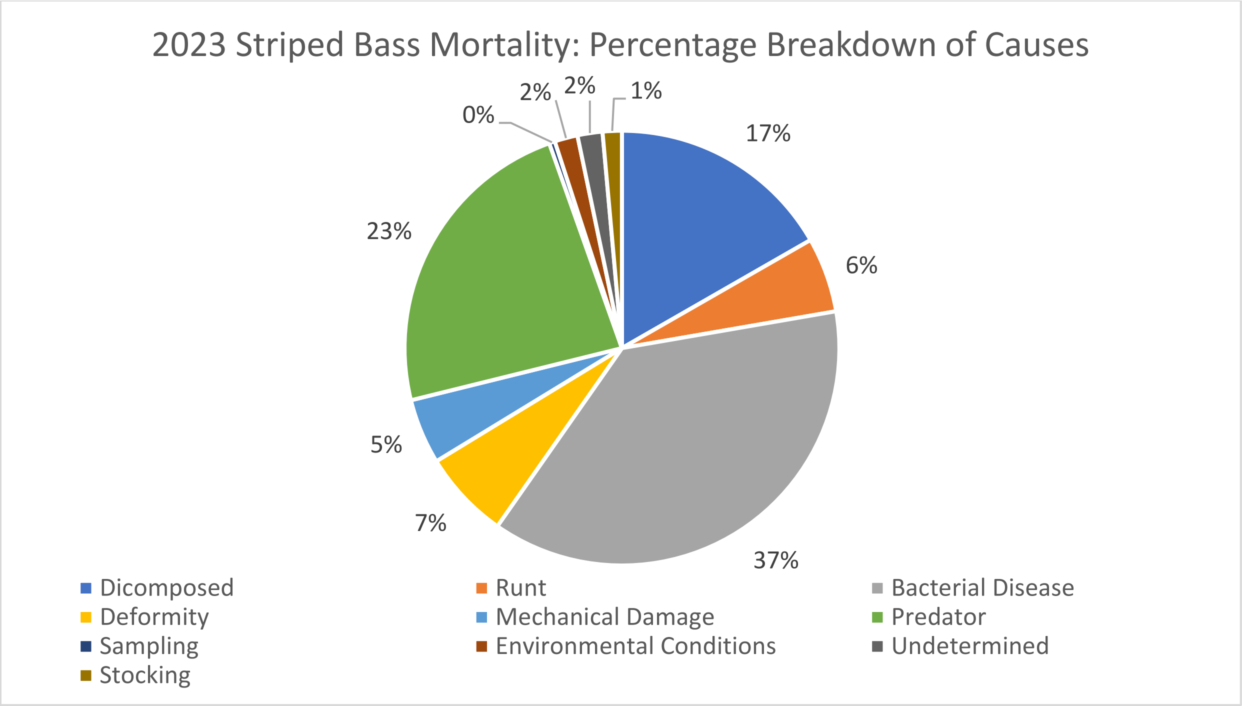

Figure 19: Percentage breakdown of causes of mortality for striped bass for 2023 (pers comm, Pacifico Aquaculture representatives, November 2023).

As shown in Figure 19, bacterial diseases are the leading cause of mortality, mainly because of *tenacibaculosis* and *vibrosis* (pers comm, Pacifico Aquaculture representatives, November 2023). While the average shown is 37.43% (i.e., an average disease-related mortality rate out of the total reported mortality of 8.94% for the calendar year 2023), bacterial diseases were responsible for 84% to 89% of mortalities for the three most recently stocked cohorts (2021 to 2023). The producer attributes these high mortality rates to the increased susceptibility for disease caused by post-transfer stress; that is, the stress experienced by the fish when being transferred from the hatchery, utilizing a freshwater recirculation system, to marine open systems such as the net pens used for the grow-out stage of production. The salinity, shock, and drastic fluctuations in environmental conditions make juvenile fish susceptible to bacterial disease. The spike in mortality post-transfer occurs primarily within the first 40 days. But mortality rates remain high for younger cohorts (i.e., 2021 and 2022 cohorts). While the producer attributes these mortalities to bacterial diseases, they also highlight that the younger cohorts remain vulnerable to several factors, such as the ongoing stress from temperature fluctuations (notably during winter months), varying current velocities, and suboptimal stocking weights, which range from 11 to 12 g (pers comm, Pacifico Aquaculture representatives, November 2023) (Manchanayake et al., 2023).

It is worth mentioning that the producer is actively implementing efforts to increase the weight when the fish are stocked from hatchery to marine net pens, with the target of increasing the stocking weight from about 12 g to 70–80 g. They are in the process of increasing their hatchery capacity to be able to raise fry for longer in a controlled environment before performing the transfer to marine net pens. In addition, the producer is maintaining a stocking density below the maximum recommended 15 kg/m^3 advised by the Federal Institution of Fisheries and Aquaculture. Specifically, they are operating at 10.3 kg/m^3, a deliberate strategy aimed at mitigating the risk of disease outbreaks (pers comm, Pacifico

Aquaculture representatives, November 2023) (Manchanayake et al., 2023) (Carta Nacional Acuicola, 2022).

