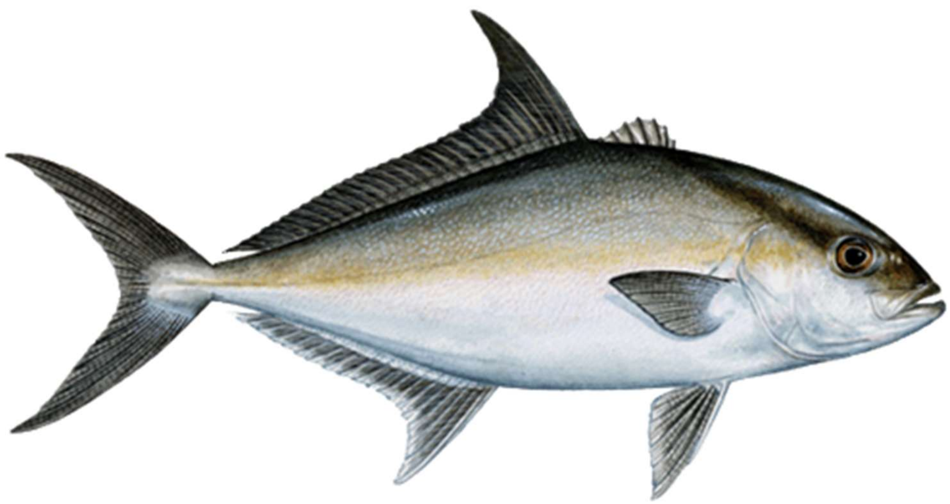
Monterey Bay Aquarium
Seafood Watch®

Farmed Almaco Jack

Seriola rivoliana



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United States

Marine Net Pens

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Disclaimer

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

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About Seafood Watch

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

Each sustainability recommendation on the regional pocket guides is supported by a Seafood Watch Assessment. Each assessment 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." This ethic is operationalized in the Seafood Watch standards, available on our website here. In producing the assessments, 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 assessments 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 Watch assessments in any way they find useful.

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 farms must possess to be considered sustainable by the Seafood Watch program. Sustainable aquaculture farms and collective industries, by design, management and/or regulation, address the impacts of individual farms and the cumulative impacts of multiple farms at the local or regional scale by:

1. **Having robust and up-to-date information on production practices and their impacts available for analysis;**
   Poor data quality or availability limits the ability to understand and assess the environmental impacts of aquaculture production and subsequently for seafood purchasers to make informed choices. Robust and up-to-date information on production practices and their impacts should be available for analysis.
2. **Not allowing effluent discharges to exceed, or contribute to exceeding, the carrying capacity of receiving waters at the local or regional level;**
   Aquaculture farms minimize or avoid the production and discharge of wastes at the farm level in combination with an effective management or regulatory system to control the location, scale and cumulative impacts of the industry's waste discharges.
3. **Being located at sites, scales and intensities that maintain the functionality of ecologically valuable habitats;**
   The siting of aquaculture farms does not result in the loss of critical ecosystem services at the local, regional, or ecosystem level.
4. **Limiting the type, frequency of use, total use, or discharge of chemicals to levels representing a low risk of impact to non-target organisms;**
   Aquaculture farms avoid the discharge of chemicals toxic to aquatic life or limit the type, frequency or total volume of use to ensure a low risk of impact to non-target organisms.
5. **Sourcing sustainable feed ingredients and converting them efficiently with net edible nutrition gains;**
   Producing feeds and their constituent ingredients has complex global ecological impacts, and the efficiency of conversion can result in net food gains or dramatic net losses of nutrients. Aquaculture operations source only sustainable feed ingredients or those of low value for human consumption (e.g. by-products of other food production), and convert them efficiently and responsibly.
6. **Preventing population-level impacts to wild species or other ecosystem-level impacts from farm escapes;**
   Aquaculture farms, by limiting escapes or the nature of escapees, prevent competition, reductions in genetic fitness, predation, habitat damage, spawning disruption, and other impacts on wild fish and ecosystems that may result from the escape of native, non-native and/or genetically distinct farmed species.

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

7. **Preventing population-level impacts to wild species through the amplification and retransmission, or increased virulence of pathogens or parasites;**
   Aquaculture farms pose no substantial risk of deleterious effects to wild populations through the amplification and retransmission of pathogens or parasites, or the increased virulence of naturally occurring pathogens.
8. **Using eggs, larvae, or juvenile fish produced from farm-raised broodstocks thereby avoiding the need for wild capture;**
   Aquaculture farms use eggs, larvae, or juvenile fish produced from farm-raised broodstocks thereby avoiding the need for wild capture, or where farm-raised broodstocks are not yet available, ensure that the harvest of wild broodstock does not have population-level impacts on affected species. Wild-caught juveniles may be used from passive inflow, or natural settlement.
9. **Preventing population-level impacts to predators or other species of wildlife attracted to farm sites;**
   Aquaculture operations use non-lethal exclusion devices or deterrents, prevent accidental mortality of wildlife, and use lethal control only as a last resort, thereby ensuring any mortalities do not have population-level impacts on affected species.
10. **Avoiding the potential for the accidental introduction of secondary species or pathogens resulting from the shipment of animals;**
    Aquaculture farms avoid the international or trans-waterbody movements of live animals, or ensure that either the source or destination of movements is biosecure in order to avoid the introduction of unintended pathogens, parasites and invasive species to the natural environment.

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

Criterion	Score	Rank	Critical?
C1 Data	8.18	GREEN	
C2 Effluent	9.00	GREEN	NO
C3 Habitat	9.33	GREEN	NO
C4 Chemicals	8.00	GREEN	NO
C5 Feed	2.91	RED	NO
C6 Escapes	6.00	YELLOW	NO
C7 Disease	6.00	YELLOW	NO
C8X Source	0.00	GREEN	NO
C9X Wildlife mortalities	-2.00	GREEN	NO
C10X Introduced species escape	0.00	GREEN	
Total	**47.43**		
Final score (0-10)	**6.78**		

OVERALL RANKING

Final Score	6.78
Initial rank	GREEN
Red criteria	1
Interim rank	YELLOW
Critical Criteria?	NO

FINAL RANK

YELLOW

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

- Best Choice = Final score > 6.66 and ≤10, **and** no Red criteria, **and** no Critical scores.
- Good Alternative = Final score > 3.33 and ≤6.66, **and/or** one Red criterion, **and** no Critical scores.
- Avoid = Final score ≥ 0 ≤ 3.33, **or** more than one Red criterion, **or** one or more Critical scores.

Summary

The final score for Almaco jack produced in submersible net cages in Hawaii is 6.78 out of 10 which is in the green range. With one red criterion the final recommendation is a “Good Alternative”.

Executive Summary

There is currently one commercial producer of *Seriola rivoliana* (Almaco jack, amberjack, or kampachi) in Hawaii and the United States. For the past six years the company has produced a total of 2,287 metric tons (MT) of Almaco jack which is less than one percent of the global *Seriola* spp. production. The company has a hatchery and an offshore growout site; the latter is the focus of this assessment and consists of a set of submersible sea cages located offshore in 200 ft (60 m) of water in a well-flushed area about one-half mile from the coast.

This Seafood Watch assessment involves criteria covering impacts associated with effluent, habitats, wildlife and predator interactions, chemical use, feed production, escapes, introduction of non-native organisms (other than the farmed species), disease, the source stock, and general data availability. The assessment covers only the growout phase of the species.

Since the entire US Seriola industry is composed of one commercial operation in Hawaii, there is little publicly available or peer-reviewed scientific literature specific to this regional industry. However, data required for this assessment were obtained from the farm upon request, and monitoring reports by state agencies are available online. The company also provides water quality and benthic monitoring data online. The overall data availability and quality is good and the score for Criterion 1 – Data is 8.2 out of 10.

Because effluent data quality and availability is good for Hawaii Almaco jack, the Evidence-Based Assessment was used. Based on the nature of the production system (i.e., submersible marine net pens), all effluent waste generated by the cultured fish immediately enters the ocean environment and cannot be treated before being released. Thus, the only way to manage the amount of effluent generated, and any subsequent environmental impacts, is by actively managing the quantity and content of the feed provided to the fish, stocking density, and siting of the farm. Even though the farm directly discharges its effluent to the environment, monitoring of the local environment, in combination with ongoing water quality monitoring by the nearby state-run energy laboratory, indicates that nutrient concentrations have been well below regulatory permit limits. Nutrient inputs are highly unlikely to have had any substantial adverse impacts on the surrounding water quality or the seabed since the farm's construction. The final score for Criterion 2 – Effluent is 9 out of 10.

The farm conducts regular water and benthic monitoring, and publishes the results on its website. Additionally, in combination with ongoing water quality monitoring that includes information on ecosystem health, interactions with protected species and changes in benthic assemblage have been conducted since the inception of the operation in Hawaii. All of the data from these monitoring efforts indicate that the marine habitat has experienced minimal habitat impacts and no loss of habitat functionality as a result of the presence and operation of this farm. In addition, because the aquaculture operation under assessment is located adjacent to a

National Marine Sanctuary, there are strict regulations and strong enforcement to prevent future habitat impacts. The score for Criterion 3 – Habitat is 9.3 out of 10.

The farm reports that the only chemical used in production is hydrogen peroxide, which is used in bath treatments as a disinfectant and anti-parasiticide. This chemical is considered to be "low regulatory priority" and, according to the U.S. Food and Drug Administration, degrades rapidly after treatment, and is considered minimally hazardous to the environment. As such, the risk of chemical impacts on the environment from these treatments is minimal. Any additional chemical use is strictly regulated by the State of Hawaii and requires close monitoring and regulatory oversight; however, by design marine net pens allow any chemicals used to be discharged directly into the marine environment. As such, the score for Criterion 4 – Chemical Use is 8 out of 10.

Almaco jack growout feed contains 37% protein with 30% fishmeal inclusion and 12% fish oil inclusion. 34% of fishmeal and 48% of fish oil are sourced from by-products, and the average economic feed conversion ratio (eFCR) for the past three years is 2.0. The Feed Fish Efficiency Ratio (FFER) is driven by fish oil and was calculated to be 2.48, resulting in a score of 3.81 out of 10. Source fisheries for marine ingredients in the Almaco jack feeds are all rated in FishSource. Scores for management exceed ≥6, and the scores for health range between ≥6 and 10, resulting in a sustainability score of –3 for sustainability of the source of wild fish (SSWF). Due to the high use of marine ingredients and moderately high eFCR, Factor 5.1 scores 2.32 out of 10. The net loss of protein was calculated to be –47.09%, due to high use of plant proteins considered "edible" for human consumption, resulting in a score of 5 out of 10 for Factor 5.2. The total feed footprint (ocean and land area) required to produce the feed ingredients necessary to grow one ton of farmed Almaco jack is calculated to be 22.3 hectares (ha), resulting in a score of 2 out of 10 for Factor 5.3. When the scores for Factors 5.1, 5.2, and 5.3 are combined, the final score for Criterion 5 – Feed is 2.9 out of 10.

There is an inherent risk of escape in marine net pen systems, and data from the farm show small-scale escape events (i.e., trickle losses or leakage) are common. A total of 11 major escape events have occurred between 2011 to 2017; however, there is evidence of a 40% recapture rate in such events. Almaco jack is a native species and wild populations exist within the assessed region. The industry relies on wild, locally caught broodstock, thus reducing any potential genetic impacts of escapes. Any farmed fish that enter the ecosystem are expected to interact with and impact surrounding species. Although the escape risk is high, the recapture rate and also the genetic similarity with wild fish (only 1 generation removed) reduce the risk of significant impact. The score for Criterion 6 – Escapes is 6 out of 10.

As disease data quality and availability is moderate (i.e., Criterion 1 score of 5 out of 10 for the disease category), the Seafood Watch risk-based assessment was used. Due to the nature of the production system and the presence of wild conspecifics, there is an inherent risk of amplification and transmission of disease from the farm to wild fish. However, the farm follows strict protocols to minimize disease outbreaks and there have been no bacterial or viral disease outbreaks reported since 2010. Skin fluke parasites are prevalent on the farm, as with all marine cultured Seriola. Although data on their numbers for farmed fish are not available for all the years except 2018, several years of monitoring indicate that the prevalence of the most common ectoparasite on the farmed fish, *Neobenedenia* spp., is not increasing in wild fish. Overall, the risk of disease transmission is considered to be low to moderate, and the score for Criterion 7 – Disease is 6 out of 10.

The farm relies completely on sourcing local wild broodstock, but the numbers caught to maintain a captive population are low (18 over a three-year period) and the source is considered sustainable. With no use of wild fish from unsustainable sources, the score for Criterion 8X – Source of Stock is a deduction of 0 out of –10.

Although the farm site occasionally attracts predators and wildlife, effective management and prevention measures have been developed to limit mortalities to exceptional cases. There have been two recorded mortality events (in 2005 and 2017) and, although both involved a near-threatened or protected species, they did not contribute to further decline or prohibit recovery of either species and multi-stakeholder measures were enacted to mitigate future events. Interactions between the wildlife and the net pens appears to be limited to rare occasions, indicating the enacted management plan is effective. As such, the score for Criterion 9X – Wildlife and Predator Mortalities is –2 out of –10.

International or trans-waterbody live animal shipments have the potential to introduce invasive alien species and/or pathogens into the environment. Since the entire life cycle of the farmed fish takes place within one location in Hawaii, there is no risk of the introduction of invasive species; thus, the score for Criterion 10X – Escape of Secondary Species is 0 out of –10.

The final score for Almaco jack produced in submersible net cages in Hawaii is 6.78 out of 10, which is in the green range. With one red criterion the final recommendation is a “Good Alternative.”

Introduction

Scope of the analysis and ensuing recommendation

Species
Almaco jack (*Seriola rivoliana,* Valenciennes 1833).

Geographic Coverage
United States of America (Hawaii)

Production Method(s)
marine net pens

Species Overview

Brief overview of the species
Seriola spp., belonging to the Carangidae family, are of high interest for aquaculture diversification, with a well-established market already for some species (Sicuro and Luzzana 2016). *Seriola rivoliana* (longfin yellowtail, amberjack, or Almaco jack) are globally distributed; they are found in the Indo-West Pacific, east Pacific, and western Atlantic oceans with some records of sightings in the Mediterranean Sea (Benetti 2004) (Sicuro and Luzzana 2016). Almaco jack has an elongated body, moderately deep, and is slightly compressed. The maximum recorded weight and length in the wild are 59.9 kg and 160 cm, respectively. Almaco jack is benthopelagic and found to depths of 160 m or more. The natural diet of Almaco jack consists mainly of fish and invertebrates (FishBase[2]).

There is no commercial exploitation of wild Almaco jack due to concerns over ciguatera fish poisoning (CFP) and internal parasites in the flesh (Tamaru et al. 2016). CFP is a human foodborne illness that presents gastrointestinal and neurological symptoms caused by the consumption of fish that contain ciguatoxin, which originates from microscopic algae (dinoflagellates in the genus *Gambierdiscus*) in the food web (Friedman et al. 2017). Amberjack was one of the species of fish associated with ciguatera fish poisoning cases in Hawaii from 1963 to 2012 (Copeland et al. 2014). Fortunately, this problem can be eliminated in aquaculture settings through prudent management of hatchery and growout operations (Benetti 2004) (Campora et al. 2010) (Tamaru et al. 2016). Though Almaco jack is occasionally targeted by sport fishermen, extraction pressure on this fish is relatively low, and there has been no determination of endangered or conservation concern status for this species.

Production system
Seriola spp. are of high interest for aquaculture diversification. The yellowtail (*S. quinqueradiata*) is one of the *Seriola* spp. that has the longest farming history, which started in

[2] FishBase: https://www.fishbase.de/summary/seriola-rivoliana

the early 1960s relying on wild stocks (Sicuro and Luzzana 2016). Following the success for rearing yellowtail, other species including *S. rivoliana* were considered for farming (Sicuro and Luzzana 2016).

Almaco jack adapts well to culture conditions and dry commercial feed. Although hormonal induction of spawning is possible in *S. rivoliana*, it is not practiced in every culture system e.g., (Roo et al. 2014) (Sicuro and Luzzana 2016).

Currently, there is only one commercial producer of Almaco jack in Hawaii, and the United States (Blue Ocean Mariculture, personal communication March 2018). There are two other sites in Hawaii that occasionally raise Almaco jack; however, these are primarily research facilities that conduct trials for offshore aquaculture and feeds for Almaco jack in federal waters (N. Sims, personal communication October 2019)

The company began operating at this farm site in 2009 though the site was originally founded by a separate company in 2005 (Blue Ocean Mariculture[3]). The company has a land-based hatchery and an offshore growout site. The land-based hatchery consists of live feeds production, larval rearing, broodstock maintenance, and nursery holding. The offshore site is a 90-acre lease area about one-half mile offshore from Ulualoha Point, North Kona, Hawai`i County, and consists of a set of sea cages located in a grid (Blue Ocean Mariculture, personal communication March 2018).

The site consists of five SeaStation® Single Rim copper-alloy mesh (CAM) cages, with a volume of 8,000 cubic meters (m^3) each. There are about 130,000 fish stocked in each cage. The fish are fed an EWOS/Cargill yellowtail feed. The fish are stocked at about 20 to 30 g and harvested at 2 to 3 kg. Once the marketable size is reached, the fish are harvested into ice totes and delivered to a land-based processing facility (Blue Ocean Mariculture, personal communication March 2018).

Production Statistics

Global aquaculture of *Seriola* spp. is in excess of 150,000 metric tons (MT)[4] per year. For the past six years the farm has produced between 247 and 566 MT per year of Almaco Jack (Figure 1), which is less than one percent of the global production of *Seriola* spp.

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[3] Blue Ocean Mariculture: http://www.bofish.com/

[4] Food and Agriculture Organization of the United Nations: http://www.fao.org/fishery/statistics/global-aquaculture-production/query/en

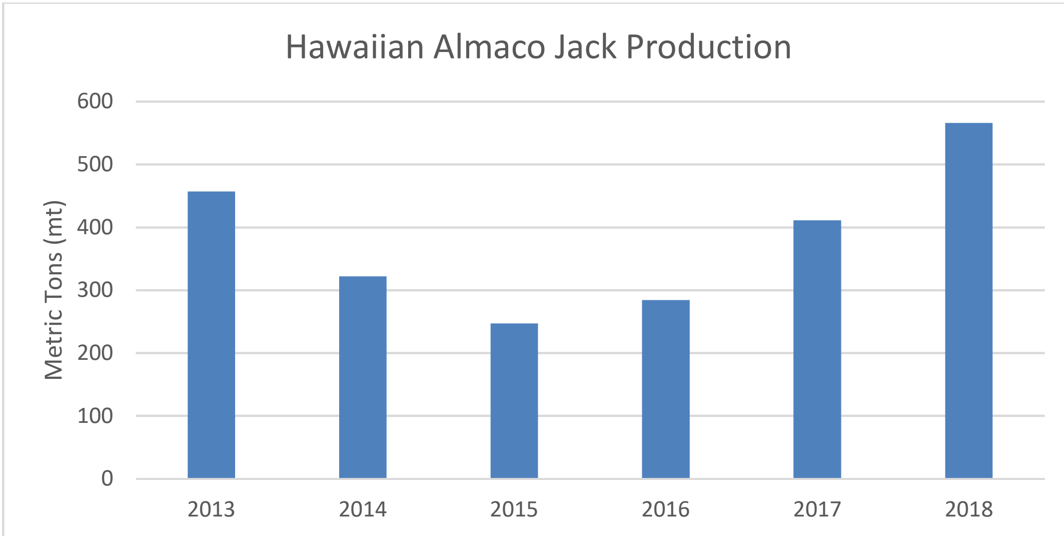


Figure 1. Production of Almaco jack by the only producer in the US, located in Hawaii (source: BOM, June 2019).

Import and Export Sources and Statistics
The great majority (99.9%) of United States farmed Almaco jack remain in the domestic market, with the remainder being exported to Canada (Blue Ocean Mariculture, personal communication March 2018).

Common and Market Names

Scientific Name	*Seriola rivoliana*
Common Names	Kampachi, kahala, Almaco jack, long-fin yellowtail

Product forms
The fish are available whole, as a collar cut, or as a whole or belly fillet.

Criterion 1: Data quality and availability

Impact, unit of sustainability and principle

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

Criterion 1 Summary

Data Category	Data Quality	Score (0-10)
Industry or production statistics	10	10
Management	10	10
Effluent	10	10
Habitat	10	10
Chemical use	7.5	7.5
Feed	7.5	7.5
Escapes	5	5
Disease	5	5
Source of stock	7.5	7.5
Predators and wildlife	7.5	7.5
Introduced species	10	10
Other – (e.g., GHG emissions)	Not Applicable	n/a
Total		**90**

C1 Data Final Score (0-10)	8.2	GREEN

Brief Summary

Because the entire US *Seriola* industry is composed of one commercial operation in Hawaii, there is little publicly available or peer-reviewed scientific literature specific to this regional industry. However, data required for this assessment were obtained from the farm upon request, and monitoring reports by state agencies are available online. The company also provides water quality and benthic monitoring data online. The overall data availability and quality is good and the score for Criterion 1 – Data is 8.2 out of 10.

Justification of Rating

Production

The global production volume of *Seriola* species is available from the Food and Agriculture Organization (FAO) and country-level production is reported through the National Oceanic and Atmospheric Administration (NOAA) in the United States. The FAO country-level estimates are based on the single producer in the US, and farm-level information was provided through direct personal communication from Blue Ocean Mariculture. The data score for the industry and production statistics is 10 out of 10.

Management

Detailed permit documentation and regulatory reporting was provided by the farm. Other information related to various regulations related to permits; water quality management is available through various agencies including the U.S. Environmental Protection Agency (EPA), U.S. Army Corps of Engineers (USACE), The U.S. Coast Guard, Department of Land and Natural Resources, State of Hawaii, NOAA office for Coastal Management, The U.S. Environmental Protection Agency (EPA), Hawaii State Department of Health (DOH), and the Division of Aquatic Resources (DAR), DLNR, State of Hawaii. The data score for management is 10 out of 10.

Effluent

The farm conducts on-farm monitoring of the local environment and the results from the sampling tests are publicly available on the farm's website.[5] Reports up to the year 2015 are available online and the latest report used in this assessment was provided by personal communication with the farm. Additionally, the farm is located directly offshore from the Natural Energy Laboratory of Hawaii Authority (NELHA) which has several ocean-water intake pipes, all of which are monitored for water quality. Overall there is a comprehensive water quality monitoring program on the farm, which is also corroborated by information from the water quality monitoring program of a neighbouring government facility. The data score for the effluent category is 10 out of 10.

Habitat

The data used to assess the Habitat criterion include regular benthic monitoring provided by the farm and ongoing water quality monitoring by NELHA which evaluates ecosystem health, interactions with protected species and changes in benthic assemblages. A public comment period and an open public hearing were required as part of the approval process for the permit modification to allow the farm to expand. The process for adding new pens specifically requires several studies of potential habitat impacts, including an Environmental Impact Statement for further expansion, as well as a review of environmental concerns with existing state and county planning processes. The Environmental Assessments and Environmental Impact Statement are publicly available with respect to the company's existing permit. Much of the waters near Hawaii are already included in a National Marine Sanctuary (the Hawaiian Islands Humpback Whale National Marine Sanctuary), and there is a well-established set of regulations available from the State of Hawaii and US federal government. Additionally, information relating to permits and monitoring requirements, and enforcement of the legal requirements are available

[5] Blue Ocean Mariculture: http://www.bofish.com/stewardship/monitoring/

upon request from the farm and/or agency responsible for monitoring. The overall score for the Habitat category is 10 out of 10.

Chemical Use

Chemical use is regulated by several federal agencies in the US. The discharge of any chemicals into the waters at the farm is prohibited without a specific permit of approval within the Hawaiian Island Humpback Whale National Marine Sanctuary. For this reason, the company relies primarily on the use of hydrogen peroxide, which requires submission of a treatment plan to the Fish and Wildlife Service division responsible for INADs (Investigation of New Animal Drug), which then supplies the information to the FDA. Data on the use of any chemical, and the quantities used, were provided by Blue Ocean Mariculture. Communication with the farm, as well as with members of regulatory agencies helped inform this criterion. The Chemical Use category data score is 7.5 out of 10.

Feed

All data on the feed conversion ratio, inclusion rates, yields and sources for all proteins and oils were obtained from the farm. The information for the feed was provided to the farm by the feed manufacturer. Some data on the fishery management and status of various fish stocks used in the feed were obtained from Fishsource. The feed category Data score is 7.5 out of 10.

Escapes

In general, the inherent escape risks associated with marine net pens are well studied. The farm reports escape events (>50 fish) to the Division of Aquatic Resources, State of Hawaii. Data on escape events and trickle losses (or leakage) were provided by the farm. Data on the fate of the escapees, and their impacts on wild stock genetics is limited. The data score for the Escapes category is 5 out of 10.

Disease

The farm performs disease and parasite monitoring. No antibiotics have been administered during the current owners' tenure. This information was confirmed by the State Aquatic Veterinarian and an independent veterinarian. In an event of disease, the farm is required to report to the Office of Conservation and Coastal Lands (OCCL), Division of Aquatic Resources (DAR), State of Hawaii, and the State Aquatic Veterinarian. Ectoparasite prevalence in wild fish is reported to OCCL. Data on the ectoparasite levels in wild fish were available from the farm, but no data on the ectoparasite levels in the farmed fish were available at the writing of this assessment. The data used for this criterion are mainly from the farm, and thus the Disease category score is 5 out of 10.

Source of Stock

The industry relies on catching a small number of locally caught, wild fish as broodstock each year. The date, time, place, and condition of all local broodstock that are captured is recorded by the farm. The wild stock is considered healthy because there is limited demand for the fish either as subsistence or in the market; however, there is no stock assessment performed for the species. The species is distributed globally, and it is highly fecund. The species is not considered threatened or endangered.[6] The data source for this category is 7.5 out of 10.

Wildlife and Predator Mortalities

The farm reports all interactions with wildlife to the appropriate agencies. The data used for the assessment are from the farm, and reports from regulatory agencies. The score for the predators and wildlife category is 7.5 out of 10.

Introduction of Secondary Species

The farm is the only offshore commercial farm in Hawaii. The hatchery for the farm is located on land. Based on information from the farm, maps, and licenses, there is no possibility for trans waterbody movements between these facilities. Therefore, the score of this category is 10 out of 10.

Conclusions and Final Score

The bulk of the data for this assessment were provided by the farm. In some cases, the data were verified by other agencies, from peer-reviewed literature or from personal communication with members of regulatory agencies. Overall, the peer-reviewed literature on Almaco jack is limited and information is utilized from other marine species as a proxy, where necessary. Overall, the data quality is good and the final score for Criterion 1 – Data is 8.2 out of 10.

[6] https://www.iucnredlist.org/species/16507347/16510402

Criterion 2: Effluent

Impact, unit of sustainability and principle

- Impact: aquaculture species, production systems and management methods vary in the amount of waste produced and discharged per unit of production. The combined discharge of farms, groups of farms or industries contributes to local and regional nutrient loads.
- Sustainability unit: the carrying or assimilative capacity of the local and regional receiving waters beyond the farm or its allowable zone of effect.
- Principle: 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)	**9**	**GREEN**
Critical?	NO	

Brief Summary

Since effluent data quality and availability is good for Hawaii Almaco jack, the Evidence-Based Assessment was used. Based on the nature of the production system (i.e., submersible marine net pens), all effluent waste generated by the cultured fish immediately enters the ocean environment and cannot be treated before being released. Thus, the only way to manage the amount of effluent generated, and any subsequent environmental impacts, is by actively managing the quantity and content of the feed provided to the fish, stocking density and siting of the farm. Even though the farm directly discharges its effluent to the environment, monitoring of the local environment, in combination with ongoing water quality monitoring by the nearby state-run energy laboratory, indicates that nutrient concentrations have been well below regulatory permit limits. Nutrient inputs are highly unlikely to have had any substantial adverse impacts on the surrounding water quality or the seabed since the farm's construction. The final score for Criterion 2 – Effluent is 9 out of 10.

Justification of Rating

Criterion 2 – Effluent, assesses the ecological impact of aquaculture operations *beyond* that of an "allowable zone of effect" whereas Criterion 3 – Habitat, assesses those impacts within this zone. Regulatory agencies often have allowable-impact and monitoring standards that differ with respect to distance from farm infrastructure.

The benthic monitoring data in Criterion 3 shows there is no difference between samples taken directly below the cages and those taken roughly 300 m from the cages. None of the samples show a significant impact. Therefore, the farm is not considered to impose a benthic impact beyond the AZE. Criterion 2 therefore focuses on the water column impacts only.

Since effluent data quality and availability is good (i.e., Criterion 1 score of 10 out of 10 for the effluent category), the Evidence-Based Assessment was used.

Most of the feed consumed is retained by the fish for activity and growth. The rest is released as dissolved inorganic nutrients (ammonia [NH_3] and phosphate [PO_4]) through excretion; and particulate organic nutrients (particulate organic nitrogen [PON] and particulate organic phosphorous [POP]) through defecation (Olsen et al. 2008) (Figure 2).

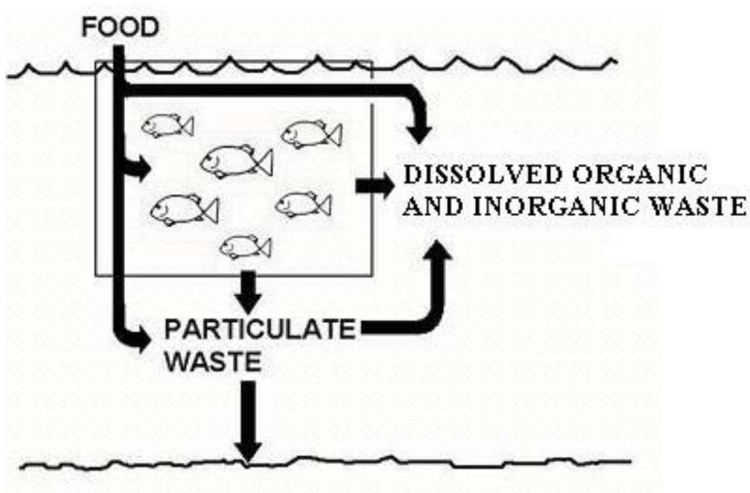


Figure 2. Feed is assimilated by the fish, and metabolites are released as particulate waste and dissolved organic and inorganic waste (source: Olsen et al. 2008).

Net pen production systems are open to the environment, which results in enrichment of the waters through the release of nutrients (Holmer 2010) (Price et al. 2015). The environmental impact of net pen production depends on the stocking density and total biomass, feeding strategy and location (e.g., background nutrient levels, proximity to sensitive habitats, currents, and depth), among other factors (Gentry et al. 2017).

At the farm, particulate organic matter is released from uneaten feed, feces, and the organic matter (biofouling) released from cleaning of the net pens. The discharge of various nutrients has the potential to affect different parts of the marine system. Particulate organic matter sinks to the benthos, and has the potential to affect the benthic communities, whereas dissolved nutrients stay within the water column, and more directly affect the pelagic communities (Olsen et al. 2008). Net pens located in deeper water and stronger currents are less likely to have a negative impact on the local environment because of the higher diffusion of organic matter (Gentry et al. 2017). Price et al. (2015) conclude that modern site selection processes and operating procedures have minimized impacts of most individual fish farms on marine water quality. Effects on dissolved oxygen and turbidity have been largely eliminated through better feed management, and near-field nutrient enrichment to the water column is usually not detectable beyond 100 m of the farm (when formulated feeds are used, when feed waste is minimized, and when farms are properly sited in deep waters with flushing currents) (Price et al. 2015).

Marine waters in Hawaii can fall under two classifications: either A or AA (both bounded by 100 fathom contour or 600-foot depth contour). Class A waters can be used for “recreational purposes and aesthetic enjoyment,” whereas Class AA waters are to “remain in their natural pristine state as nearly as possible with an absolute minimum of pollution or alteration of water quality from any human-caused source or actions.”[7] The farm is situated in surrounding waters that are classified as AA by the Hawaii Department of Health (Hawaii Water Quality Standards Map[8]).

The U.S. Environmental Protection Agency (EPA) administers the National Pollutant Discharge Elimination System (NPDES) program which, under the Clean Water Act, requires an authorization or permit[9] in order to legally discharge any pollutant. The farm operates under the NPDES permit issued by EPA after a standard National Environmental Policy Act (NEPA) evaluation process from over 20 federal and state agencies. It is managed by the Federal EPA (District 9) and State of Hawaii Department, Clean Water Branch (Blue Ocean Mariculture, personal communication September 2018).

Based on the NPDES permit, the farm conducts monthly monitoring of the following water quality parameters: temperature, salinity, dissolved oxygen, pH, turbidity, total nitrogen, total ammonia nitrogen, nitrate + nitrite, and total phosphorous. These water quality parameters are taken at three different depths (surface, mid-water, and bottom depths) and at various locations (control sites, an effluent-origin site, and nearby zone-of-mixing sites) (Blue Ocean Mariculture, personal communication September 2018). The locations for these samples are outlined in Figure 3.

[7] http://health.hawaii.gov/cwb/files/2013/05/PN_20140826_1154Proposed.pdf
[8] https://health.hawaii.gov/cwb/files/2013/05/IslandHawaii.pdf
[9] Clean Water Act: https://www.epa.gov/laws-regulations/summary-clean-water-act

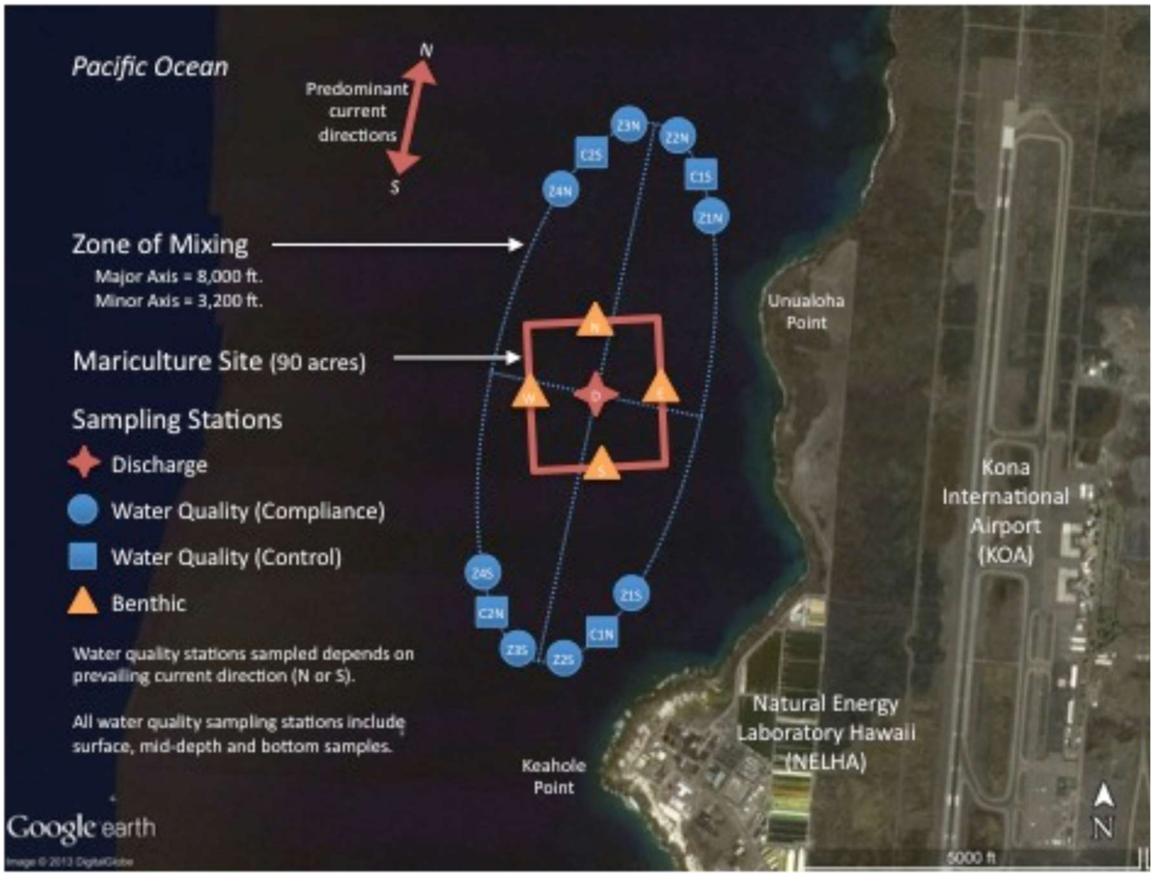


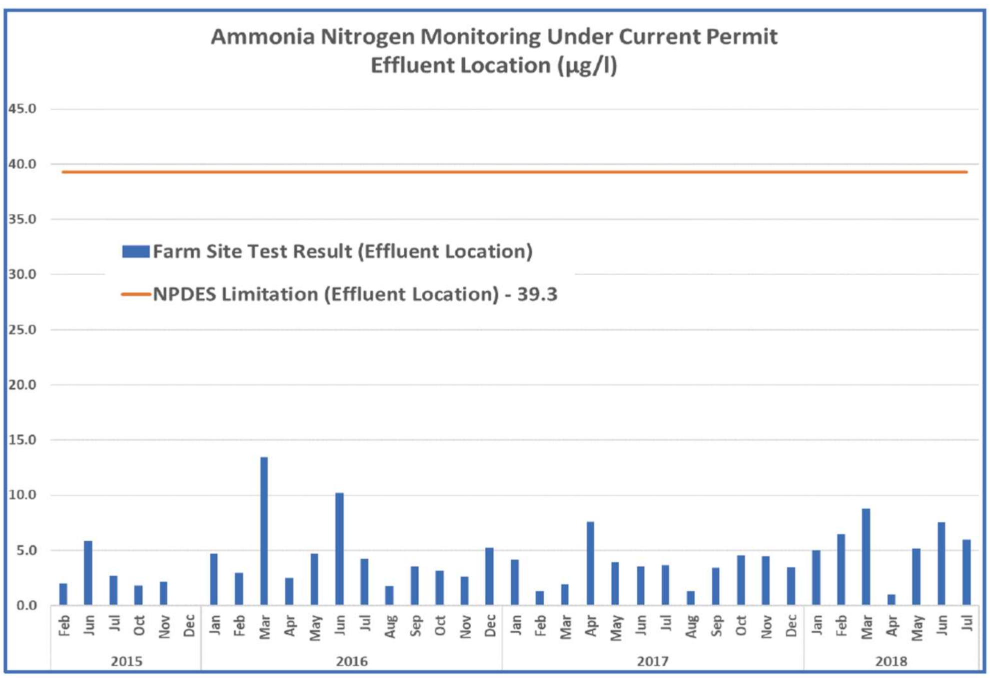
Figure 3. Blue Ocean Mariculture farm site. The orange triangles represent the locations utilized for benthic sampling (image taken directly from BOM benthic monitoring report 2017).