Regarding the bacterial diseases listed previously, *Tenacibaculum maritimum* is a member of the family Flavobacteriaceae, which usually affects fish by eroding their mouth, causing skin ulcers, fin necrosis, and tail rot; such injuries are susceptible to other opportunistic pathogens, such *Vibrio* spp. (Perez-Pascual et. al., 2017). While *T. maritimum* can be isolated from sediment, tank surfaces, and water cultures exposed to infected stocks, studies indicate that seawater might not be a significant route of transmission for this pathogen (Avendaño-Herrera, 2006). But *T. maritimum* lacks strict host specificity, posing a potential risk to numerous species of anadromous and marine fish for which the disease has not yet been described.

Moreover, *Vibrio* spp. play a pivotal role as pathogens in various aquaculture systems and are commonly found in tropical and temperate marine environments. They constitute a part of the normal flora in the marine setting and are present in the intestines of numerous aquatic species (Manchanayake et al., 2023). *Vibrio* spp. generally exhibit higher survival and infectivity in brackish and marine waters compared to freshwater. Pathogenic *Vibrio* strains can be isolated from seemingly healthy fish and pond sediments over extended periods, with their seasonal abundance linked to environmental and physico-chemical water parameters (Manchanayake et al., 2023). The risk of infections is heightened in intensive fish farming because of factors such as poor water quality, high stocking density, and stress. Mohamad et al. (2019) observed elevated *Vibrio* counts in the sediment of net pen fish farms over a 9-month study period compared to the water, suggesting that sediment serves as a likely reservoir for pathogenic *Vibrio* spp. Given their opportunistic nature, continuous environmental persistence is crucial for *Vibrio* organisms. Consequently, vibriosis stands out as a significant fish disease affecting both cultured and wild fish (Manchanayake et al., 2023).

Parasites

While several parasitic species pose potential threats to cultured striped bass, as discussed earlier, the producer has primarily observed a notable presence of *Trichodina* sp. Moreover, this parasite has exhibited signs of adapting to the initial salinity shock, which was previously employed as a method to keep its prevalence below significant levels. Consequently, the producer conducted and documented *Trichodina* sp. counts from 44 samples collected between February and October 2023, with each sample comprising 10 fish from their net pens that showed the presence of the parasite. The observed prevalence of this parasite in the samples was consistently 100%. The reported parasite counts were aggregated and are illustrated in Figure 20. The analysis revealed that the majority of the samples (28 out of 44) exhibited 20 or fewer parasite counts per fish, as depicted in Figure 20. But 6 of the reported samples showed counts exceeding 50 parasites per fish.

Infections caused by *Trichodina* sp. have been documented in both wild and intensively cultured fish across various countries and aquatic environments, encompassing freshwater and marine habitats (AbouLaila and Igarashi, 2013). *Trichodina* sp. is frequently reported as a parasite affecting numerous fish species; however, it seldom reaches levels that pose a significant threat to the host's health (Plumb, 1997). While the specific subspecies of *Trichodina* affecting striped bass in Todos Santos Bay was not specified, previous records of *Trichodina rectuncinata* have been documented in diverse demersal or benthic fish species spanning 11 fish families globally, with a prevalence in *Blennidae* and *Labridae* (Lom and Dyková, 1992). The broad range of host species and geographical locations where *T. rectuncinata* has been identified suggests a lack of host specificity for this ciliate species. Recently, Aguilar-Aguilar et al. (2015) further expanded the host range by discovering this species in two additional fish families:

Gobiesocidae and *Tripterygiidae*. Notably, this study marks the first documentation of a marine *T. rectuncinata* in Mexico and the second in the Americas. While there is not any readily available information directly addressing the transmission risk of *Trichodina* sp. from cultured striped bass in net pens to wild species, the reported 100% prevalence of *Trichodina* parasites in the observed samples, coupled with the documented low host specificity, raise significant concerns regarding the potential transmission and amplification of this parasite from cultured striped bass to the wild fauna.