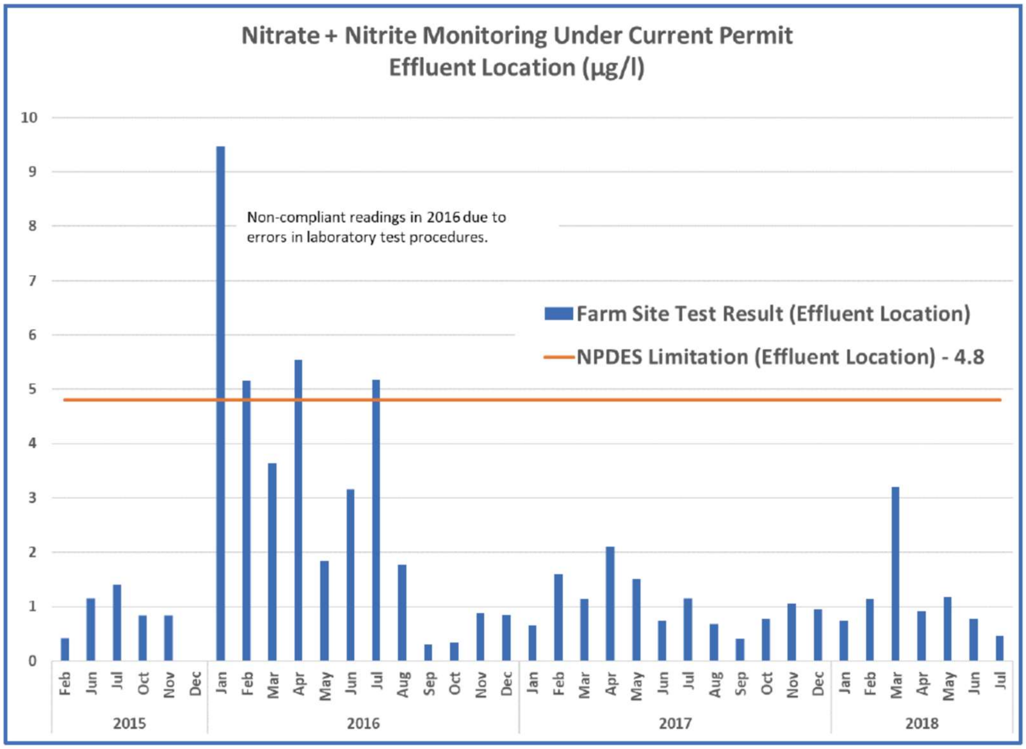
The temperature, salinity, and dissolved oxygen at the control sites near the farm remain relatively stable throughout the year (see Table 1). The focus of the effluent assessment is on nutrient effect. Parameters such as pH, temperature, and salinity are less likely to be affected by the farm, and they will not be the focus of this criterion.

Table 1 Sea water characteristics at control sites near the farm 2013–2018

Parameter	Mean	Range	Unit
Temperature	26.19	23.80-28.40	°C
Salinity	36.17	34.61-37.06	ppt
Dissolved Oxygen	6.44	5.71-8.26	mg/l

Based on the water quality data, provided by the farm, from 2015 to mid-2018, there was no indication of nutrient enrichment beyond the allowed NPDES permit concentration limits, which are based on the State of Hawaii definition of class AA Marine waters (Blue Ocean Mariculture, personal communication September 2018). Ammonia nitrogen, nitrite and nitrate, and turbidity measured at the farm from 2015 to 2018 can be found in Figure 4. This dataset is regularly compared to NPDES permit limitations for water quality of effluent from offshore aquaculture cages. Ammonia nitrogen did not exceed the NPDES limit permit (Figure 4). Nitrite and nitrate did not exceed the NPDES limit permit except for the year 2016 due to errors in laboratory testing. Since the farm's inception in 2009, the levels of all compounds monitored by the NPDES permit have been well below the permissible effluent limits, which are based on the State of Hawaii definition of class AA Marine waters HAR 11-54-06, for the following six primary water quality parameters: pH, turbidity, total nitrogen, ammonia nitrogen, nitrate + nitrite, and total phosphorous. These results confirm that there has been no significant impact from the farm's nitrogenous and phosphorous effluents.





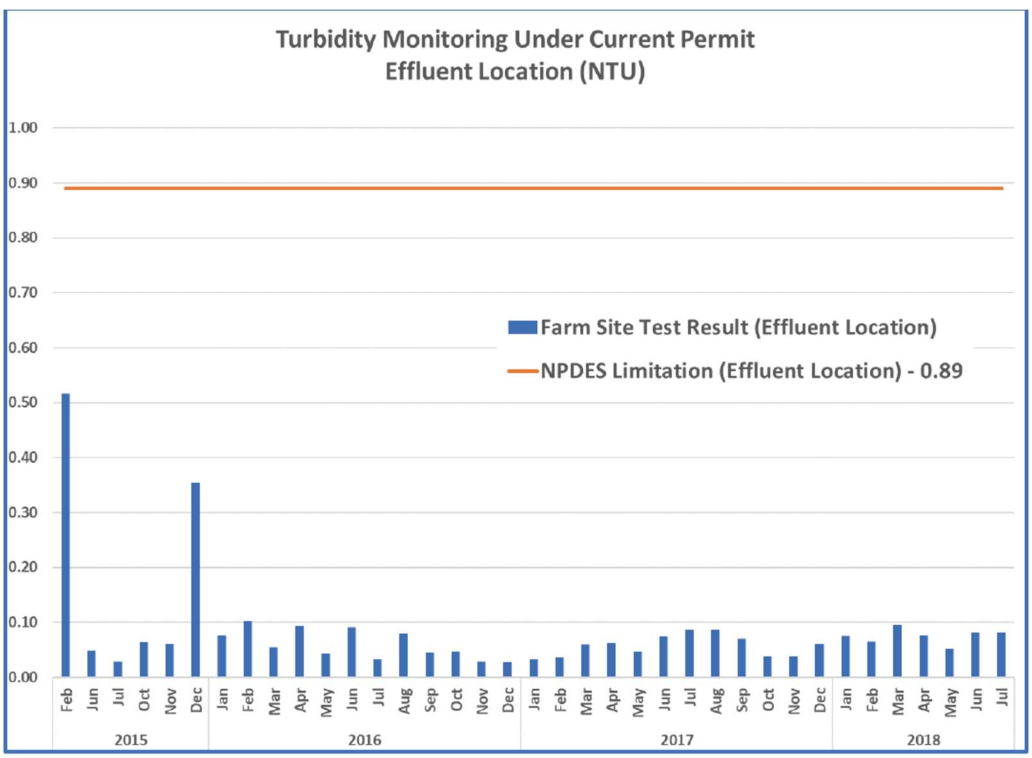


Figure 4. Monitoring results for key nutrient parameters (ammonia nitrogen, nitrite and nitrate, and turbidity) measured at the farm from 2015 to 2018. (Source: Blue Ocean Mariculture 2018).

In 2014, the farm conducted an environmental analysis of its current operation alongside its proposal to expand its operation. The application for expansion was from a maximum of five cages with individual volume no more than 7,000 m^3 with maximum capacity of 24,000 m^3 to eight cages with individual volume of 8,000 m^3 and a maximum capacity of 72,000 m^3. In this environmental assessment, the total load of nitrogen from the facility was estimated to be 134 MT of nitrogen per year, as compared to background nutrient load in the water column of 38,032 MT of nitrogen per year. This indicates that the farm contributes 0.35% of the total nitrogen identified at discharge monitoring stations, which is insignificant.[10]

The farm further estimated that the proposed increase in farmed biomass (from 500 MT per year to a projected of 1,100 MT/year by 2018) would increase projected nitrogen readings at discharge monitoring stations to approximately 100.78 µg/l, whereas their NPDES permit would allow up to 150 µg/l[11]. The farm gained approval for its expansion plans, although the production for 2018 did not reach the projected 1,100 MT (Blue Ocean Mariculture, personal communication 2019).

The farm is located immediately offshore from the Natural Energy Laboratory of Hawaii Authority (NELHA). This is a Hawaii state agency that operates the Hawaii Ocean Science and Technology Park, which houses many commercial, research, and educational operations.[12] Because this facility provides its tenants with a steady supply of ocean water from various offshore pipes, it has been conducting water quality monitoring since 1982. Though much of the focus of these studies has been on onshore and near-shore water quality measures, the facility also tests water quality in the offshore environment along transects sampled from a boat. The offshore component of the NELHA monitoring program has been sampling water quality quarterly at the Keahole Point area since 1993. A total of six transects, with five sampling points, perpendicular to the Keahole Point (500 m seawards) are sampled. The two most northern sampling points (Transect 1 Station 5 and Transect 2 Station 5) are within 1,000 m of the farm (see Appendix 2).

The results of the NELHA water sampling project have shown that in the years since BOM began operations (since 2009), the annual geometric mean of turbidity, total dissolved nitrogen, total ammonia nitrogen, nitrate + nitrite, ortho-phosphate, and chlorophyll-a show no significant increase in the sampling sites closest to the Almaco Jack pens. At times the values do exceed the limits of the Hawaii Department of Health limit in Class AA ocean waters, however, there is no indication that this has increased since the start of the farm in 2009. Although there have been some fluctuations in the parameters (e.g., total ammonia nitrogen) this has not been

[10] http://oeqc2.doh.hawaii.gov/EA_EIS_Library/2014-10-08-HA-FEA-Capacity-Increase-at-Blue-Ocean-Mariculture-Facility.pdf
[11] https://dlnr.hawaii.gov/occl/files/2013/08/3720-staff-report-and-permit.pdf
[12] NELHA: http://nelha.hawaii.gov/

attributed to anthropogenic or natural nutrient inputs. The most likely cause of these results are sampling and analytical errors.[13]

Conclusions and final score

Based on the farm monitoring program as a requirement for the NPDES permit, and the NELHA long-term monitoring of water quality parameters in the area, the data show the effluent discharge is of similar quality as the influent water supply, and show no evidence that effluent discharges cause or contribute to cumulative impacts at the water body regional scale. Finally, since the farm was established, the surrounding waters have remained classified as AA by the Hawaii Department of Public Health, which indicates high quality waters. Thus, the final score for Criterion 2 – Effluent is 9 out of 10.

[13] https://nelha.hawaii.gov/wp-content/uploads/2018/05/1982-2018_NELHA_CEMP_ReportV5.pdf

Criterion 3: Habitat

Impact, unit of sustainability and principle

- Impact: Aquaculture farms can be located in a wide variety of aquatic and terrestrial habitat types and have greatly varying levels of impact to both pristine and previously modified habitats and to the critical "ecosystem services" they provide.
- Sustainability unit: The ability to maintain the critical ecosystem services relevant to the habitat type.
- Principle: 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
F3.2a Content of habitat regulations	5	
F3.2b Enforcement of habitat regulations	5	
F3.2 Regulatory or management effectiveness score		10
C3 Habitat Final Score (0-10)		**9.3**
Critical?	NO	**GREEN**

Brief Summary

The farm conducts regular water and benthic monitoring, and publishes the results on its website. Also, in combination with ongoing water quality monitoring that includes information on ecosystem health, interactions with protected species and changes in benthic assemblage have been conducted since the inception of the operation in Hawaii. All data from these monitoring efforts indicate that the marine habitat has experienced minimal habitat impacts and no loss of habitat functionality as a result of the presence and operation of this farm. In addition, since the aquaculture operation under assessment is located adjacent to a National Marine Sanctuary, there are strict regulations and strong enforcement to prevent future habitat impacts. The score for Criterion 3 – Habitat is 9.3 out of 10.

Justification of Rating

Factor 3.1. Habitat conversion and function

For net pen farms, Factor 3.1 describes any ecological impacts beneath and within 30 m from the farm footprint (inside the "allowable zone of effect"). The ecological impacts are evaluated by ongoing functionality of the habitat and any historic habitat conversion or loss of ecosystem services as a result of the presence of the farm.

Kona Blue Water Farms was initially given Federal and State permits for aquaculture in 2004 (Sims 2013), and by 2011 it was transferred to Blue Ocean Mariculture. The farm is situated approximately one-half mile (~ 0.8 km) off the coast from a shoreline of diverse coral reef community with a steep basaltic (lava) cliff. The farm is sited in waters over 200 feet (~ 61 m) deep, over flat sandy bottom. The waters in the area are relatively nutrient-poor and have good visibility. Strong, turbulent currents are found in the area, which disperse and allow for the assimilation of nutrients[14] (Sims 2013). Farms located in areas with well-flushed water typically have lower impacts on water quality and habitat (Price et al. 2015).

Seafood Watch defines offshore habitats (low value) to be located three or more nautical miles from the shoreline. Although the farm is located in deep waters over a flat, sandy bottom, it is still within three nautical miles of the narrow coral reef shoreline, and it is considered, based on the Seafood Watch Aquaculture Standard, to be situated in, if not directly adjacent to a high-value coastal habitat.

Historically, the farm lease area has had limited public use because of the depth, barren benthic environment, and low fish residency (Sims 2013). Since the physical structure of net pens have little direct effect on the habitat, it is the operational impacts of the farm discharges (fish waste, uneaten feed, bio-fouling material from cages) on the chemical composition and biological communities beneath the farm and the adjacent areas that are considered.

The farm ensures that these concerns are addressed in a transparent and objective monitoring of the environment by using third parties to collect and analyze samples, and use of local water quality laboratories, such as NELHA. The farm monitors the water quality as part of the NPDES requirements. Any reports on the environmental monitoring of the farm are placed in local repositories so that the public can review them.[15]

The farm conducts annual benthic monitoring from different locations around the farm, as outlined in Criterion 2 (see Figure 3).

The annual benthic reports (up to the year 2015) can be found on the farm's website.[16] Each sample collected is assessed for general appearance, macro-fauna, macro-algae, oxidation/reduction potential, odor (presence of H_2S), total organic carbon, benthic sand characterization, micromollusc characterization, copper and zinc characterization. Based on the latest benthic monitoring report for 2017, no changes in sediment were apparent prior to the establishment of the farm. This report was provided by the farm (Blue Ocean Mariculture, personal communication 2018). Total organic carbon and oxidation-reduction potential for the period 2010 to 2017 shows some fluctuations, but within expected limits (see Figures 5 and 6).

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[15] Blue Ocean Mariculture: http://www.bofish.com/stewardship/monitoring/
[16] Blue Ocean Mariculture: http://www.bofish.com/stewardship/monitoring/

The total organic carbon (TOC) measures the overall carbon from organic compounds such as decaying vegetation, bacterial growth, and metabolic activities of living organisms or chemicals. High levels of TOC indicate contaminant discharged from the farm. Based on the TOC data collected between 2007 and 2017 (Figure 5) variability has been decreasing except for the period between 2007 and 2009 (BOM benthic monitoring report 2017). The decreasing trend in TOC noted since earlier years is suggested to be due to improved food technology and waste management. Any differences that may be found in benthic composition over the years are more likely related to the natural hydrological characteristics of the farm location, induced by the strong currents, rather than the farm itself (BOM benthic monitoring report 2017).

The modelling software AquaModel was designed to predict effects of fish aquaculture on the sea bottom and water column (Rensel et al. 2015). The model was also used previously in Hawaii to evaluate theoretical impacts of a fish farm and cumulative effects of multiple farms on the environment (Rensel et al. 2015). The AquaModel was applied for the first time to evaluate the impacts of the farm on the benthos for the year 2013–2014 (Rensel et al. 2015). Neither the modelled nor measured organic carbon indicated any risk for increased biological activity below the sea cages. This is mainly because the farm has an overall low fish production, is located in deep waters with moderately strong currents, and all the nutrients are assimilated into the food web (Rensel et al. 2015).

The AquaModel is still used by the farm. The model was used to produce a site-wide dilution analysis in 2018 as part of the Federal EPA NPDES permit (Blue Ocean Mariculture, personal communication 2019).

Oxygen-reduction potential (ORP) measures the ability of the water to accept or release electrons, which is an indirect measure for biological activity in the benthos. Low (negative) ORP value indicates higher anaerobic conditions. A farm releases organic waste, which could lead to a decrease in the ORP. High variability in ORP values has been noted from 2010 to 2017 below the farm (Figure 6). For the period 2010 to 2017 the recorded ORP values have all exceeded 100 millivolts (BOM benthic monitoring report 2017).

Based on the latest benthic report of the farm (2017) the micromollusc sampling indicated variation in the number of individual molluscs across different sampling sites (Figure 7) and an overall increase (from 2013 to 2017) in number of mollusc species across the different sampling sites with some sites (e.g., west) indicating steeper increase than other sites (e.g., north) (Figure 8). When classified by feeding habits, the micromolluscs found at the site in 2016 were found to be predominantly microherbivores, followed by suspension feeders, and detritivores (Figure 9). The BOM benthic monitoring report for 2017 indicates an overall increase in diversity in species, with variability in abundance between 2013 and 2017.

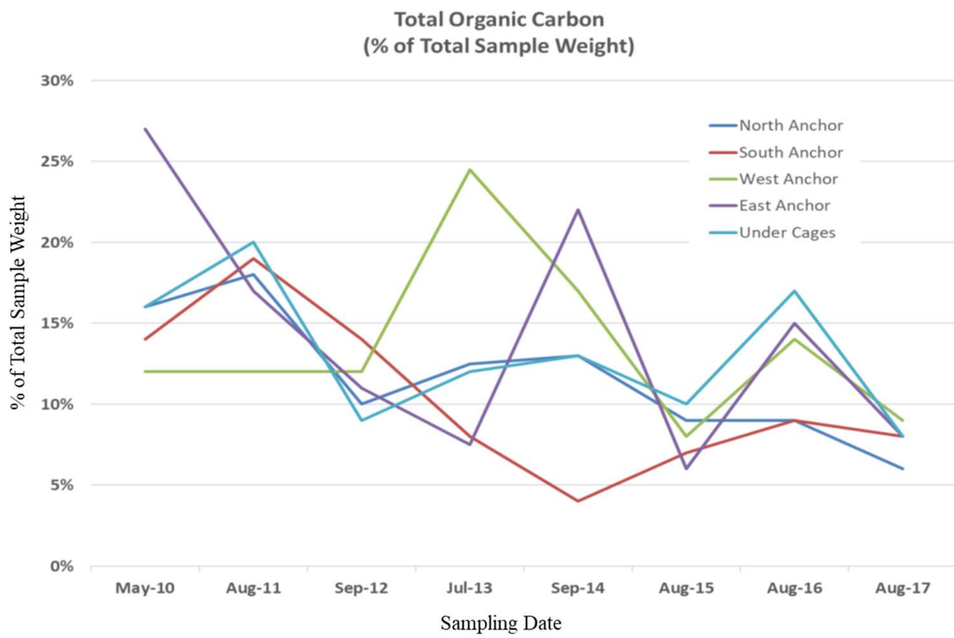

Figure 5. Total organic carbon for five locations sampled around the farm site from 2010 to 2017 (source: BOM benthic report 2017).

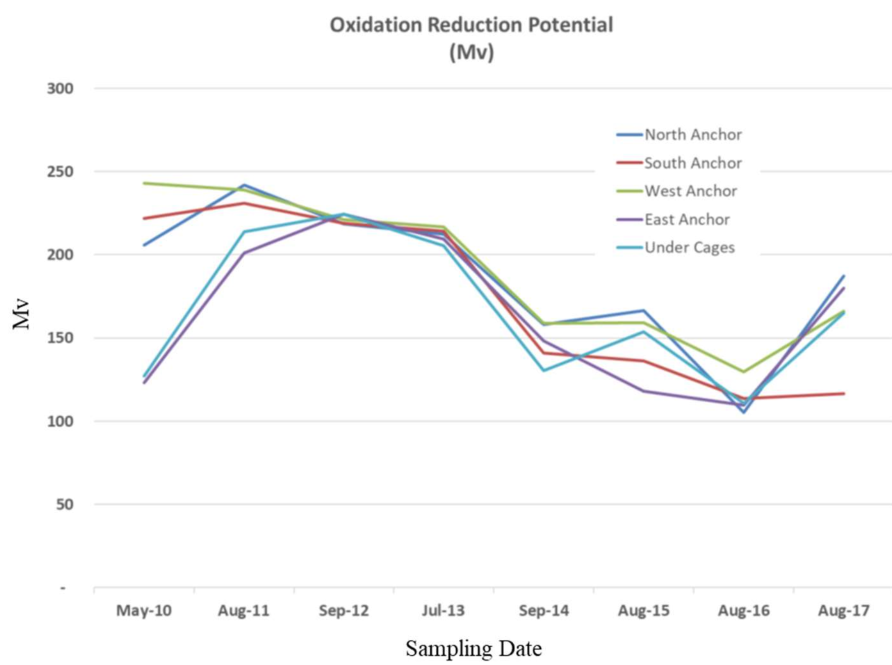

Figure 6. Oxidation reduction potential for five sampling locations around the farm site from 2010 to 2017 (source: BOM benthic report 2017).

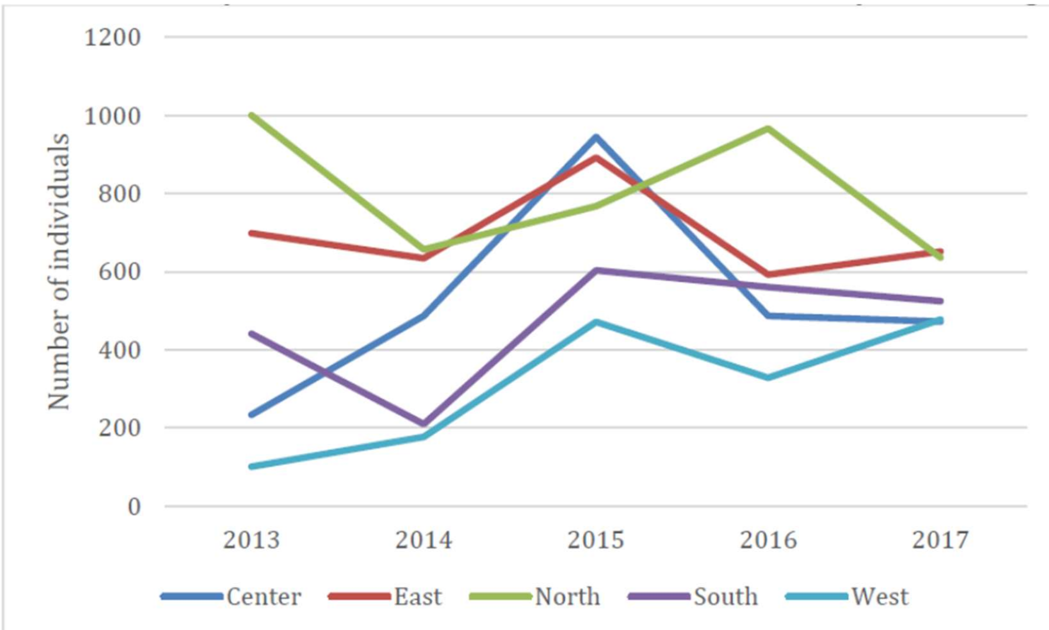

Figure 7. The number of individual molluscs sampled at five different stations from 2013 to 2017 (source: BOM benthic report 2017).

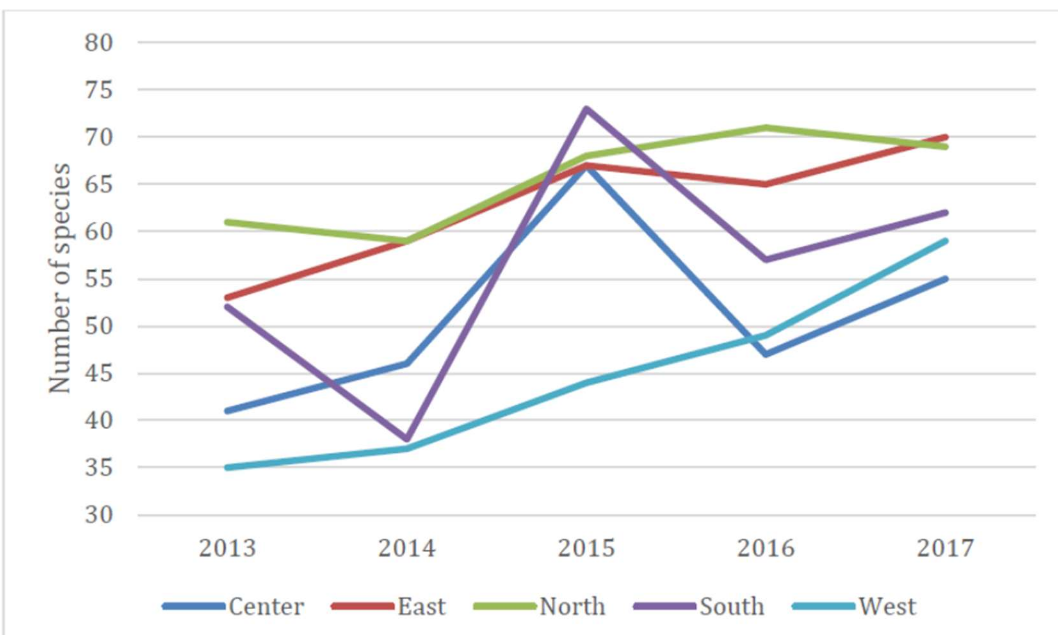

Figure 8. The number of species of molluscs sampled at five different stations from 2013 to 2017 (source: BOM benthic report 2017).

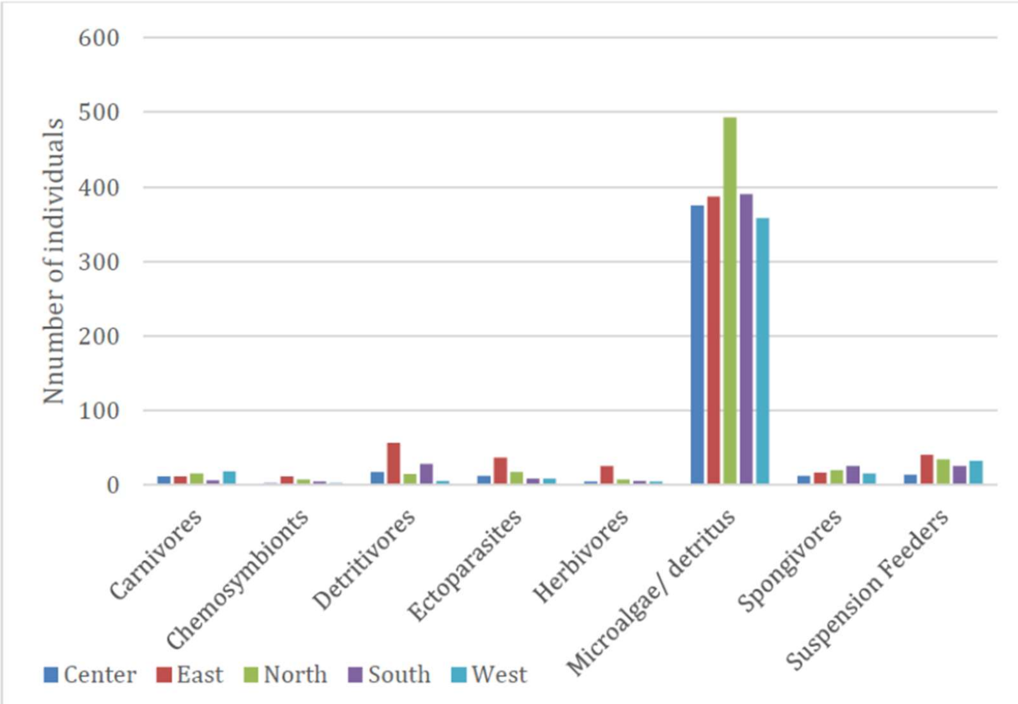

Figure 9. The abundance of micromolluscs based on feeding habit classification for 2016. (source: BOM benthic report 2017).

The report from the NELHA ongoing monitoring program of the benthos, biota, and water quality from 1982 through 2018 around the farm and other marine sites on the west coast of Hawaii indicated that the overall water quality has remained stable. This period also includes the time the farm has been in operation. The NELHA report also indicates that the coral cover has been slowly increasing and stabilizing between 30 to 50% for the last seven years of the report. The increase in coral cover has been taking place prior to the start of the farming activity. The nearshore fish communities have remained diverse and productive, indicating that overall no impacts have resulted from any human activities. The levels of chlorophyll-a or phytoplankton biomass have never exceeded the State of Hawaii Department of Health (HDoH) limit.[17]

Based on the farm's published data and NELHA's water quality monitoring there appears to be minimal farm impact, if any, on the local habitat. The benthic monitoring data from the farm and NELHA also indicate minimal impact on the benthos. The habitat conversion and function has remained relatively stable since the start of fish farming at this location and thus the score for Factor 3.1 is 9 out of 10.

Factor 3.2. Farm siting regulation and management

[17] https://nelha.hawaii.gov/wp-content/uploads/2018/05/1982-2018_NELHA_CEMP_ReportV5.pdf

Ecosystem impacts are driven largely by the cumulative effects of multiple farms in a location, habitat type, region or country, and on their separation distances, connectivity, and overall intensity. This factor (3.2) is a measure of the presence and effectiveness of regulatory or management measures appropriate to the scale of the industry. It is also, therefore, a measure of confidence that the cumulative impacts of farms sited in the habitats declared in Factor 3.1, above, are at appropriate spatial scales.

Factor 3.2a: Content of habitat management measures

Several federal agencies are involved in marine aquaculture policies: U.S. National Oceanic and Atmospheric Administration[18] (NOAA), the U.S. Fish and Wildlife Service,[19] U.S. Army Corps of Engineers[20] (USACE), U.S. Environmental Protection Agency[21] (EPA), U.S. Coast Guard,[22] U.S. Food and Drug Administration,[23] U.S. Department of Agriculture,[24] and the U.S. Coast Guard.[25] Most of the regulations and laws in state waters that allow for and control marine aquaculture activities are issued by state agencies. Table 2 offers an overview of the agencies and some of the permits required when starting an aquaculture operation in Hawaii.[26]

[18] U.S. National Oceanic and Atmospheric Administration: https://www.noaa.gov/
[19] U.S. Fish and Wildfish Service: https://www.fws.gov/
[20] Army Corps of Engineers: https://www.usace.army.mil/
[21] U.S. Environmental Protection Agency: https://www.epa.gov/
[22] U.S. Coast Guard: https://www.gocoastguard.com/
[23] U.S. Food and Drug Administration: https://www.fda.gov/
[24] U.S. Department of Agriculture: https://www.usda.gov/
[25] U.S. Coast Guard: https://www.uscg.mil/
[26] https://hdoa.hawaii.gov/ai/files/2013/03/Permits-and-Regulatory-Requirements-For-Aquaculture-in-Hawaii-2011-Final.pdf

Table 2 Agencies and some of the permits required when starting an aquaculture operation in Hawaii

Agencies	Permits
The U.S. Environmental Protection Agency (EPA)	Environmental Assessment/Environmental Impact Statement (EA/EIS)
U.S. Army Corps of Engineers (USACE), The U.S. Coast Guard	Department of the Army (DA) Permit (also involves USACE consultation with all other Federal agencies)
Department of Land and Natural Resources, State of Hawaii	Conservation District Use Permit (CDUP)
NOAA office for Coastal Management	Coastal Zone Management Consistency Review
The U.S. Environmental Protection Agency (EPA), Hawaii State Department of Health (DOH)	National Pollutant Discharge Elimination System/Zone of Mixing (NPDES/ZOM Permit)
Division of Aquatic Resources (DAR), DLNR, State of Hawaii	Aquaculture License

As of 2019, the entire Almaco jack industry in Hawaii consists of just one commercial farm. There are two other sites in Hawaii that occasionally raise Almaco jack; however, these are primarily research facilities that conduct trials for offshore aquaculture and feeds for Almaco jack in federal waters (N. Sims, personal communication 2019). Though the Almaco jack farming industry is quite small in Hawaii, the potential for cumulative impacts is managed through an extensive environmental assessment process. This process explicitly requires analysis of site-specific conditions and potential environmental impacts, including the potential for cumulative impacts (Hawaii Administrative Rule §11-200-10(7), State of Hawaii, Department of Health, Office of Environmental Quality Control).[27]

The Government of Hawaii[28] and the County of Hawaii are primarily responsible for regulating the farm activities. Water resources within 3 miles of land are managed through different divisions of the Hawaii State Department of Land and Natural Resources[29] which also overlaps with other state and federal agencies (Jokiel, et al. 2011). An aquaculture facility in state waters needs to have NPDES and ZOM (zone of mixing) permits in order to discharge effluent into state waters.[30]

Siting aquaculture in Hawaii depends on the state and county level zoning classifications (Corbin et al. 2017). Site approval or expansion of aquaculture activities is required from the State of Hawaii DLNR. Activities on the coastal and nearshore areas are managed under the Hawaii Coastal Zone Management Act 205A, Hawaii Revised Statutes. The Coastal Zone Management Program (CZMP) creates a network of various organizations (national, state,

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[27] Hawaii Administrative Rules, Title 11, Chapter 200: http://files.hawaii.gov/luc/docs/har_11_200.pdf
[28] The Government of Hawaii: https://portal.ehawaii.gov/
[29] Hawaii State Department of Land and Natural Resources: http://dlnr.hawaii.gov/
[30] https://hdoa.hawaii.gov/ai/files/2013/03/Permits-and-Regulatory-Requirements-For-Aquaculture-in-Hawaii-2011-Final.pdf

county, and private) whose actions affect the coastal resources in Hawaii[31] (Corbin et al. 2017). Any application for aquaculture activities requires a Conservation District Use Permit (CDUP), which requires an environmental assessment (SOH DLNR Applications and Forms[32]).

The National Environmental Policy Act of 1969 (NEPA) requires the review of environmental impacts of any project that requires an "action" by the federal government. This is done by preparing an environmental assessment.[33]

The environmental assessment required for a Conservation District Use Permit comes from Hawaii's Statutes Chapter 343.[34] This statute provides the basis for the promulgation of Hawaii's Administrative Rule 200, which provides the specifics surrounding an Environmental Impact Statement (SOH OEQC Guide to the Implementation and Practice of the Hawaii Environmental Policy Act). The environmental assessments specifically require analysis of every aspect of the proposed action, including all phases of aquaculture production, and all other technical, economic, social, and environmental characteristics (Hawaii Administrative Rule §11-200-10(4), SOH OEQC Guide). They require analysis of site-specific environmental conditions (Hawaii Administrative Rule §11-200-10(5), SOH OEQC Guide), as well as analysis of potential cumulative impacts of the project in conjunction with the surrounding environment, community, and other similar projects (Hawaii Administrative Rule §11-200-10(6), SOH OEQC Guide). In addition, the Environmental Assessment specifically requires the applicant to identify potential impacts (including cumulative impacts), and to identify measures to mitigate against direct, indirect, and cumulative impacts of the proposed actions (Hawaii Administrative Rule §11-200-10(7), SOH OEQC Guide). While the environmental assessment process is elaborate, and requires extensive interaction with various governmental agencies, there is no specified limit to the impacts of such facilities.

The application forms themselves indicate that the activities authorized must be consistent with promotion of conservation of high-value natural and cultural resources, and requires the applicant to address Hawaii's Administrative rules Title 13, Chapter 5, which addresses "conserving, protecting, and preserving the important natural and cultural resources of the State through appropriate management and use to promote their long-term sustainability and the public health, safety and welfare" (SOH DLNR CDUA Application) (SOH Administrative Rules Chapter 13-5).

A Special Coral Reef Ecosystem Fishing Permit (SCREFP) was issued in 2016 by the National Marine Fisheries Services (NMFS) to Kampachi Farms, LLC, to allow the testing of a new type of net pen for the culture and harvest of Almaco Jack in federal waters (offshore west of Keauhou

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[31] http://files.hawaii.gov/dbedt/op/czm/program/doc/czm_program_description_2011.pdf
[32] https://dlnr.hawaii.gov/occl/forms-2/
[33] https://hdoa.hawaii.gov/ai/files/2013/03/Permits-and-Regulatory-Requirements-For-Aquaculture-in-Hawaii-2011-Final.pdf
[34] Hawaii revisited statutes, Chapter 343: https://dlnr.hawaii.gov/occl/files/2013/07/hrs_343.pdf

Bay on the Island of Hawaii) for a two year period.[35] The fingerlings for the project were obtained from the farm. This demonstration pen site is now operated by Forever Oceans, LLC. Kampachi Farms is also in the process of applying for State and Federal permits for an offshore macroalgae (seaweed) R&D array (N. Sims, personal communication September 2019). No other new marine farms have been approved in recent years, other than the expansion of the current farm's activities.

The lease site is located at the southernmost boundary of the Hawaiian Islands Humpback Whale National Marine Sanctuary (HIHWNMS). One of the regulations that impacts aquaculture activities within the area states that discharge of any material is prohibited without an authorization (see Crecco 2013 and references therein).

The content of the habitat management measures is comprehensive, containing cumulative management with aquaculture farm siting integrated with other industries based on maintaining ecosystem functionality of the affected habitats.

The score for Factor 3.2a is 5 out of 5.

Factor 3.2b: Enforcement of habitat management measures

As noted in the previous section several agencies are responsible for overseeing aquaculture development and enforcement of regulations in the coastal zone of Hawaii. For example, at the federal level, NOAA's National Marine Fisheries Service Office of Law Enforcement (OLE) Pacific Islands Division, as well as the U.S. Coast Guard's District Fourteen, enforce aquaculture related regulations. At the state level, the State of Hawaii, Department of Land and Natural Resources, Division of Conservation and Resource Enforcement (DOCARE) enforces aquaculture related issues.[36]

In order to assure that the farm complies with various regulations, each regulatory agency has the right to visit the farm at their convenience (Blue Ocean Mariculture, personal communication June 2019). For example, the NOAA Marine Mammal Protection agency visits the farm roughly once per year, the State of Hawaii DLNR, Office of Conservation and Coastal Lands visit the farm once every 1 to 2 years, the State of Hawaii Department of Health, Clean Water Branch visit the farm once every 3 to 4 years and the State of Hawaii, Division of Aquatic Resources visit the farm every 1 to 2 years (Blue Ocean Mariculture, personal communication June 2019).

For water quality monitoring relating to state and federal permits, the farm is required to maintain records of all samples for inspection, which is done at least once per year. If the farm does not comply with regulations under the NPDES permit, the permit could be revoked.[37] Non-

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[35] https://www.regulations.gov/docket?D=NOAA-NMFS-2015-0137

[36] http://www.wpcouncil.org/managed-fishery-ecosystems/hawaii-archipelago/regulations-and-enforcement-hawaii/

[37] https://www.epa.gov/sites/production/files/2014-12/documents/hi-chapter55-wqs.pdf

compliance can result in fines or, in more extreme cases, a legal hearing.[38] Reports related to waste discharges are available to the public, unless there are confidentiality-related issues.[39]

In general, when a permit parameter is found to be out of compliance, the following actions occur:

1. The non-compliant item is reported to the appropriate agency immediately.
2. The farm writes a report on the cause of the non-compliance and the mitigation steps to bring the parameter back into compliance.
3. Follow-up tests are performed either by farm or regulatory agency to confirm the problem has been corrected.