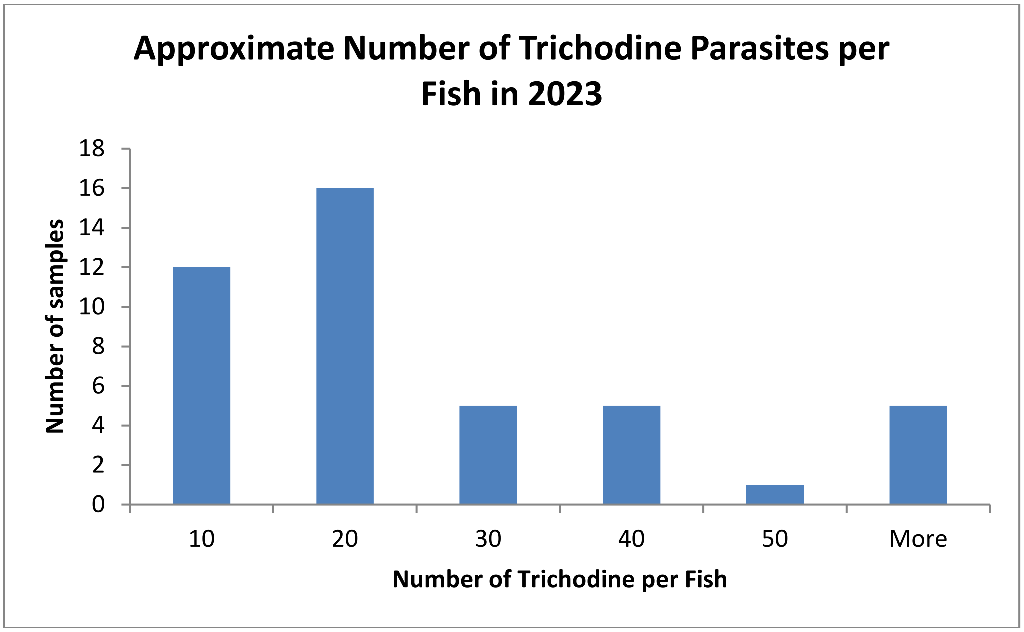

Figure 20: Number of samples for each *Trichodine* parasite group based on parasite count per fish, in 2023 (pers comm, Pacifico Aquaculture representatives, November 2023).

Regulation and Management

Although limited, the Carta Nacional Acuicola (updated version available: DOF,[47] June 2022) provides recommendations on sanitary practices for both the striped bass hatchery and net pen stages of production. For instance, it requires producers to perform bacteriological water monitoring to track bacterial load; to prevent potential outbreaks through prophylactic treatment of organisms as needed; and to rotate the cultivation methods during the fattening phase. Although the producer's Veterinary Plan for Sanitation and Animal Welfare offers valuable sanitary guidelines (discussed further in the next section on Biosecurity), it is important to note that these recommendations are voluntary for producers and do not have legal standing, nor can they result in administrative sanctions. But the producer's Veterinary Plan and implemented biosecurity protocols seem to align with some of the government guidelines described previously; for example, the annual PCR screenings for VHS disease.

Though not specific to aquaculture or striped bass, the Federal Law of Animal Welfare[48] establishes the foundation for diagnosing, preventing, controlling, and eradicating diseases and pests that affect animal welfare. It also regulates best practices in primary production and processing facilities involved in the production of live organisms for human consumption. This law assigns jurisdictional responsibilities to the General Secretary, who oversees all aspects of animal health outlined in the law. The producer

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[47] https://www.dof.gob.mx/nota_detalle.php?codigo=5668529&fecha=17/10/2022#gsc.tab=0

[48] https://www.diputados.gob.mx/LeyesBiblio/pdf/LFSA.pdf

appears to comply with this Federal law by having veterinarians inspect the facility to identify any signs detrimental to the organisms' well-being (pers comm, Pacifico Aquaculture representatives, November 2023).

The General Law of Fisheries and Aquaculture[49] promotes and implements actions to align federal animal welfare and disease prevention measures with those established in other countries. It also defines the responsibilities of the National Health Service for Food Safety and Quality (SENASICA) regarding the application of sanitary measures mandated by this law. The Internal Ruling of the National Service of Welfare, Safety, and Quality of the Agri-food Sector[50] establishes the internal mechanisms for the functioning of SENASICA, outlining the responsibilities from the General Director to those of the regional technical units.

Moreover, Mexico has established state-level aquaculture health committees in collaboration with SENASICA to promote health practices among aquaculture farms within their states. These committees track disease outbreaks, implement prevention measures, carry out farm visits, and collect farm-level data throughout the grow-out season (pers comm, Soledad Delgadillo, FAO, September 2023). They comprise representatives from academia, state government, and federal government, and they possess regulatory authority to ensure animal health and farm biosecurity. As mentioned in Criterion 4—Chemical Use, representatives from SENASICA at both the state and federal levels conduct one to three inspections annually at the striped bass facilities. These inspections aim to ensure compliance with the relevant sanitary requirements necessary for obtaining the "Certificado por el Cumplimiento de las Buenas Prácticas Acuícolas," which remains valid for 2 years. This certification encompasses various aspects such as hazard identification, sanitation practices, hygiene standards, pest control measures, microorganism management, waste disposal protocols, cleaning procedures, aquatic health criteria, feed handling practices, chemical management guidelines, harvest protocols, traceability measures, and training initiatives. Furthermore, the producer has supplied an updated certification from SENASICA, indicating their adherence to SENASICA's sanitary requirements and best practice standards for the years 2021 and 2022.

Biosecurity

In addition to the aforementioned laws and regulations, the producer's Veterinary Plan for Sanitation and Animal Welfare serves as their primary sanitary guide, outlining measures to reduce the risk of disease outbreaks and maintain proper sanitary conditions on farms. The manual encompasses various biosecurity best practices, including equipment and personnel control, the use of tested and quarantined fry sources, veterinary oversight, wildlife entry barriers, water quality monitoring and treatment, disease outbreak reporting, waste management, and record-keeping. In the case of equipment, the manual outlines specific protocols to ensure cleanliness and prevent cross-contamination. Disease detection involves routine inspections by technical staff, with anomalies reported promptly. Veterinarians inspect the facility to identify signs detrimental to the organisms' well-being. Any observed changes prompt reports to the assistant, hatchery and farm managers, and the veterinarian. Necessary measures, including organism sampling, are taken for specific health reviews. If pathogens are suspected in the environment, water samples are tested for microbiological cultivation, and external/internal parasites are identified. Disease control is initiated promptly if an infectious

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[49] https://www.diputados.gob.mx/LeyesBiblio/pdf/LGPAS.pdf

[50] https://www.gob.mx/cms/uploads/attachment/file/145508/REGLAMENTO_INTERIOR_DEL_SENASICA_FORMATO_EDITORIAL.pdf

condition requiring oral therapeutic agents is confirmed, aiming to prevent pathogen spread within the hatchery facility.