Penalties for non-compliance would be considered on a case-by-case basis but could range from no action to an immediate project shutdown and voidance of the permit. For instance, language from the CDUP permit regarding penalties for impacting marine protected species is as follows (Blue Ocean Mariculture, personal communication June 2019):

"In the event of any significant adverse impact on marine protected species, e.g., collision, entanglement, injury, etc., DAR will coordinate a consultation as soon as possible between the permit holder and marine protected species experts to determine an appropriate course of action. DAR staff will then coordinate with OCCL to make recommendations to the BLNR. Activity modifications may range from increased monitoring to immediate project shutdown and removal of the entire structure, depending on the severity of the impact and its likelihood of reoccurrence."[40]

The reports that are required under the permits are outlined in Table 3.

Table 3 Permit reporting requirements (source: Blue Ocean Mariculture 2019)

Authority	Item	Frequency	Submittal	Distribution
EPA (NPDES permit HI 0021825)				
Part A (Effluent), Part C (ZOM & Controls)	Water Quality (9 variables)	Quarterly Sample	DMR (30 days)	EPA (Region 9), CWB (Hawaii), OCCL, DAR, Website
Part B (Whole Effluent Toxicity)	Whole Effluent Toxicity (Hydrogen Peroxide)	Quarterly Test	WET Test Report (30 days)	EPA (Region 9), CWB (Hawaii), FWS

[38] https://law.justia.com/codes/hawaii/2011/division1/title19/chapter342d/342d-13/
[39] https://law.justia.com/codes/hawaii/2011/division1/title19/chapter342d/342d-14/
[40] https://dlnr.hawaii.gov/occl/files/2013/08/Keahole-Reporting-Plan-2011.pdf

Part B (Whole Effluent Toxicity)	Whole Effluent Toxicity (antibiotic)	Per Application Test	WET Test Report (30 days)	EPA (Region 9), CWB (Hawaii), FWS
Part D (Bottom Biological Communities)	Benthic (In situ, Chemical micromollusc)	Annual Sample	Benthic Monitoring Report (30 Days)	EPA (Region 9), CWB (Hawaii), OCCL, DAR, Website
Part F (Noncompliance)	Noncompliance with Permit	Per Occurrence	Call (24 hours), Letter (5 days)	CWB (Hawaii)
Part F (Other)	Other (Incidental Take, Nets Lost, Unusual Occurrences)			
OCCL (CDUP HA-3497)				
Operational Plan	Mooring System Failure	Per Occurrence	Call, Letter	OCCL
Operational Plan	Theft of Vandalism	Per Occurrence	Call, Letter	OCCL
Operational Plan	Fish Escapes (>50)	Per Occurrence	Call, Letter	DAR
Fish Health Plan	Disease Outbreak	Per Occurrence	Call, Letter	OCCL, DAR, State Aquatic Veterinarian
Fish Health Plan	Ectoparasite Prevalence Report	Annually	Ectoparasite Prevalence Report	OCCL
Historic Resources Plan	Discovery of Historic Resources	Per Occurrence	Call, Letter	OCCL, State Historic Preservation Office
Marine Protected Species Plan	Marine Mammal Contact, Injury, Entanglement	Per Occurrence	Call	NMFS, DAR
Shark Management Plan	Dangerous Shark Behavior	Per Occurrence	Call, Letter	DAR
Dolphin Management/Marine Mammal Rep Marine Mammal Sighting, Counts, Behavior etc.	Monthly	Ectoparasite Report	Email	NMFS Protected Species

<table>
<tr><td></td><td>Summary of Chemicals used</td><td>Yearly (January 28th of the following year)</td><td></td><td></td></tr>
<tr><td></td><td>Noncompliance w/Permit</td><td>Within 24 hours of awareness of noncompliance</td><td></td><td></td></tr>
<tr><td></td><td>Noncompliance w/Permit</td><td>Within 5 days of awareness of noncompliance</td><td></td><td></td></tr>
<tr><td></td><td>Loss of a Net</td><td>30 days of the loss</td><td></td><td></td></tr>
<tr><td></td><td>Incidental Take of Marine Mammals</td><td>Within 30 days of occurrence</td><td></td><td></td></tr>
<tr><td></td><td>“Unusual Occurrences” (i.e., Algal Blooms, Fish Kills)</td><td></td><td></td><td></td></tr>
<tr><td></td><td>Ocean Use Conflict (e.g., Fishing Net Entanglement)</td><td>Per Occurrence</td><td></td><td></td></tr>
<tr><td colspan="5">Report immediately to NOAA Fisheries (1 888 256-98-40) & DAR (808 587-0106)</td></tr>
<tr><td colspan="5">1. Any observed or reported direct physical contact by any marine mammal or sea turtle with any part of the pen, cage, or moorings</td></tr>
<tr><td colspan="5">2. Any observed of reported injured of entangled marine mammal or sea turtle within 100 meters of any part of the pen, cage or moorings</td></tr>
<tr><td colspan="5">Report within one week to DAR (808 587-0106)</td></tr>
<tr><td colspan="5">1. Any observed approach less than 10 meters by any marine protected species to any part of the cage moorings.</td></tr>
</table>

Permits related to the farm site and any permits for further expansion were issued through the Federal NEPA process (National Environmental Protection Act of 1969, Public Law 91-190, 42 USC 4321 et seq.). Accordingly, in 2014 the farm applied for permit of expansion of its operations and was required to submit a draft environmental assessment which was subject to comprehensive environmental and wildlife impact assessment. Prior to approval of the application, the Office of Conservation and Coastal Lands (OCCL) referred it for review and comments from a number of agencies including: Office of Hawaiian Affairs; Hawaii County Planning; Department of Land and Natural Resources (Land Division, Historic Preservation Division, Conservation and Resources Enforcement, Aquatic Resources Division); Kanaka Council; US Army Corps of Engineers; US Fish and Wildlife Service; US Coast Guard; National Marine Fisheries Service, and the State Department of Health (Clean Water Branch).

Following a thorough evaluation of the application in 2014, the OCCL concluded that the farm is compliant with all protocols of the Conservation District Use Permit (CDUP). Based on data collected by the farm since start of the farm operations, no significant impacts on benthos, nearby reefs and wild fish populations have been found and therefore the OCCL approved the expansion of the farm. The OCCL also found the farm to operate under an exemplary management plan.[41]

The farm publishes the results of annual Water Quality Reports and annual Benthic Reports under the NPDES permit requirements on their website for the public to review.[42]

The score for Factor 3.2b is 5 out of 5. When combined with the Factor 3.2a score of 5 out of 5, the final Factor 3.2 score is 10 out of 10.

Conclusions and final score

The farm conducts regular water and benthic monitoring and publishes most of the results on its website (up to 2015). Additionally, NELHA's water quality monitoring, which also includes changes in benthic assemblages has been conducted since the inception of the farm and these data indicate little to no effect on the surrounding habitat. The content of habitat management measures is appropriate for the scale of the industry and enforcement is considered highly effective. Factors 3.1 and 3.2 combine to give a final Criterion 3 – Habitat score of 9.3 out of 10.

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[41] https://dlnr.hawaii.gov/occl/files/2013/08/3720-staff-report-and-permit.pdf

[42] http://www.bofish.com/stewardship/monitoring/

Criterion 4: Evidence or Risk of Chemical Use

Impact, unit of sustainability and principle

- Impact: Improper use of chemical treatments impacts non-target organisms and leads to production losses and human health concerns due to the development of chemical-resistant organisms.
- Sustainability unit: non-target organisms in the local or regional environment, presence of pathogens or parasites resistant to important treatments
- Principle: limiting 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)	**8**	
Critical?	NO	**GREEN**

Brief Summary

The farm reports that the only chemical used in production is hydrogen peroxide, which is used in bath treatments as a disinfectant and anti-parasiticide. This chemical is considered to be of "low regulatory priority" according to the U.S. Food and Drug Administration, degrades rapidly after treatment, and is considered minimally hazardous to the environment. As such, the risk of chemical impacts on the environment from these treatments is minimal. Any additional chemical use is strictly regulated by the State of Hawaii and requires close monitoring and regulatory oversight; however, by design marine net pens allow any chemicals used to be discharged directly into the marine environment. As such, the score for Criterion 4 – Chemical Use is 8 out of 10.

Justification of Rating

The expansion of commercial aquaculture has necessitated the routine use of veterinary medicines to prevent and treat disease outbreaks, assure healthy stocks, and maximize production (FAO 2012). However, the characteristics of chemical use are highly variable, according to the species produced, the target pest, parasite or pathogen, and the farm management characteristics. As the growout facility at the farm uses marine net pens, any use of chemicals will result in the release of chemicals from the farm into the natural environment.

The chemicals used most often in aquaculture as indicated by Seafood Watch includes pesticides (parasiticides, piscicides), disinfectants, antibiotics, antifoulants, anesthetics, and herbicides.

Chemical use on the farm site is governed by the Federal EPA permit, which limits antibiotic and other chemical use to those approved by the FDA or authorized by the FDA under the USFWS INAD program.[43] The farm is permitted by the FDA, through the U.S. Fish & Wildlife Service, to use in-feed antibiotics to treat disease under the Federal Investigative New Animal Drug (INAD) program. However, no antibiotics have been used at the farm site in the past eight years (Blue Ocean Mariculture, personal communication September 2018). Moreover, the Veterinary Medical Officer of the State of Hawaii and an independent fish veterinarian were contacted to confirm that no antibiotics have been used since the start of the farm (personal communication 2019).

According to the farm (personal communication September 2018), the only chemical used in production is hydrogen peroxide (H_2O_2) (Figure 12). In aquaculture, hydrogen peroxide has been found to be effective against various pathogens including external parasites, bacteria, yeasts, viruses, and fungi (Marking et al. 1994). When used as a waterborne therapeutant at appropriate concentrations, the US Food and Drug Administration—a governing body of chemical use in the United States—considers this use to be of "low regulatory priority" (USGS 2006). Upon contact with water, hydrogen peroxide is shown to dissociate rapidly into water and elemental oxygen by natural mechanisms (USGS 2006). The toxicity of hydrogen peroxide is concentration-dependent, with other vertebrates and mammals being much more tolerant than fish (USGS 2006). The growth of some bacteria may be adversely affected by hydrogen peroxide, but this is mitigated by the relatively short exposure times due to rapid dilution and decay, and the ability of microorganisms to rapidly rebound and repopulate (USGS 2006). For these reasons, no long-term effects on populations or communities of microorganisms are expected to result from the use of hydrogen peroxide in aquaculture (USGS 2006).

In 2014, the farm published information indicating that it had performed 56 hydrogen peroxide treatments from 2009 to 2013, to remove skin and gill fluke ectoparasites. In the years since, the treatment frequency for hydrogen peroxide has decreased, thanks to improved net pen biofouling management (Figure 10) (Blue Ocean Mariculture, personal communication, September 2018). As production has increased over this period, the relative consumption of hydrogen peroxide (i.e., MT of hydrogen peroxide used per MT of fish biomass) has also decreased (Figure 11).

As with any parasiticide, there is a risk that parasites could become resistant to the hydrogen peroxide treatment. This has been observed in other regions. As the production of the species scales up, there is a higher likelihood of parasitic infections and mortalities (Bui et al. 2017) (Vivanco-Aranda et al. 2019).

In the case of kampachi produced in Hawaii, there are not yet any indications of hydrogen peroxide resistance as observed in other regions, and since the production is small-scale, and both the frequency and relative use have decreased in recent years (Figures 10 and 11), the risk of resistance is assumed here to be low.

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[43] https://www.fws.gov/fisheries/aadap/home.htm

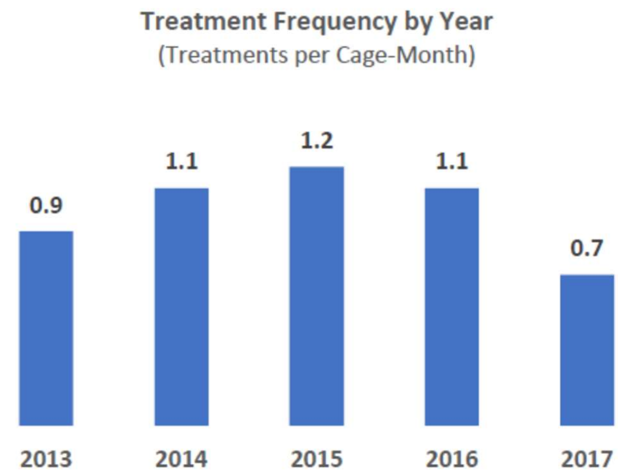

Figure 10. Hydrogen peroxide treatment frequency by year (source: Blue Ocean Mariculture 2018).

The farm is permitted by the U.S. Fish & Wildlife Service (UWFWS) to use 35% hydrogen peroxide to treat ectoparasites under Federal INAD #11-669. This formulation (marketed as 35% PEROX-AID®) has been the only chemical discharged at the farm site in the past eight years (Blue Ocean Mariculture, personal communication September 2018). The treatment process is done on an as-needed basis, averaging one application (of roughly 1,800 L) per pen every two months. The fish are sampled monthly to check the abundance of parasites, and the results of this testing dictate the schedule/necessity for a hydrogen peroxide bath (Blue Ocean Mariculture, personal communication September 2018).

The chemical treatment procedure involves concentrating the fish in a small area within the pen and isolating/surrounding the fish with a tarp. The chemical bath is applied within the tarp to allow for control of the concentration of the peroxide, and the period of exposure. Once the bath is completed, the fish are released from the tarp into the full volume of the pen, and a sample of the effluent water is taken (Blue Ocean Mariculture, personal communication, September 2018). As part of its operational permit, the facility is required to use an effluent toxicity test after every use of chemicals (Blue Ocean Mariculture, personal communication September 2018). The toxicity test is standardized and the facility has repeatedly shown compliance within regulatory limits (Blue Ocean Mariculture, personal communication September 2018).

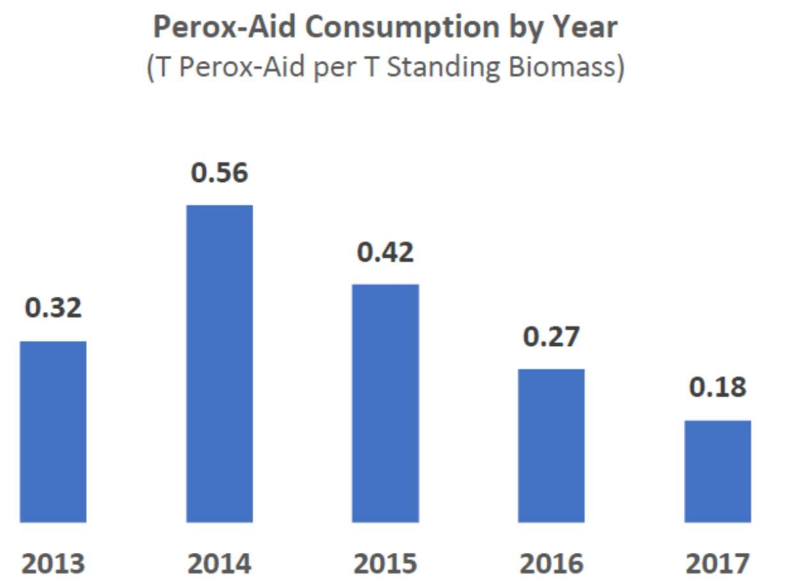

Figure 11. Relative hydrogen peroxide consumption (Perox-Aid per MT of fish biomass) by year for the period 2013-2017. (Source: BOM).

Under the water quality monitoring requirements of The farm's NPDES permit, Perox-Aid treatments are tested using a whole effluent toxicity (WET) test with a PASS limitation. Eighty WET tests for Perox-Aid were conducted during the period Jan 2009 to Jun 2018, with 76 resulting in Pass. All four failed WET tests were determined to be a result of improper sample collection (sample collected prior to the end of the Perox-Aid treatment).

Conclusions and Final Score

The facility relies solely on hydrogen peroxide for chemical treatments. The use of this chemical has been shown to be in compliance with applicable regulations, and minimally hazardous to the environment (USGS 2006); therefore, the risk of chemical impacts on the environment is minimal. Despite the repeated use of hydrogen peroxide, the risk of developing resistance in the parasites appears low. Although the farm does have the requisite permits in place for providing in-feed antibiotics, this has not been used since at least 2009. Despite the lack of evidence of impacts, marine net pens allow any chemicals used to directly enter the ocean environment, and the potential remains for poorly understood impacts. For these reasons, the final score for Criterion 4 – Chemical Use is 8 out of 10.

Criterion 5: Feed

Impact, unit of sustainability and principle

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

Criterion 5 Summary

Feed parameters	Value	Score
F5.1a Forage Fish Efficiency Ratio (FFER)	2.48	3.81
F5.1b Source fishery sustainability score	-3.00	
F5.1: Wild fish use score		2.32
F5.2a Protein IN (kg/100kg fish harvested)	60.93	
F5.2b Protein OUT (kg/100kg fish harvested)	32.82	
F5.2: Net Protein Gain or Loss (%)	-46.13	5
F5.3: Feed Footprint (hectares)	22.29	2
C5 Feed Final Score (0-10)		**2.91**
Critical?	NO	**RED**

Brief Summary

Almaco jack growout feed contains 37% protein with 30% fishmeal inclusion and 12% fish oil inclusion. Of fishmeal, 34% and 48% of fish oil are sourced from byproducts, and the average economic feed conversion ratio (eFCR) for the past three years has been 2.0. The Feed Fish Efficiency Ratio (FFER) is driven by fish oil and was calculated to be 2.48, resulting in a score of 3.81 out of 10. Source fisheries for marine ingredients in the Almaco jack feeds are all rated in FishSource. Scores for management exceed ≥6, and the scores for health range between ≥6 and 10, resulting in a sustainability score of –3 for sustainability of the source of wild fish (SSWF). Due to the high use of marine ingredients and moderately high eFCR, Factor 5.1 scores 2.32 out of 10. The net loss of protein was calculated to be –47.09%, due to high use of plant proteins considered “edible” for human consumption, resulting in a score of 5 out of 10 for Factor 5.2. The total feed footprint (ocean and land area) required to produce the feed ingredients necessary to grow one ton of farmed Almaco jack is calculated to be 22.3 ha, resulting in a score of 2 out of 10 for Factor 5.3. When the scores for Factors 5.1, 5.2, and 5.3 are combined, the final score for Criterion 5 – Feed is 2.9 out of 10.

Justification of Rating

Factor 5.1. Wild Fish Use

Factor 5.1 combines an estimate of the amount of wild fish used to produce farmed Almaco jack with a measure of the sustainability of the source fisheries. Table 4 shows the data used and the calculated Fish Feed Equivalency ratio (FFER) for fishmeal and fish oil.

Factor 5.1a – Feed Fish Efficiency Ratio (FFER)

Regarding marine ingredients, Almaco jack feed consists of 30% fishmeal, of which a third (34%) is produced from by-products, and the fish oil inclusion level is 12%, of which approximately half (48.4%) comes from by-products (Blue Ocean Mariculture, personal communication, September 2018). The average economic feed conversion ratio (eFCR) for the years 2014 to 2017 was reported to be 2.0 (Blue Ocean Mariculture, personal communication September 2018). Since no specific information on fishmeal and fish oil yields was available, global averages[44] of 22.5% for fishmeal and 5% for fish oil were used.