Furthermore, the oversight and enforcement of the producer's Veterinary Plan for Sanitation and Animal Welfare and their Biosecurity Plan are actively overseen by an independent third-party certification entity. These plans must align with the Best Aquaculture Practices Standard set by the certification body. The general principles regarding biosecurity outlined in the standard include:

1. Implementation of an operational Animal Health Management Plan or manual, subject to review and approval by an aquatic animal health specialist, encompassing the elements specified in the Implementation Guidelines (e.g., disease surveillance and characterization of the health status of the farm).
2. Establishment of biosecurity controls to prevent the introduction and spread of disease agents within the farm or to neighboring farms, with details provided in an operational Biosecurity Plan that adheres to the Implementation Guidelines (e.g., the steps followed shall include reporting to the Competent Authority if the disease is listed by the OIE or is required by local regulations).
3. Training of farm staff in biosecurity procedures, with compliance expected from all visitors.
4. For farms situated in areas with over three aquaculture facilities (hatcheries, farms, processing plants) per 10 km^2 sharing the same surface water body, initiation or participation in an Area Management Plan to coordinate biosecurity measures with neighboring sites. This requirement applies irrespective of BAP certification status, unless a documented disease risk assessment confirms a low risk of disease transmission among facilities.

Overall, the company has established a Veterinary Plan for Sanitation and Animal Welfare, as well as a Biosecurity Plan, which comply with both governmental guidelines and BAP certification standards. Despite these measures, it seems that several bacterial pathogens (i.e., *Tenacibaculum maritimum* and *Vibrio* spp.) and parasites (i.e., *Trichodina* sp.) continue to affect the cultured striped bass, leading to increased mortalities, particularly during the vulnerable stage of fingerlings, such as when they are transferred from the hatchery to the marine net pens.

Impacts to Wild Species

Although most of the diseases recorded for striped bass produced in Mexico have the potential to spread to other organisms, it remains unclear the degree to which these diseases can affect wild populations. The studies referenced previously on this topic either did not fully study wild populations or provided only isolated observations on horizontal pathogenic transfers, but nonspecific to transfers from striped bass to wild fauna. The limitation of this information makes it challenging to determine the degree to which pathogens may be discharged from striped bass net pens in Mexico, and then affect fish in the wild (i.e., outside of the farm environment, where the conditions such as unnatural stocking densities and reduced water quality are considered to increase the susceptibility of striped bass to pathogens).

All the parasites and pathogens listed are considered to originate in the local environment, and because of the open nature of the net pen grow-out system, there is an inherent risk of pathogen amplification and retransmission from cultured to native wild fish, even though wild fish are most likely the source of initial infection in the production system (Manchanayake et al., 2023) (AbouLaila and Igarashi, 2013). There is also a risk of pathogen transfer from the hatchery (i.e., freshwater system) to the marine grow-out site, although again, these are likely to mimic natural pathogen movements from freshwater environments to the ocean.

Conclusion and Final Score

Despite being recognized as a disease-resistant cultured species, striped bass is susceptible to various infectious and noninfectious diseases. Primary diseases affecting cultured striped bass in the Americas include gram-negative and gram-positive bacteria, fungi, and parasites. Although numerous studies have delved into diseases affecting cultured striped bass, information regarding their impact on wild populations remains scarce. Net pens, deemed “open” to the environment, pose a potential risk of pathogen amplification and subsequent release into waters shared with wild fish. The implementation of biosecurity measures (i.e., Veterinary Plan for Sanitation and Animal Welfare and the Biosecurity Plan) and best practices by the producer, verified through third-party certification (Best Aquaculture Practices), is evident. Despite these efforts, it appears that various bacterial pathogens like *Tenacibaculum maritimum* and *Vibrio* spp., along with parasites such as *Trichodina* sp., persist in affecting the cultured striped bass, resulting in heightened mortalities, especially during vulnerable stages like the transfer of fingerlings from the hatchery to the marine net pens. As a result, the risk of potential pathogen transmission from the cultured striped bass to wild fish in the surrounding area persists. Limited data, especially on the potential impacts on wild fish, prompt the use of a risk-based assessment (Data criterion score for the Disease section < 7.5 out of 10). Considering the potential pathogen and parasitic transfer risk to wild species, the openness of production systems, the prevalence of parasites, and the documented disease-related mortalities of the grow-out net pens across various cohorts (i.e., an average disease-related mortality rate of 37.43% out of the total reported mortality of 8.94% for the calendar year 2023), as well as the company’s documented implementation of biosecurity protocols, the final 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
- *Unit of Sustainability:* Wild fish populations
- *Principle:* Using eggs, larvae, or juvenile fish produced from farm-raised broodstocks 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	
C8X Independence from unsustainable wild fisheries (0–10)	0	
Critical?	NO	GREEN

Brief Summary

With a purpose-built hatchery and dedicated broodstock facility, striped bass production is fully independent of wild fisheries for broodstock and juveniles. Therefore, the final score for Criterion 8X—Source of Stock is a deduction of 0 out of –10.

Justification of Rating

The industry is supported by one purpose-built freshwater hatchery at the shore base in the town of Ensenada. The broodstock are of farm origin, having been domesticated from strains originally imported from the East Coast of the United States (Delmarva Aquatics, Delaware). The marine site at Isla Todos Santos holds broodstock before they are transferred to the hatchery for spawning. With this system, there is no sourcing of any wild broodstock or fry for its operations (pers comm, Pacifico Aquaculture representatives, November 2023). The final score for Criterion 8X—Source of Stock is 0 out of –10.

Criterion 9X: Wildlife Mortalities

Impact, unit of sustainability and principle

- *Impact:* Mortality of predators or other wildlife caused or contributed to by farming operations
- *Unit of sustainability:* Wildlife or predator populations
- *Principle:* Preventing population-level impacts to predators or other species of wildlife attracted to 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)	0	
Critical?	NO	GREEN

Brief Summary

The colonies of seals and sea lions and large numbers of birds are the primary concern for wildlife interactions with the farm, but the company has a comprehensive written policy of exclusion, which was observed in practice with seal and bird nets on all net pens (during the site visit in 2016). Though impossible to verify, there were no documented cases of accidental or deliberate wildlife mortalities reported by the farm under scope from 2019 to 2023, and the company has actively instituted a wildlife interaction mitigation plan. The dedicated efforts of conservation groups in the Pacific islands of Mexico have led to positive ecological enhancements; however, they recognize the aquaculture operations of the region (including the production under scope for this assessment) as a threat or an industry of concern for marine bird species' population recovery. Overall, the farm is in an area of high ecological value and preventive measures appear to be effective, because it appears that no wildlife mortalities have resulted from the assessed operation, and observed disturbances on seabirds appear highly unlikely to affect the health of the wild populations. The final numerical score for Criterion 9X—Wildlife Mortalities is 0 out of –10.

Justification of Rating

Because the wildlife and predator mortality data quality and availability is high (Criterion 1 score of 10 out of 10), the Seafood Watch Evidence-Based Assessment was utilized.

There are over 230 islands and islets in northwest (NW) Mexico harboring considerable biodiversity, including a wide taxonomic range of endemics (Knowlton et al., 2007) (Donlan et al., 2000 and references within). The presence of farmed fish in net pens, at higher densities than they are found in the wild, inevitably attracts opportunistic coastal marine mammals, seabirds, and fish that normally feed on native fish stocks (Sepulveda et al., 2015). Aligned with this theory, the producer reports rough estimates of over 10 marine mammal sightings per month from 2019 to 2022 in the farm's vicinity (pers comm, Pacifico Aquaculture representatives, November 2023). But for 2023, the producer reports total sightings of 266 marine mammals, which results in a higher estimate of roughly 22 marine mammal sightings per month (i.e., harbor seals, sea lions, elephant seal, dolphin, gray whale, and fin whale). In addition, for 2023 the producer also reports sightings of 49 terrestrial mammals (i.e., rodents), and 13 reptiles (i.e., lizards and snakes). It is worth noting that elephant seals have been observed to also use the islands as a haul-out site. During the site visit by a SFW representative in May 2016, both harbor seals and sea lions were seen to be hauled out on the island, and two harbor seals were observed on the floating collars of the farm's net pens. The producer reports over 100 bird sightings per month from 2019 to 2023, including species such as cormorants, western gull, great egret, and grey heron.

As mentioned (i.e., Criterion 3—Habitat), some interactions—such as disruptions of natural seabird behaviors (mainly gulls) because of the artificial lights used by the producer during night hours to increase fish appetite and prevent vandalism—have been identified as potential threats to these species (pers comm, Pacifico Aquaculture representatives, July 2024) (pers. comm., Anonymous, July 2024). In addition, the frequent presence of hikers and other individuals on Todos Santos Island, presumably staff from the striped bass operation, has been identified as a potential threat to wildlife recovery on this island, which is part of the buffer zone of the Todos Santos Archipelago in the Islas del Pacífico de la Península de Baja California Biosphere Reserve (DOF 07-12-2016). Researchers conducting wildlife surveys in the region have raised increasing concerns that these disturbances could lead to population-level impacts on local seabird species (pers comm, Anonymous, July 2024).