Table 4 The parameters used and their calculated values to determine the use of wild fish in feeding farmed Almaco jack

Parameter	Data
Fishmeal inclusion level	30%
Percentage of fishmeal from byproducts	34%
Fishmeal yield (from wild fish)	22.5%
Fish oil inclusion level	12%
Percentage of fish oil from byproducts	48.4%
Fish oil yield (from wild fish)	5.0%
Economic Feed Conversion Ratio (eFCR)	2.0
Calculated Values	
Feed Fish Efficiency Ratio (FFER) (fishmeal)	1.76
Feed Fish Efficiency Ratio (FFER) (fish oil)	2.48
Seafood Watch FFER Score (0-10)	**3.81**

Using these values, Feed Fish Efficiency Ratios (FFER) of 1.76 for fishmeal and 2.48 for fish oil were calculated. The FFER score is derived from the higher of the two FFER values, which in this case is 2.48 for fish oil, meaning that 2.48 t of wild fish are required to produce the fish oil necessary to grow one t of farmed Almaco jack. This equates to a score for Factor 5.1a – Feed Fish Efficiency Ratio of 3.81 out of 10.

[44] From the Seafood Watch Aquaculture Standard, 22.5% for fishmeal and 5% for fish oil are fixed values based on global values of the yield from typical forage fish, based on Tacon and Metian (2008).

Factor 5.1b – Sustainability of the Source of Wild Fish

The FFER score is adjusted by a sustainability factor determined by the fisheries used to provide marine ingredients (from reduction fisheries, not by-product sources). The default adjustment value of 0 considers that aquaculture should use sustainable feed ingredients, and an increasingly negative penalty is generated by increasingly unsustainable sources. The source fisheries for the fishmeal and fish oil can be found in Table 5.

Table 5 Source of marine ingredients used in the diet of Almaco jack (table obtained from the feed company via the farm)

SNo.	Origin	Fish Type	Management Score*	Health Status Score *
Fish Meal				
1	Pacific Southeast Ocean-Southern Peru Northern Chile-(FAO Zone 87)	Anchoveta (*Engraulis ringens*)	≥6 and ≥8	≥6
2	Gulf of Mexico – US EEZ (3-200 nm** from shore) in the Gulf of Mexico	Gulf Menhaden (*Brevoortia patronus*)	≥6 and ≥8	10
3	Pacific Ocean (FAO Zone 77)	Thread Herring (*Opisthonema* spp.)	≥6	≥6
4	Pacific Ocean (FAO Zone 67)	North Pacific Hake / Pacific Whiting (*Merluccius productus*)	10	10
5	Pacific Southeast Ocean (FAO Zone 87)	Jack Mackerel (*Trachurus murphyi*)	≥6 and 10	8.1
6	Bering Sea (FAO Zone 67)	Yellowfin Sole (*Limanda aspera*)	≥6 and 10	≥8
Fish Oil				
1	Gulf of Mexico – US EEZ (3-200 nm from shore) in the Gulf of Mexico.	Gulf Menhaden (*Brevoortia patronus*)	≥6 and ≥8	10
2	Bering Sea and Pacific Northeast Ocean (FAO Zone 67)	Alaskan Pollock (*Gadus chalcogramma*)	10	7.3
3	Pacific Ocean (FAO Zone 67)	North Pacific Hake / Pacific Whiting (*Merluccius productus*)	10	10
*** Fish Source scores available at https://www.fishsource.org/about** **** nautical miles**				

Note: No fish meal or fish oil originated from IUU (illegal, unregulated, unreported) catches or from species categorized as "Vulnerable" or "Endangered" according to the IUCN Red List of threatened species are used in EWOS Canada feeds. **Source: EWOS, September 13, 2018**
Note: All marine ingredient sources except the anchoveta, and seemingly some stocks of the thread herring fishery, have a Marine Stewardship Council certification.

Based on FishSource,[45] the management quality and health status for the fish stocks used in the feed are typically well managed and the current health status of the stocks is "good." All FishSource scores for management exceed ≥6, and the scores for stock health range between ≥6 and 10; therefore, the score for Factor 5.1b – Sustainability of the Source of Wild Fish is –3 out of –10, resulting in an adjustment of –1.49 from Factor 5.1a.

When combined, Factor 5.1a and Factor 5.1b result in a final score of 2.32 out of 10 for Factor 5.1 – Wild Fish Use.

Factor 5.2. Net Protein Gain or Loss

Factor 5.2 uses the protein inputs in feed (from marine, crop sources) and the protein output (of harvested, edible farmed fish) to calculate a protein budget. Table 6 shows the data used for this calculation.

With respect to protein inputs, the protein content of Almaco jack feed used in Hawaii is 37% (Blue Ocean Mariculture, personal communication September 2018). The protein sources and their total inclusion in the diet are 30% fishmeal and the rest are edible crops (no land animal ingredients). Overall, there is calculated to be 60.43 kg of edible protein input per 100 kg of harvested Almaco jack.

With respect to protein outputs, the protein content of harvested whole fish is 22.2%.[46] The edible yield of whole fish for human consumption is estimated at 75%, since the fish are sold with minimal processing. Additionally, approximately 90% of the by-products from harvested farmed fish are utilized further (Blue Ocean Mariculture, personal communication, September 2018). Overall, the net utilized protein output is calculated to be 21.65kg per 100kg of harvested Almaco jack.

By comparing the edible protein inputs to the utilized protein outputs, the net loss of protein is calculated to be 47.09%, and results in a Factor 5.2 – Net Protein Gain or Loss score of 5 out of 10.

[45] FishSource: https://www.fishsource.org/about
[46] https://www.bofish.com/fish/health/

Table 6 The parameters used and their calculated values to determine the protein gain or loss in feeding farmed Almaco jack

Parameter	Data
Protein content of feed	37%
Percentage of protein from edible sources (whole fish FM, edible crops)	81.67%
Percentage of total protein from non-edible sources (byproducts, etc.)	18.33%
Economic Feed Conversion Ratio	2.0
Edible protein INPUT per 100kg of farmed Almaco jack	60.43 kg
Protein content of whole harvested fish	22.2%
Edible yield of harvested fish	75%
Percentage of farmed fish byproducts utilized	90%
Utilized protein OUTPUT per 100kg of farmed fish	21.65 kg
Net protein loss	-47.09%
Seafood Watch Factor 5.2 Score (0-10)	**5**

Factor 5.3. Feed Footprint

By considering the grouped inclusion levels of marine, terrestrial crop, and terrestrial land animal feed ingredients (Table 7), Factor 5.3 approximates the ocean and land area appropriated per ton of Almaco jack production.

Regarding feed footprint, the 42% inclusion level of marine ingredients in the feed results in an ocean area of 21.9 ha required to produce the aquatic ingredients necessary to grow one ton of farmed Almaco jack. There is a 58% inclusion level of crop feed ingredients. This level of terrestrial ingredient inclusion corresponds to a land area of 0.4 ha being required to produce the ingredients necessary to grow one ton of farmed fish.

Table 7 The parameters used and their calculated values to determine the ocean and land area appropriated in the production of farmed Almaco jack

Parameter	Data
Marine ingredients inclusion	42%
Crop ingredients inclusion	58%
Land animal ingredients inclusion	0%
Ocean area (hectares) used per ton of farmed fish	21.85
Land area (hectares) used per ton of farmed fish	0.44
Total area (hectares)	22.3
Seafood Watch Factor 5.3 Score (0-10)	**2**

When the ocean and land areas are combined, the total feed footprint is calculated to be 22.3 ha per ton of fish production, resulting in a score of 2 out of 10 for Factor 5.3 – Feed Footprint.

Conclusions and Final Score

The final score is a combination of the three factors with a double-weighting for the Wild Fish Use factor per the Seafood Watch Standards Factors 5.1 (2.32 out of 10), 5.2 (5 out of 10), and 5.3 (2 out of 10) combine to result in a final Criterion 5 – Feed score of 2.91 out of 10.

Criterion 6: Escapes

Impact, unit of sustainability and principle

- Impact: competition, genetic loss, predation, habitat damage, spawning disruption, and other impacts on wild fish and ecosystems resulting from the escape of native, non-native and/or genetically distinct fish or other unintended species from aquaculture operations
- Sustainability unit: affected ecosystems and/or associated wild populations.
- Principle: 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	0	
F6.1 Recapture adjustment	4	
F6.1 Final escape risk score		4
F6.2 Competitive and Genetic Interactions		8
C6 Escape Final Score (0-10)		**6**
Critical?	NO	**YELLOW**

Brief Summary

There is an inherent risk of escape in marine net pen systems, and data from the farm show small-scale escape events (i.e., trickle losses, or leakage) are common. A total of 11 major escape events have occurred between 2011 to 2017; however, there is evidence of a 40% recapture rate in such events. Almaco jack is a native species and wild populations exist within the assessed region. The industry relies on wild, locally caught broodstock, thus reducing any potential genetic impacts of escapes. Any farmed fish that enter the ecosystem are expected to interact with and impact surrounding species. Although the escape risk is high, the recapture rate and also the genetic similarity with wild fish (only 1 generation removed) reduce the risk of significant impact. The score for Criterion 6 – Escapes is 6 out of 10.

Justification of Rating

This criterion assesses the risk of escape (Factor 6.1) and the potential for impacts, according to the nature of the species being farmed (Factor 6.2). Evidence of recaptures is a component of Factor 6.1.

Factor 6.1. Escape risk

Net pen systems retain an inherent risk of escapes (Zimmermann 2012) (Waples 2012) (Glover et al. 2017). The farm employs various practices to minimize the risk of escape events, including the use of predator-resistant netting materials such as KikkoNet and copper alloy mesh, daily or twice-daily mortality removal to reduce predator attractants, daily net pen inspections, and periodic training on proper rigging techniques (Blue Ocean Mariculture, personal communication September 2018).

Despite these measures, data from 2011 to 2017, provided by the farm, indicate a total of 11 major escape events, with at least one event in six of the seven years, and five events in 2016. Total annual escape numbers range from 800 to 6,400. The main causes for the escape events are improper rigging (45%), predator bite (shark) (46%), and net failure (9%) (see Figure 12). Small escape events, such as 1 or 2 fish escaping while a diver is entering the pen, are frequent, but considered less significant as these leakages are heavily preyed upon (Blue Ocean Mariculture, personal communication September 2018).

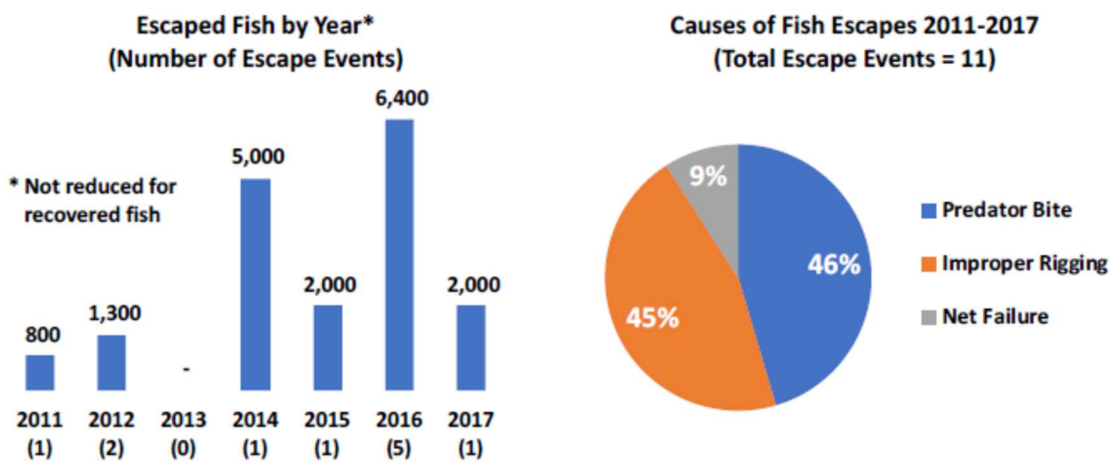

Figure 12. Number of escape events from 2011 to 2017 (figure on left) and causes of fish escapes (Source: BOM).

Escape prevention and reporting is governed by Blue Ocean's State of Hawaii CDUP permit and associated Management Plans, which require reporting of escapes (>50 fish) to several state agencies within 24 hours of the event (Blue Ocean Mariculture, personal communication September 2018). On average, escape events that require reporting to the Department of Land and Natural Resources occur once per year[47] (Blue Ocean Mariculture, personal communication September 2018) (see Table 4).

Overall, the data and information provided by the farm indicate a demonstrably high risk of escape. Although Best Management Practices (BMPs) are employed, the record of high numbers of fish escapes calls into question the robustness and/or efficacy of these BMPs. Ultimately, the base score for Factor 6.1 – Escape Risk is 0 out of 10.

Recaptures

[47] Permits and regulatory requirements for aquaculture in Hawaii: https://hdoa.hawaii.gov/ai/files/2013/03/Permits-and-Regulatory-Requirements-For-Aquaculture-in-Hawaii-2011-Final.pdf

When escapes do happen, the farm reports that fish tend to remain near the pen facility. Representatives from the farm have indicated that this allows for a recovery rate of approximately 40% in both 2016 and 2017 (Blue Ocean Mariculture, personal communication September 2018). Escaped fish remain near the net pens for 2 to 3 days after the escape event, and during this period farm divers attempt to recover as many fish as possible, using brailing or seining methods (Blue Ocean Mariculture, personal communication September 2018).

Based on the information provided by the farm, there is a demonstrably high risk of escape, both through trickle losses and major events. However, recapture success partially mitigates the potential impact of escaped fish. With a recapture success of 40%, the base score for Factor 6.1 of 0 out of 10 is adjusted by a 40% reduction of risk.

Therefore, the final score for Factor 6.1 Escape Risk is 4 out of 10 (i.e., 40% of the difference between a score of 0 and a score of 10).

Factor 6.2. Competitive and genetic interactions

Farmed Almaco jack are native to the region in which they are cultured. In some circumstances, escapes of hatchery-reared native fish from farms can pose significant threats to the genetic integrity of wild conspecifics (Besnier 2011) (Holmer 2010). Genetic risks presented by escapes from aquaculture facilities are well documented (see Waples et al. 2012).

The US Almaco jack *Seriola* farming industry relies exclusively on wild-caught and locally sourced broodstock (Blue Ocean Mariculture, personal communication September 2018). This ensures that farmed stock experience minimal deviation from the genotype of the wild population. The facility maintains approximately 60 broodstock and acquires an average of 18 new broodstock every three years to maintain genetic diversity and avoid inbreeding (Blue Ocean Mariculture, personal communication September 2018).

Because the farm relies on wild broodstock, the danger of genetic impacts from escapees on wild populations are minimal (K. Hopkins, U. Hawaii, personal communication 2019). However, since so many cultured organisms originate from a relatively small number of broodstock, the danger of a genetic bottleneck and the subsequent loss of genetic integrity in the wild stock cannot be completely eliminated.

Since the farmed stock is only one generation removed from the wild, it is reasonable to presume that any escapees that are not recaptured or eaten by predators will compete with wild native populations for food and habitat space or interact with the native Almaco jack population for breeding purposes. Additionally, as a carnivorous fish, escaped farmed Almaco jack may add additional predation pressure on prey populations in the area (K. Hopkins, U. Hawaii, personal communication 2019).

The potential impacts of escaped *S. rivoliana* in Hawaiian waters have not been evaluated by the farm; however, there are preliminary results from applying the Offshore Aquaculture

Escapes Genetics Assessment (OMEGA) Model[48] to *S. rivoliana* in the Gulf of Mexico (Blue Ocean Mariculture, personal communication October 2019). This model has been developed by NOAA and partners specifically to assess impacts of escapees on the wild fish populations and this application of the model evaluated potential effects based on three levels of escape (low-level chronic leakage, moderate-level cage failure, and severe-level whole system failures). The results indicated that when second generation progeny are farmed in excess of 5,000 MT per year, low-level leakages have the most potential of impacting genetic integrity of wild populations in the long term, when compared to cage failures and catastrophic events (Blair et al. 2019). However, given the current production of the farm (<1000 MT), and the fact that the progeny are still genetically similar to their wild conspecifics, this is not considered a concern for the genetic interactions with wild fish in Hawaii.

Escaped farmed fish may also exhibit reduced survivability outside the farm due to poor feeding abilities or greater vulnerability to predators, and given the small scale of the operation, the impacts would likely be minimal (K. Hopkins, U. Hawaii, personal communication 2019). There is likely to be substantial predation of escapes, but the number is not known.

Due to the reliance on wild broodstock, the concerns regarding competition with wild fish stocks and genetic introgression are low.

The score for Factor 6.2 is 8 out of 10.

Conclusions and Final Score

The inherent vulnerability of net pen production systems to escape (both large-scale and chronic trickle losses) is supported by documented escape events at the farm. However, recapture efforts have been relatively successful in the past, and warrant a positive adjustment to the base Escape Risk score. The final score for Factor 6.1 is 4 out of 10. As broodstock are captured from the wild, the risk of genetic impact of escapees on wild conspecifics is low, and there is low risk for competition between wild fish and the escaped fish. The score for Factor 6.2 is 8 out of 10. When the scores for Factors 6.1 and 6.2 are combined, the final score for Criterion 6 – Escapes is 6 out of 10.

[48] https://www.fisheries.noaa.gov/offshore-aquaculture-escapes-genetics-assessment-omega-model

Criterion 7: Disease; pathogen and parasite interactions

Impact, unit of sustainability and principle

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

Criterion 7 Summary

Disease Risk-based assessment

Pathogen and parasite parameters	Score	
C7 Disease Score (0-10)	6	
Critical?	NO	YELLOW

Brief Summary

Because disease data quality and availability is moderate (i.e., Criterion 1 score of 5 out of 10 for the disease category), the Seafood Watch risk-based assessment was used. Due to the nature of the production system and the presence of wild conspecifics, there is an inherent risk of amplification and transmission of disease from the farm to wild fish. However, the farm follows strict protocols to minimize disease outbreaks and there have been no bacterial or viral disease outbreaks reported since 2010. Skin fluke parasites are prevalent on the farm, as with all marine cultured *Seriola*. Although data on their numbers on farmed fish are not available for all the years except 2018, several years of monitoring indicate that the prevalence of the most common ectoparasite on the farmed fish, *Neobenedenia* spp. is not increasing in wild fish. Overall, the risk of disease transmission is considered to be low to moderate, and the score for Criterion 7 – Disease is 6 out of 10.

Justification of Rating

Since the quality and availability of disease data is moderate (i.e., Criterion 1 score of 5 out of 10 for the disease category), the Seafood Watch risk-based assessment was used.

Fish grown in net pens are inherently vulnerable to infection by pathogens and parasites occurring in the wild. Depending on the stocking density, the potential for pathogen and parasite amplification within the farm population can be high. Both this increased load, and the fact that farms may serve as temporal reservoirs for disease, allow for the possibility of retransmission to wild fish (Nowak 2007) (Hammell et al. 2009) (Johansen et al. 2011) (Waples 2012).

In order for wild and farmed fish to transfer pathogens between each other, three assumptions need to be met: wild fish must be present at farm sites long enough for the pathogen transmission to occur, wild fish must move frequently to other farms and locations, and the same pathogens must be shared between farmed and wild fish (Uglem et al. 2014). The risk of transferring diseases between farmed animals and wild populations is particularly high if marine net pen farms are placed near genetically similar wild populations (Holmer 2010).

Several pathogens and pathologies have been reported to affect farmed *Seriola* spp. globally (reviewed by Sicuro and Luzzanna 2016). Mortalities associated with these diseases have been reported to be as high as 80% of the farmed stock (Sicuro and Luzzana 2016). Almaco jack production in the United States uses marine net pens and the population within the pens, in addition to being conspecific, is genetically similar to the local wild population. These factors indicate that the risk of pathogen transmission between farm and wild fish is high. Therefore, if disease incidence on the farm is common, or outbreaks are severe, there is a potential for the facility to have a negative impact on the local wild population.