Therefore, it is evident that there are several wild species in frequent interaction around and near the producer's facilities. To help mitigate these interactions, Pacifico Aquaculture's Environmental Best Management Plan details predator avoidance and deterrence measures, which are primarily aimed at exclusion. The company reports that no seals or sea lions have been accidentally or deliberately killed at the site since the company's operations began, and all the farm's net pens are covered with well-tensioned bird nets and surrounded by seal exclusion nets underwater and above the surface.[51] The company's Environmental Best Management Practices manual states a policy of no lethal control. In addition, the producer adheres to SEMARNAT's regulations by employing nonlethal methods to manage predators and by conducting comprehensive assessments of the local fauna as part of their approved EIA. Furthermore, the General Law of Wildlife strictly prohibits any cruelty toward wildlife and requires SEMARNAT's approval for any lethal actions targeting protected species. SEMARNAT also possesses the authority to close industries in cases of imminent risk to wildlife. But the effectiveness of enforcement measures for these protections is not well-documented, and there are no legal obligations in Mexico to report wildlife mortalities.

In the broader Baja California coastal region, Arrallano-Peralta & Medrano-Gonzalez (2015) report that there are 43 marine mammal species, of which 8 are threatened, including the critically endangered vaquita (*Phocoena sinus*); however, it is important to note that this region also includes eastern coastlines on the Gulf of California. Arrallano-Peralta & Medrano-Gonzalez (2015) show the species richness in the region of the Isla Todos Santos to be of moderate marine mammal species richness, and after assessing a variety of human impacts in the region, they did not list aquaculture as a threat.

The company also operates a small shore base on the main (south) island (Todos Santos Sur), with security staff and basic facilities for farm workers. Donlan et al. (2000) show that this facility was previously built to service an abalone farm that occupied the site before tuna ranching operations and, subsequently, Pacifico Aquaculture's operations. Isla Todos Santos, and specifically the south island, are

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[51] The predator nets allow seals to rest on the walkway around the edge of each circular pen but prevent them from entering the pen itself.

reported to be "depauperate[52] in botanical endemism"; however, Donlan et al. (2000) and references therein note that there are three endemic extant vertebrates:

- Todos Santos ringneck snake (*Diadophis punctatus anthonyi*)
- Todos Santos mountain kingsnake (*Lampropeltis zonata herrarae*)
- Todos Santos white-footed mouse (*Peromyscus maniculatus dubius*)

Moreover, Grupo de Ecología y Conservación de la Isla (GECI), an island conservation organization, has played an active role in the integrated conservation and sustainable development of Mexico's islands. Their latest reported findings, as documented by Méndez Sánchez et al. (2022) and Bedolla-Guzman et al. (2019), present an optimistic outlook regarding the biodiversity trends in the Todos Santos Bay area. GECI recently verified the breeding of ashy storm petrel (*Oceanodroma homochroa*) on the southern Todos Santos Islands, finding the first active nest in 2014. Notably, 40% of the brown pelican (*Pelecanus occidentalis*) breeding population is centralized on the southern Todos Santos Island. Over the monitoring period from 2013 to 2017, GECI documented nesting of the pelagic cormorant (*Phalacrocorax pelagicus*) on Coronado Sur, Coronado Medio, both Todos Santos islands, and, for the first time in 2017, on San Jerónimo Island, signifying an expansion of its breeding territory to the south (Bedolla-Guzman et al., 2019). In addition, population trends for 61 colonies of 19 seabird species identified 4 of these species to present increasing trends on Todos Santos Island, with no decreasing trends detected, considering data until 2019 (Méndez Sánchez et al., 2022). Despite these successes, the study identifies ongoing threats that could result in population-level impacts, such as the potential reintroduction of invasive mammals, invasive plants, habitat modification, egg exploitation, human disturbance, fisheries impacts, pollution, and aquaculture operations in the region (i.e., including the striped bass operation) (pers comm, GECI representatives, July 2024) (Méndez Sánchez et al., 2022) (Bedolla-Guzman et al., 2019).

The Western Hemisphere Shorebird Reserve Network[53] (WHSRN) covers 2,091.9 hectares of the most important shorebird habitats in Estero Punta Banda, located in the southern part of Todos Santos Bay. The site hosts over 4% of the Pacific population of the subspecies known as *Charadrius nivosus*, considered "Threatened" in both Mexico and the United States and "Near Threatened" globally. Todos Santos Bay regularly supports a significant number of the subspecies *Calidris canutus roselaari* (an endangered species in Mexico), *Sternula antillarum* (under special protection), the inornatus subspecies of *Tringa semipalmata*, and *Limosa fedoa*.

While it is possible that the activities at the shore site disturb these organisms, the activities cover a very small area. During the site visit, a tourist boat was also seen to moor off the south island and shuttle passengers to the island. According to Knowlton et al. (2007) and Donlan et al. (2000), the dominant impact to the island's biodiversity has been the introduction of cats and rabbits in the early and mid-1900s (trapping efforts in 1997 and 1998 subsequently removed them), and the prior extinction of endemic species and the local extinction of other species is attributed to the cats. Although the current activities of the striped bass producer in Mexico may alter species behavior because of staff presence on the island, it appears doubtful that these impacts lead to wildlife mortalities or affect the population levels of the species interacting with the operation. In addition, the operation is conducted in a very restricted shore-based area, making it highly unlikely to pose a significant threat to the wildlife species inhabiting the island or the broader archipelago.

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[52] Lacking in numbers or variety of species

[53] https://whsrn.org/es/whsrn_sites/bahia-de-todos-santos/

Conclusions and Final Score

The colonies of seals and sea lions and large numbers of birds are the primary concern for wildlife interactions with the farm, but the company has a comprehensive written policy of exclusion, which was observed in practice with seal and bird nets on all net pens (during the site visit in 2016). Though impossible to verify, there were no documented cases of accidental or deliberate wildlife mortalities reported by the farm under scope from 2019 to 2023, and the company has actively instituted a wildlife interaction mitigation plan. The dedicated efforts of conservation groups in the Pacific islands of Mexico have led to positive ecological enhancements; however, they recognize the aquaculture operations of the region (including the production under scope for this assessment) as a threat or an industry of concern for marine bird species' population recovery. Overall, the farm is in an area of high ecological value and preventive measures appear to be effective, because it appears that no wildlife mortalities have resulted from the assessed operation and observed disturbances on seabirds appear highly unlikely to affect the health of the wild populations. The final numerical score for Criterion 9X—Wildlife Mortalities is 0 out of –10.

Criterion 10X: Introduction of Secondary Species

Impact, unit of sustainability and principle

- *Impact:* Movement of live animals resulting in introduction of unintended species
- *Unit of sustainability:* Wild native populations
- *Principle:* Avoiding the potential for the accidental introduction of secondary species or pathogens resulting from the shipment of animals.

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

Introduction of secondary species parameters	**Score**	
F10Xa International or trans-waterbody live animal shipments (%)	10	
F10Xb Biosecurity of source/destination	n/a	
C10X Introduction of secondary species Final Score	**0**	**GREEN**

Brief Summary

Striped bass is nonnative to the Pacific, and although there is an established population in the San Francisco Bay with historic active stocking of hatchery-raised fish, Pacifico Aquaculture originally imported juveniles and broodstock from a selective breeding program in Delaware in the United States. The company now has a broodstock unit at the Isla Todos Santos site and a freshwater hatchery established on the mainland in Ensenada. Movements of fish between these two locations on either side of Ensenada Bay are considered to be within the same waterbody, and there are also quarantine facilities at the hatchery. Production is now considered independent of international or trans-waterbody movements of fish, and the final numerical score for Criterion 10X—Introduction of Secondary Species is a deduction of 0 out of –10.

Justification of Rating

This criterion provides a measure of the risk that nonnative species, apart from the farmed species, might be unintentionally introduced into a distinct waterbody (i.e., one in which they are not native or present) during the transportation of live fish. For example, in Mexico, the trade of ornamental and exotic fish species has led to the introduction of several species of aquatic plants, such as *Eichhornia crassipes*, *Hydrilla verticillata*, *Hygrophila polysperma*, and *Salvinia molesta* (Mendoza-Alfaro et al., 2021). Such introductions can have negative environmental impacts. For instance, *Hydrilla verticillata* can produce a toxin that is deadly to birds, causing avian vacuolar myelinopathy.

Factor 10Xa—International or Trans-Waterbody Live Animal Shipments

Striped bass is nonnative to the Pacific, and although there is an established population in the San Francisco Bay with stocking of hatchery-raised fish in the past, Pacifico Aquaculture originally imported juveniles and broodstock from 2012 to 2014 from a selective breeding program in Delaware in the United States (Delmarva Aquatics). Since then, broodstock cages have been located at the Todos Santos Island site, and with the hatchery operating in Ensenada, the company is now considered independent of imports of live animals.

A routine movement of fish also occurs between the freshwater hatchery and the sea site, but this is considered to be in the same waterbody, particularly because the primary source of unintended organisms coming into the hatchery would be the movement of broodstock from the sea site into the hatchery (where quarantine procedures were observed on the site visit in 2016). Therefore, there are not considered to be any international or trans-waterbody movements of live fish, and the score for Factor 10Xa is 10 out of 10.

Factor 10Xb—Biosecurity of Source and Destination

Because international or trans-waterbody movements of fish do not occur, and Factor 10Xa is scored 10 out of 10, Factor 10Xb is not relevant.

Conclusions and Final Score

With no international or trans-waterbody movements of fish, Factor 10Xb is not relevant, and the final numerical score for Criterion 10X—Introduction of Secondary Species is a deduction of 0 out of –10.

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

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Appendix 1: Data Points and all Scoring Calculations

Criterion 1: Data	
Data Category	**Data Quality**
Production	10.0
Management	7.5
Effluent	7.5
Habitat	7.5
Chemical Use	7.5
Feed	5.0
Escapes	7.5
Disease	5.0
Source of stock	10.0
Wildlife mortalities	10.0
Introduction of secondary species	10.0
C1 Data Final Score (0–10)	**7.955**
	Green

Criterion 2: Effluent	
Effluent Evidence-Based Assessment	**Data and Scores**
C2 Effluent Final Score (0–10)	**8**
Critical?	NO

Criterion 2: Effluent Risk-based assessment	
2.1a Biological waste production	**Data and Scores**
Protein content of feed (%)	43.000
eFCR	2.690
Fertilizer N input (kg N/ton fish)	46.000
Protein content of harvested fish (%)	19.550
N content factor (fixed)	0.160
N input per ton of fish produced (kg)	231.072
N output in each ton of fish harvested (kg)	31.280
Waste N produced per ton of fish (kg)	199.792