To combat on-farm disease, robust monitoring procedures are in place, including regular inspection for parasites or other diseases. To ensure good animal health and to proactively prevent disease, the farm relies on maintaining low stocking densities, conducting health checks, using vaccines prior to stocking fish in cages, daily visits to the offshore facilities to inspect for and remove mortalities, and periodic cleaning of the offshore facilities.[49] According to Dr. Kevin Hopkins from the University of Hawaii, the risk of disease at the farm are minimal since the fish densities are low and the cages are found in areas of high water exchange (personal communication 2019).

The farm relies on BMPs to minimize fish health issues offshore as described in the EPA "1500824 HI 0021825 NPDES" permit (section E), and the Hawaii "141027 CDUP HA-3720" permit (Fish Health Management Plan) (Blue Ocean Mariculture, personal communication September 2018). These permits include BMPs related to feed management, waste collection and disposal, discharge related to fish transport or harvesting, carcass (mortality) removal, net cleaning, maintenance, training, and disease control. The farm also records daily mortalities (including cause), conducts regular fish health checks, and weekly parasite checks, and uses high quality feed to optimize fish health. Moreover, the farm ensures that general cleanliness is maintained, such as weekly cleaning of nets to maximize water exchange through nets (the top part of the net is raised to the surface and allowed to dry under the sun), and seine net disinfection prior to use and after harvest (Blue Ocean Mariculture, personal communication September 2018). At the time of this assessment, none of the regular maintenance logs were available, excepting a summary of mortalities.

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[49] http://oeqc2.doh.hawaii.gov/EA_EIS_Library/2014-10-08-HA-FEA-Capacity-Increase-at-Blue-Ocean-Mariculture-Facility.pdf

The company-authored environmental assessment for facility expansion in 2014 states that, between 2009 and 2014, the only infection found was bacterial (*Vibrio* spp.) in 2010. The outbreak was determined to be caused by nutrient deficiency in the diet and Blue Ocean Mariculture responded by changing the diet. No transmission of the bacterial infection was detected on wild fish populations in this incident. As noted in the expansion application of the farm: "The Farm Site has not experienced a bacterial infection offshore or delivered an antibiotic treatment offshore since February 2011 and does not expect an increase in antibiotic treatment frequency under the Proposed Action." [50] This was confirmed by an independent veterinarian and the government State Veterinarian (see also section Criterion 4 – Chemical Use).

Ectoparasites are common in marine fish. The most common parasite occurring in wild *Seriola* spp. is a skin fluke (*Benedenia seriolae* and *Neobenedenia* spp). *Neobenedenia* is the only parasite that has been found in any numbers on farmed Almaco jack since the start of the farm. Blue Ocean Mariculture has published annual reports on the prevalence of *Neobenedenia* on wild Almaco jack along the Kona coast (CDUP HA-3497, Ectoparasite Monitoring Plan; Blue Ocean Mariculture, personal communication September 2018). *Neobenedenia* and sea lice (*Caligus* spp.) have been the only ectoparasites found on wild fish caught for brood use over the past few years (Figure 13). Based on the Environmental Assessment in 2014, the presence of *Neobedenia* has been consistently low and the predominant ectoparasite found on wild Almaco jack has been sea lice (*Caligus* spp.). Because no sea lice have ever been reported on the farmed fish, (Blue Ocean Mariculture, personal communication October 2019), it does not appear that wild fish-hosted sea lice are transmitted to farm fish. This is likely due to the copper alloy netting, which reduces biofouling on the net pens, thereby reducing the available attachment sites for *Neobenedenia* cysts.[51]

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[50] http://oeqc2.doh.hawaii.gov/EA_EIS_Library/2014-10-08-HA-FEA-Capacity-Increase-at-Blue-Ocean-Mariculture-Facility.pdf

[51] https://dlnr.hawaii.gov/occl/files/2013/08/3720-staff-report-and-permit.pdf

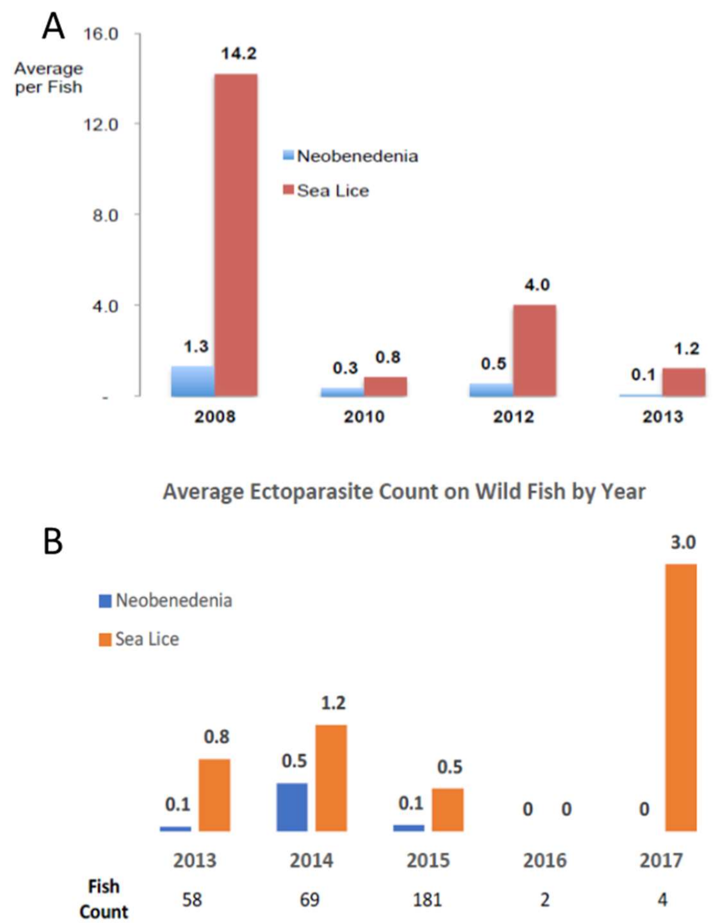

Figure 13. The average ectoparasite found on wild fish by year (Source: A) expansion application for the farm conducted in 2014;) (source: BOM 2019).

While the potential for amplification and transmission of disease exists, the facilities are obligated by OCCL to inspect the farmed stock on a regular basis to minimize the risk of outbreaks (Blue Ocean Mariculture, personal communication September 2018). No major disease outbreaks have been reported by the farm (Blue Ocean Mariculture, personal communication October 2019). Management of diseases, infections and parasites by use of hydrogen peroxide baths has been shown effective at various facilities around the world (Pedersen 2012) (Polinski 2013) and is currently in use at the farm. As such, though the production system is considered to have biosecurity protocols in place, it remains open to the introduction of local pathogens and parasites and is also open to the discharge of pathogens.

Conclusions and Final Score

Since the quality and availability of disease data is moderate (i.e., Criterion 1 score of 5 out of 10 for the disease category), the Seafood Watch risk-based assessment was used. There have been no reported bacterial or viral disease outbreaks since 2010, and there has been no antibiotic use on the farm over this period. Skin flukes are prevalent on the farm. Although data on their numbers on farmed fish are not available, there is no evidence of elevated levels in wild fish. Overall, the risk of disease transmission is considered to be low to moderate, and the score for Criterion 7 – Disease is 6 out of 10.

Criterion 8X: Source of Stock – independence from wild fisheries

Impact, unit of sustainability and principle

- Impact: the removal of fish from wild populations for on-growing to harvest size in farms
- Sustainability unit: wild fish populations
- Principle: using eggs, larvae, or juvenile fish produced from farm-raised 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

The farm relies completely on sourcing local wild broodstock, but the numbers caught to maintain a captive population are low (18 over a three-year period) and the source is considered sustainable. With no use of wild fish from unsustainable sources, the score for Criterion 8X – Source of Stock is a deduction of 0 out of –10.

Justification of Rating

All eggs used for larval production are sourced from the farm's broodstock facility in Kona, which relies entirely on wild caught broodstock. The number of wild fish captured per year is small (18 fish total between 2015 and 2017) (Blue Ocean Mariculture, personal communication September 2018). There is no commercial fishery for the species in Hawaii, nor federal restrictions. There are no local regulations or limitations on the harvest of this fish (including for sport fishing) by the Hawaii Division of Aquatic Resources.[52]

Additionally, Almaco jack has been evaluated as a species of "Least Concern" regarding its population status worldwide (IUCN Red List[53]).

Conclusions and Final Score

Although a small number of *S. rivoliana* are sourced from wild populations in Hawaii, the number is considered minimal and the stock is robust; therefore, the use of wild broodstock is

[52] http://dlnr.hawaii.gov/dar/fishing/fishing-regulations/

[53] https://www.iucnredlist.org/species/16507347/16510402

not penalized in this assessment and the final score for Criterion 8X – Source of Stock is a deduction of 0 out of –10.

Criterion 9X: Wildlife and predator mortalities

Impact, unit of sustainability and principle

- Impact: mortality of predators or other wildlife caused or contributed to by farming operations
- Sustainability unit: wildlife or predator populations
- Principle: 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)	-2	
Critical?	NO	GREEN

Brief Summary

Although the farm site occasionally attracts predators and wildlife, effective management and prevention measures have been developed to limit mortalities to exceptional cases. There have been two recorded mortality events (in 2005 and 2017) and, although both involved a near-threatened or protected species, they did not contribute to further decline or prohibit recovery of either species, and multi-stakeholder measures were enacted to mitigate future events. Interactions between the wildlife and the net pens appears to be limited to rare occasions, indicating the enacted management plan is effective. As such, the score for Criterion 9X – Wildlife and Predator Mortalities is –2 out of –10.

Justification of Rating

This criterion assesses the effects of deliberate or accidental mortality on the populations of affected species of predators or other wildlife.

In general, the addition of nutrients in a habitat increases the density of organisms (the "birdfeeder effect," reviewed by Polis et al. 1997 and Eveleigh et al. 2007), and a similar response has been found between marine organisms and sea cages (see review by Sanchez-Jerez et al. 2011). The presence of farmed fish in net pens, at higher densities than they are found in the wild, inevitably attracts opportunistic marine mammals, seabirds, and fish that normally feed on wild fish stocks (Sepulveda et al. 2015).

At the farm site, bottlenose dolphin (*Tursiops truncatus*) and spinner dolphin (*Stenella longirostris*) have been noted along with various shark species: blacktip (*Carcharhinus limbatus*), tiger (*Galeocerdo cuvier*), sandbar (*Carcharhinus plumbeus*), and Galapagos (*Carcharhinus galapagensis*) (see also Papastamatiou et al. 2011). Seabirds are often found around fishing grounds in the area, but the farm site is not part of the fishing grounds and the net pens are often submerged,[54] reducing potential for interactions. The farm site resides within the native range of two sea turtle species; the green sea turtle (*Chelonia mydas*)[55] and the hawksbill turtle (*Eretmochelys imbricate*)[56] but interactions within the farm site have not been reported. The green sea turtle is declared "Critically Endangered" and the Hawksbill Turtle "Threatened."[57] Monk seals (*Neomonachus schauinslandi* previously known as *Monachus schauinslandi*), an endangered[58] species, have been recorded within the farm site (twice in 2005). The lease area is also within the humpback whale (*Megaptera novaeangliae*) sanctuary, and whales have been observed transiting the area on seven days between 2010 and 2013.[59] Several species of fish are also reported near the pens (ulua, *Caranx ignobilis*; ōpelu, *Decapterus macarellus;* akule, *Selar crumenophthalmus*),[60] none of which are listed as "Threatened" or "Endangered" by the IUCN.

<u>Interactions with Endangered, Threatened, or Protected Species</u>
In the history of the farm, there have been two lethal incidents with protected species: one in 2005 (a tiger shark), and one in 2017 (a monk seal) as discussed below. In both cases, the farm has worked with regional and federal governments to develop and enact prevention plans for future interactions.

During prior ownership of the farm there was one incident of predator mortality involving the death of a tiger shark in 2005 (Lucas 2009). Notably, the tiger shark is considered to be "Near Threatened" by the IUCN.[61] Tiger sharks continue to occur infrequently at the site, with one or two sightings each year, but generally do not interact with divers or net pens (Blue Ocean Mariculture, personal communication September 2018).

Since that mortality event in 2005, subsequent remedial action has established a plan of action for dealing with predators on the farm.[62] The farm does not employ any proactive, harmful or lethal predator deterrents. Only passive techniques are employed, such as bite-resistant netting

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[54] http://oeqc2.doh.hawaii.gov/EA_EIS_Library/2014-10-08-HA-FEA-Capacity-Increase-at-Blue-Ocean-Mariculture-Facility.pdf
[55] https://www.fisheries.noaa.gov/species/green-turtle
[56] https://www.fisheries.noaa.gov/species/hawksbill-turtle
[57] https://www.iucnredlist.org/species/8005/12881238
[58] https://www.iucnredlist.org/species/13654/45227978
[59] https://dlnr.hawaii.gov/occl/files/2013/08/3720-staff-report-and-permit.pdf
[60] https://dlnr.hawaii.gov/occl/files/2013/08/3720-staff-report-and-permit.pdf
[61] IUCN: https://www.iucnredlist.org/species/39378/10220026
[62] http://oeqc2.doh.hawaii.gov/EA_EIS_Library/2009-05-08-HA-FSEA-Kona-Blue-Water-Aquafarm.PDF

materials, taut netting design and daily mortality removal (Blue Ocean Mariculture, personal communication September 2018).

Reporting and control methods for marine mammal predators/sharks are regulated under the U.S. Marine Mammal Protection Act/State of Hawaii CDUP permit Shark Management Plan and enforced by NOAA NMFS for marine mammals and the State of Hawaii for sharks. All control methods are passive, and Blue Ocean does not possess and has not applied for incidental take permits for any marine mammal predator species/sharks. All observations and interactions with marine mammals at the farm site are reported on a monthly basis to NOAA NMFS Protected Resources Division and other agencies, and the State of Hawaii Division of Aquatic Resources for sharks.

The farm began recording observations of sharks at the farm site in 2011 under the Shark Management Plan (CDUP HA-3497). The farm reports that sharks were on site on 33 days (38 total observations) in 2012 and on 26 days (26 total observations) in 2013. The most-frequently observed species was blacktip (*Carcharhinus limbatus*) in both years.[63] Sharks are observed around the cages several times per year (Figure 14). During 2017 and 2018 there was an increase in blacktip shark observations around the cages. This was attributed to the El Niño weather effect (Blue Ocean Mariculture, personal communication 2019).

[63] http://oeqc2.doh.hawaii.gov/EA_EIS_Library/2014-10-08-HA-FEA-Capacity-Increase-at-Blue-Ocean-Mariculture-Facility.pdf

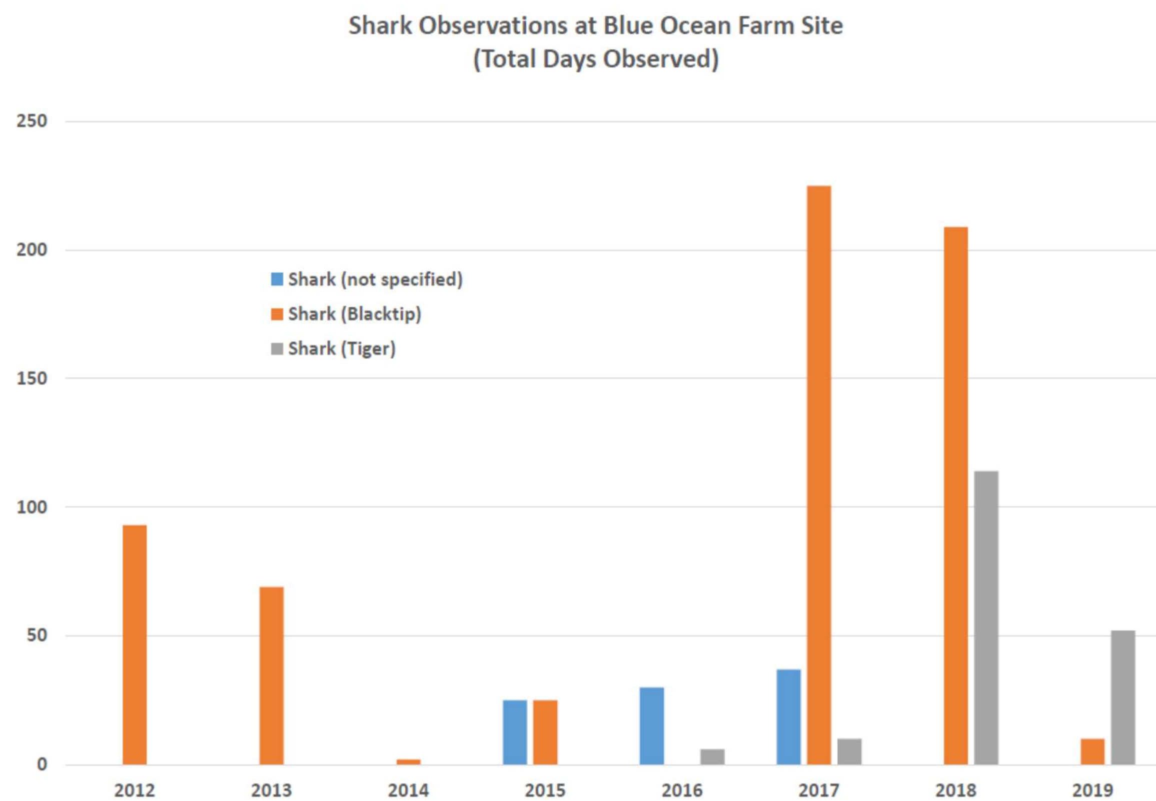

Figure 14. Shark observations at the farm (source: Blue Ocean Mariculture 2019).

On the occasion that a predator does become problematic, the facility works with government agencies to ensure the predator is removed safely and with minimal harm to all parties involved. Such operations take place with the assistance and cooperation of the Hawaii Department of Aquatic Resources, which is under the Department of Land and Natural Resources (Blue Ocean Mariculture, personal communication September 2018).

On March 5, 2017 a single Hawaiian monk seal was found expired in one of the net pens[64] (Blue Ocean Mariculture, personal communication September 2018). The incident was reported to the NOAA NMFS Protected Resources Division. The investigation conducted by the NOAA Marine Mammal Response Team concluded that the incidental take of a Hawaiian monk seal was caused by an unusual combination of events including:

1. The recent conclusion of harvesting from the net pen and its planned removal.
2. A farm crew decision the prior day to create a 1,600ft^2 opening in the net.
3. The animal's inability to navigate out of the opening once inside the net pen.

[64] https://eu.usatoday.com/story/news/nation/2017/03/17/rare-monk-seal-dies-fish-farm-off-hawaii/99295396/

Blue Ocean Mariculture worked with NOAA to develop and implement several changes in operating protocols to prevent recurrence of this event and mitigate the risk of future incidental take of Hawaiian monk seals. This includes a requirement to keep all net pens at the surface during periods of installation or removal to ensure easy access to the surface (and access to air) for any marine mammal that may enter the net pen during the installation or removal process (Blue Ocean Mariculture, personal communication September 2018).

Conclusions and Final Score

The farm site is located in a region with a diverse array of wildlife, including protected, threatened and endangered species. The farm occasionally attracts such predators and wildlife, but effective management and prevention measures have been developed to limit mortalities to exceptional cases. There have been two mortalities involving near-threatened or protected species in the last 14 years, and neither interaction contributed to further decline nor prohibited recovery of the species.