2.1b Production System discharge	**Data and Scores**
Basic production system score	0.510
Adjustment 1 (if applicable)	0.000
Adjustment 2 (if applicable)	0.000
Adjustment 3 (if applicable)	0.000
Boundary adjustment (if applicable)	0.000
Discharge (Factor 2.1b) score (0–1)	0.510
Waste discharged per ton of production (kg N ton^{-1})	101.894
Waste discharge score (0–10)	0.000

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	4
2.2 Effluent management effectiveness	3.200
C2 Effluent Final Score (0–10)	**n/a**
Critical?	No

Criterion 3: Habitat	
F3.1 Habitat conversion and function	**Data and Scores**
F3.1 Score (0–10)	9
F3.2 Management of farm-level and cumulative habitat impacts	
3.2a Content of habitat management measure	3
3.2b Enforcement of habitat management measures	4
3.2 Habitat management effectiveness	4.800
C3 Habitat Final Score (0–10)	**7.600**
Critical?	No

Criterion 4: Chemical Use	
Single species assessment	Data and Scores
Chemical use initial score (0–10)	10.0
Trend adjustment	0.0
C4 Chemical Use Final Score (0–10)	**10.0**
Critical?	No

Criterion 4: Chemical Use	
All-species assessment	**Data and Scores**
Chemical use initial score (0–10)	10
Trend adjustment	0
C4 Chemical Use Final Score (0–10)	**10**
Critical?	No

Criterion 5: Feed	
5.1 Wild Fish Use	
5.1a Forage Fish Efficiency Ratio (FFER)	**Data and Scores**
Fishmeal from whole fish, weighted inclusion level %	10.800
Fishmeal from by-products, weighted inclusion %	0.000
By-product fishmeal inclusion (@ 5%)	0.000
Fishmeal yield value, weighted %	23.300
Fish oil from whole fish, weighted inclusion level %	0.000
Fish oil from by-products, weighted inclusion %	2.400
By-product fish oil inclusion (@ 5%)	0.120
Fish oil yield value, weighted %	6.200
eFCR	2.690
FFER Fishmeal value	**1.247**
FFER Fish oil value	**0.052**
Critical (FFER > 4)?	No

5.1b Sustainability of Source fisheries	**Data and Scores**
Source fishery sustainability score	8.080
Critical source fisheries?	No
SFW red source fisheries?	No
FFER for red-rated fisheries	n/a
Critical (SFW red and FFER ≥ 1)?	No
Final Factor 5.1 Score	**6.700**

5.2 Net Protein Gain or Loss (%)	**Data and Scores**
Weighted total feed protein content	43.000
Protein INPUT kg/100 kg harvest	115.670
Whole body harvested fish protein content	19.550
Net protein gain or loss	–83.098
Species-specific Factor 5.2 score	**1**
Critical (Score = 0)?	No
Critical (FFER > 3 and 5.2 score < 2)?	No

5.3 Feed Footprint	Data and Scores
GWP (kg CO2-eq kg^{-1} farmed seafood protein)	**10.985**
Contribution (%) from fishmeal from whole fish	12.596
Contribution (%) from fish oil from whole fish	0.000
Contribution (%) from fishmeal from by-products	0.000
Contribution (%) from fish oil from by-products	1.865
Contribution (%) from crop ingredients	52.916
Contribution (%) from land animal ingredients	30.977
Contribution (%) from other ingredients	1.646
Factor 5.3 score	**7**
C5 Final Feed Criterion Score	**5.4**
Critical?	**No**

Criterion 6: Escapes	Data and Scores
F6.1 System escape risk	3
Percent of escapees recaptured (%)	0.000
F6.1 Recapture adjustment	0.000
F6.1 Final escape risk score	3.000
F6.2 Invasiveness score	6
C6 Escape Final Score (0–10)	**4.0**
Critical?	No

Criterion 7: Disease	Data and Scores
Evidence-based or Risk-based assessment	Risk
Final C7 Disease Criterion score (0–10)	**4**
Critical?	No

Criterion 8X Source of Stock	Data and Scores
Percent of production dependent on wild sources (%)	0.0
Initial Source of Stock score (0–10)	0.0
Use of ETP or SFW red fishery sources	No
Lowest score if multiple species farmed (0–10)	n/a
C8X Source of stock Final Score (0–10)	**0**
Critical?	No

Criterion 9X Wildlife Mortality parameters	Data and Scores
Single species wildlife mortality score	0
System score if multiple species assessed together	n/a
C9X Wildlife Mortality Final Score	**0**
Critical?	No

Criterion 10X: Introduction of Secondary Species	Data and Scores
Production reliant on trans-waterbody movements (%)	0
Factor 10Xa score	10
Biosecurity of the source of movements (0-10)	10
Biosecurity of the farm destination of movements (0–10)	0
Species-specific score 10X score	0.000
Multispecies assessment score if applicable	n/a
C10X Introduction of Secondary Species Final Score	**0.000**
Critical?	n/a