The enacted predator management plan is effective and predator mortalities rarely occur. As such, the final score for exceptional Criterion 9X – Wildlife Mortalities is a deduction of –2 out of –10.

Criterion 10X: Escape of secondary species

Impact, unit of sustainability and principle

- Impact: movement of live animals resulting in introduction of unintended species
- Sustainability unit: wild native populations
- 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

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

Brief Summary

International or trans-waterbody live animal shipments have the potential to introduce invasive alien species and/or pathogens into the environment. As the entire life cycle of the farmed fish takes place within one location in Hawaii, there is no risk of the introduction of invasive species and thus the score for Criterion 10X – Escape of Secondary Species is 0 out of –10.

Justification of Rating

This criterion provides a measure of the escape risk (introduction to the wild) of invasive alien species other than the principle farmed species unintentionally transported during animal shipments. Transferring fish without appropriate safety measures could lead to transfer of unwanted animals or pathogens. As an exceptional criterion, 10X generates a negative (i.e., deductive) score which is subtracted from the final score for those aquaculture operations where it is a concern.

Factor 10Xa International or trans-waterbody live animal shipments

All stocked fish at the farm are produced in onshore hatcheries from locally captured broodstock before being moved to marine net pens for growout (Blue Ocean Mariculture, personal communication September 2018). There is no international or trans-waterbody live shipment of eggs or live fish. Any potential importation of eggs or live fish would be subject to State of Hawaii Department of Health regulations and quarantine periods (Blue Ocean Mariculture, personal communication September 2018).

The final 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 (Factor 10Xa is scored 10 out of 10), Factor 10Xb is not assessed.

Conclusions and Final Score

Since the entire production of farmed fish at Blue Ocean Mariculture takes place within Hawaii and there are no international or trans-waterbody live animal shipments, the final score for Criterion 10X – Escape of Secondary Species is 0 out of –10.

Acknowledgements

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

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Appendix 1 – Data points and all scoring calculations

Criterion 1: Data quality and availability

Data Category	Data Quality (0-10)
Industry or production statistics	10
Management	10
Effluent	10
Habitats	10
Chemical use	7.5
Feed	7.5
Escapes	5
Disease	5
Source of stock	7.5
Predators and wildlife	7.5
Unintentional introduction	10
Other (e.g., GHG emissions)	n/a
Total	**90**

C1 Data Final Score (0-10)	**8.181818182**	**GREEN**

Criterion 2: Effluents

Effluent Evidence-Based Assessment

C2 Effluent Final Score (0-10)	**9**	**GREEN**
Critical?	NO	

Criterion 3: Habitat

Factor 3.1. Habitat conversion and function

F3.1 Score (0-10)	9

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

3.2a Content of habitat management measure	5
3.2b Enforcement of habitat management measures	5
3.2 Habitat management effectiveness	**10**

C3 Habitat Final Score (0-10)	**9**	**GREEN**
Critical?	NO	

Criterion 4: Evidence or Risk of Chemical Use

Chemical Use parameters	Score	
C4 Chemical Use Score (0-10)	**8**	
C4 Chemical Use Final Score (0-10)	**8**	**GREEN**
Critical?	NO	

Criterion 5: Feed

5.1. Wild Fish Use

Feed parameters	Score
5.1a Fish Feed Efficiency Ratio (FFER)	
Fishmeal inclusion level (%)	30
Fishmeal from by-products (%)	34
% FM	19.8
Fish oil inclusion level (%)	12
Fish oil from byproducts (%)	48.4
% FO	6.192
Fishmeal yield (%)	22.5
Fish oil yield (%)	5
eFCR	2
FFER fishmeal	1.76
FFER fish oil	2.48
FFER Score (0-10)	**3.81**
Critical?	NO
5.1b Sustainability of Source fisheries	
Sustainability score	-3
Calculated sustainability adjustment	-1.49
Critical?	NO
F5.1 Wild Fish Use Score (0-10)	**2.32**
Critical?	NO

5.2 Net protein Gain or Loss

Protein INPUTS	
Protein content of feed (%)	37

eFCR	2
Feed protein from fishmeal (%)	
Feed protein from EDIBLE sources (%)	82.33
Feed protein from NON-EDIBLE sources (%)	17.67
Protein OUTPUTS	
Protein content of whole harvested fish (%)	22.2
Edible yield of harvested fish (%)	75
Use of non-edible by-products from harvested fish (%)	90
Total protein input kg/100kg fish	74
Edible protein IN kg/100kg fish	60.93
Utilized protein OUT kg/100kg fish	32.82
Net protein gain or loss (%)	-46.13
Critical?	NO
F5.2 Net Protein Score (0-10)	**5**

5.3. Feed Footprint

5.3a Ocean Area appropriated per ton of seafood	
Inclusion level of aquatic feed ingredients (%)	42
eFCR	2
Carbon required for aquatic feed ingredients (ton C/ton fish)	*69.7*
Ocean productivity (C) for continental shelf areas (ton C/ha)	*2.68*
Ocean area appropriated (ha/ton fish)	21.85
5.3b Land area appropriated per ton of seafood	
Inclusion level of crop feed ingredients (%)	58
Inclusion level of land animal products (%)	0
Conversion ratio of crop ingredients to land animal products	*2.88*
eFCR	2
Average yield of major feed ingredient crops (t/ha)	*2.64*
Land area appropriated (ha per ton of fish)	0.44
Total area (Ocean + Land Area) (ha)	22.29
F5.3 Feed Footprint Score (0-10)	2

Feed Final Score

C5 Feed Final Score (0-10)	**2.91**	**RED**
Critical?	**NO**	

Criterion 6: Escapes

6.1a System escape Risk (0-10)	0	
6.1a Adjustment for recaptures (0-10)	4	
6.1a Escape Risk Score (0-10)	**4**	
6.2. Competitive and Genetic interactions score (0-10)	**8**	
C6 Escapes Final Score (0-10)	**6**	**YELLOW**
Critical?	**NO**	

Criterion 7: Diseases

Disease Evidence-based assessment (0-10)		
Disease Risk-based assessment (0-10)	6	
C7 Disease Final Score (0-10)	**6**	**YELLOW**
Critical?	NO	

Criterion 8X: Source of Stock

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

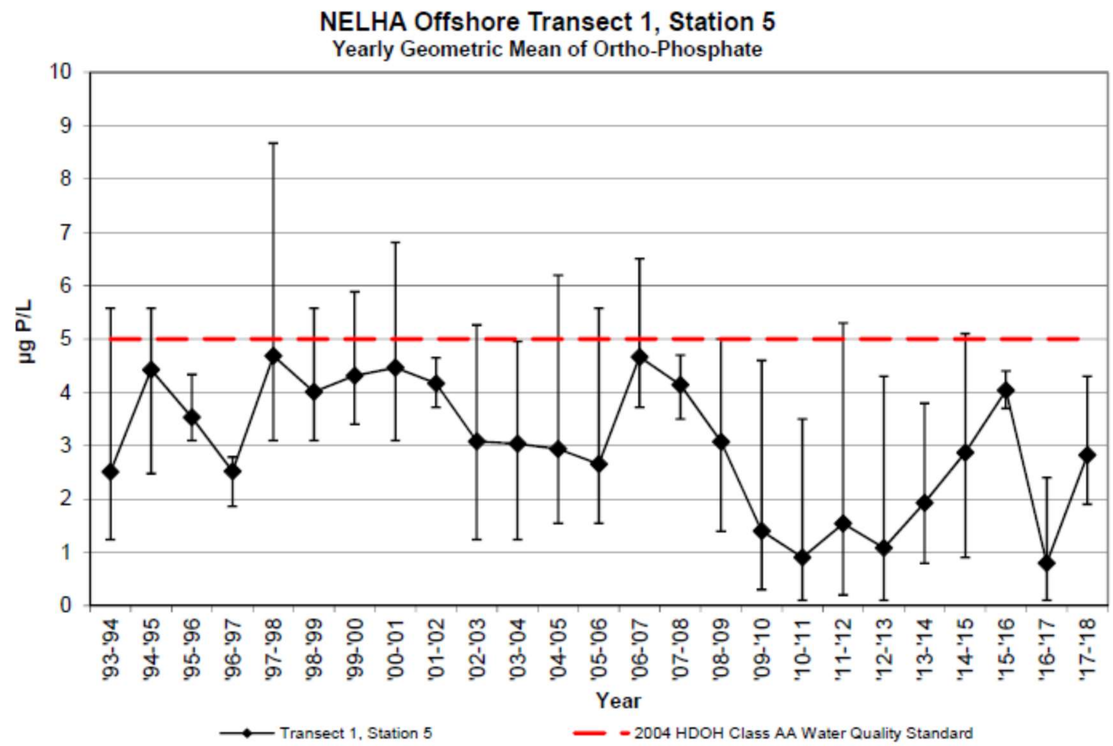
Criterion 9X: Wildlife and predator mortalities

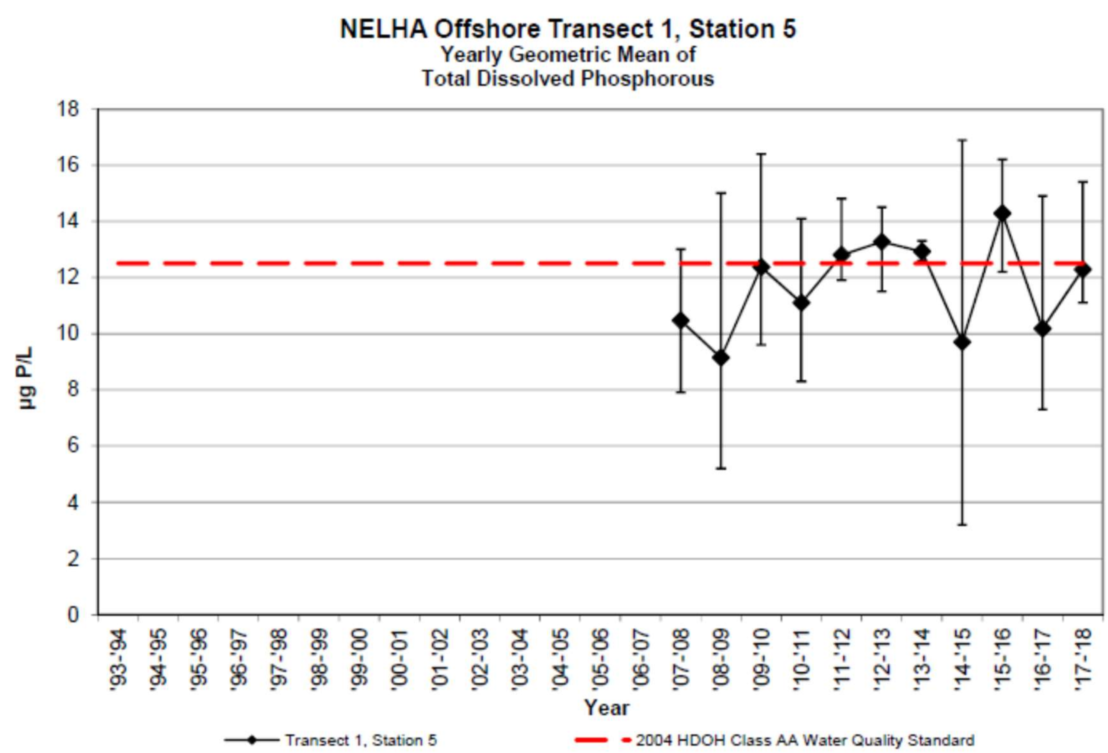
C9X Wildlife and Predator Mortalities Score (0-10)	**-2**	
C9X Wildlife and Predator Mortalities Final Score (0-10)	**-2**	**GREEN**
Critical?	NO	

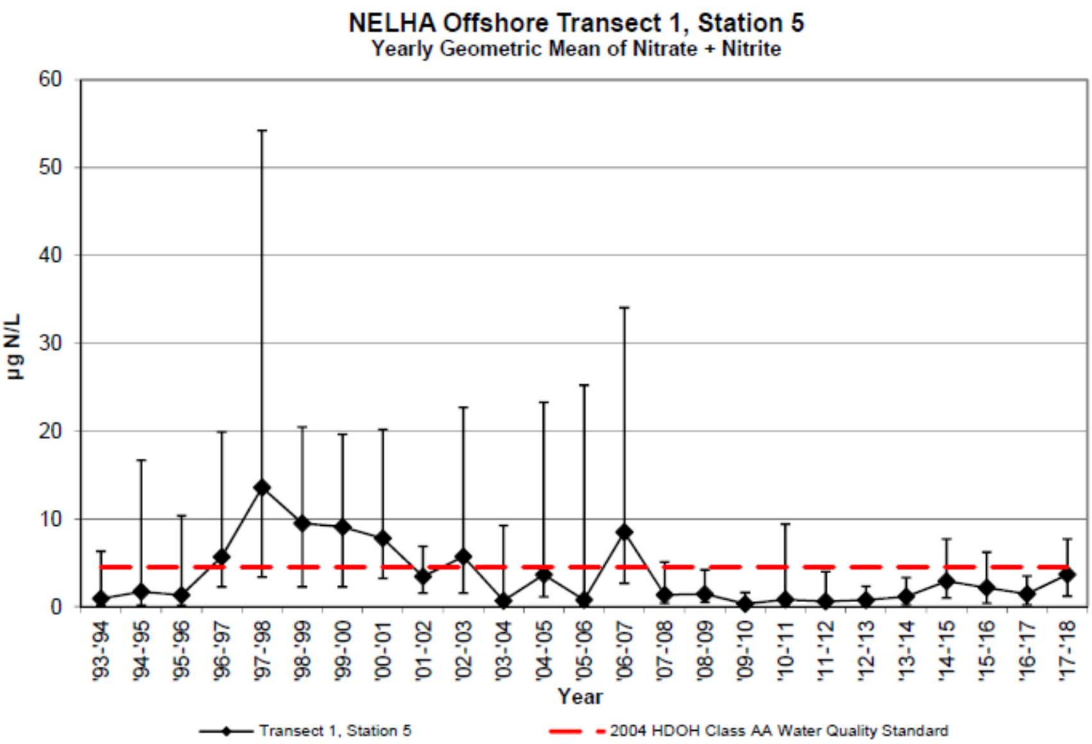
Criterion 10X: Escape of secondary species

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

Appendix 2 – Additional figures for Criterion 2-Effluent



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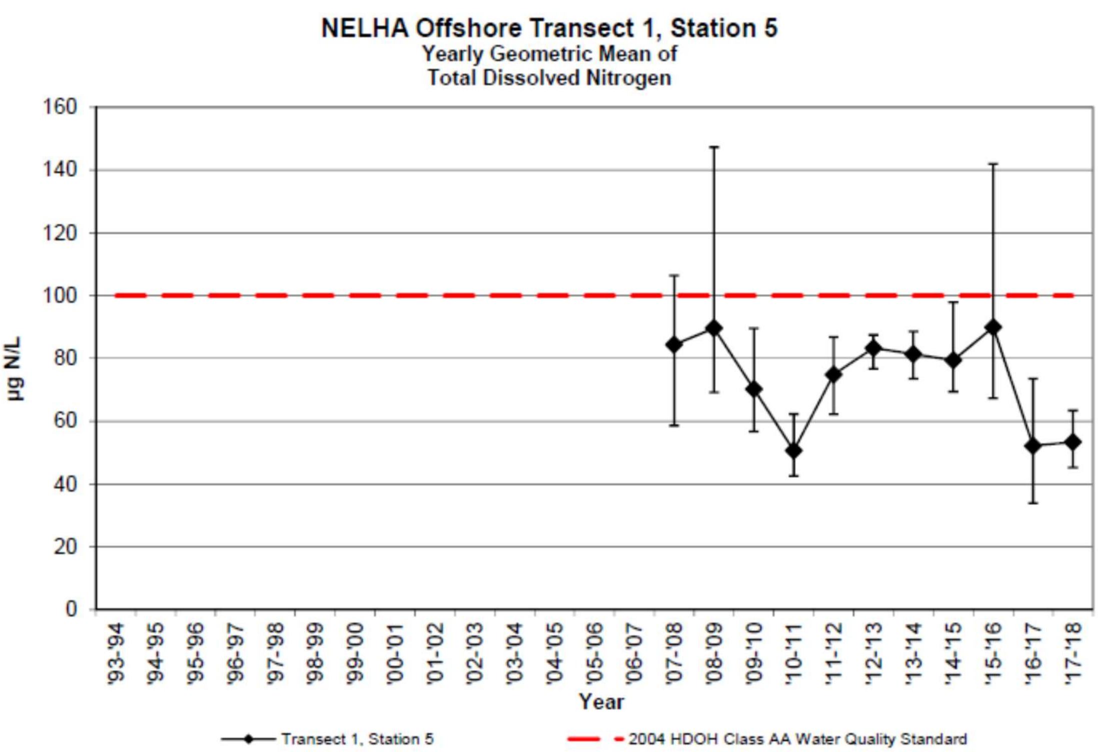
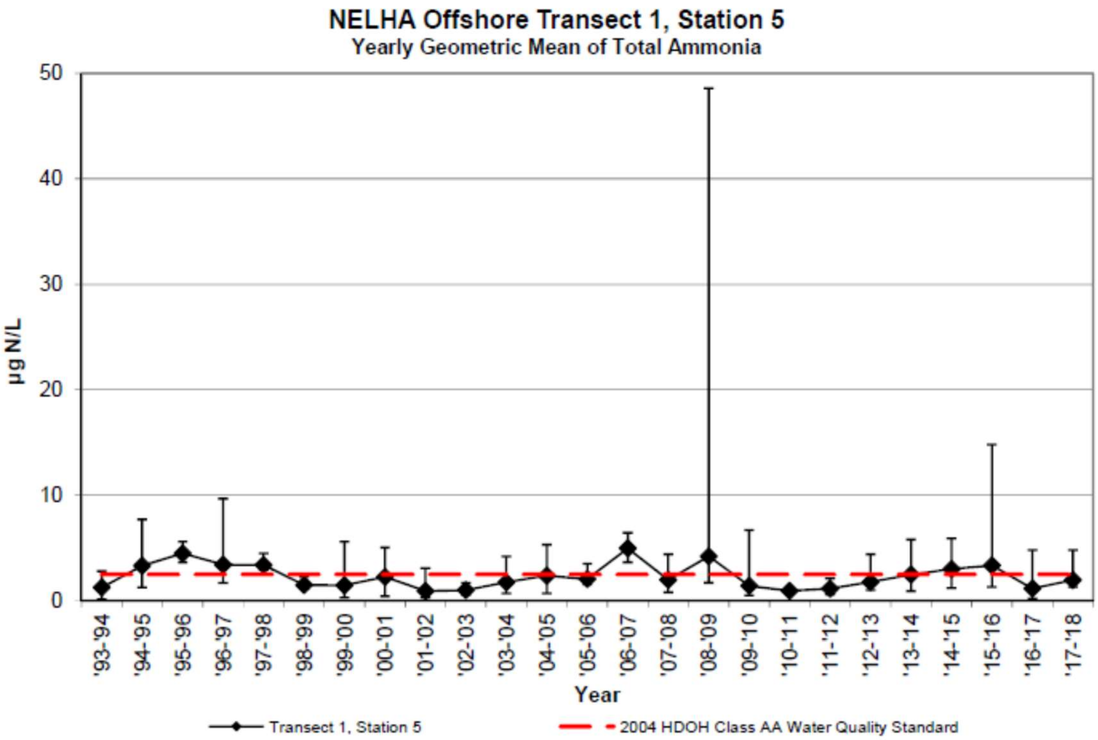
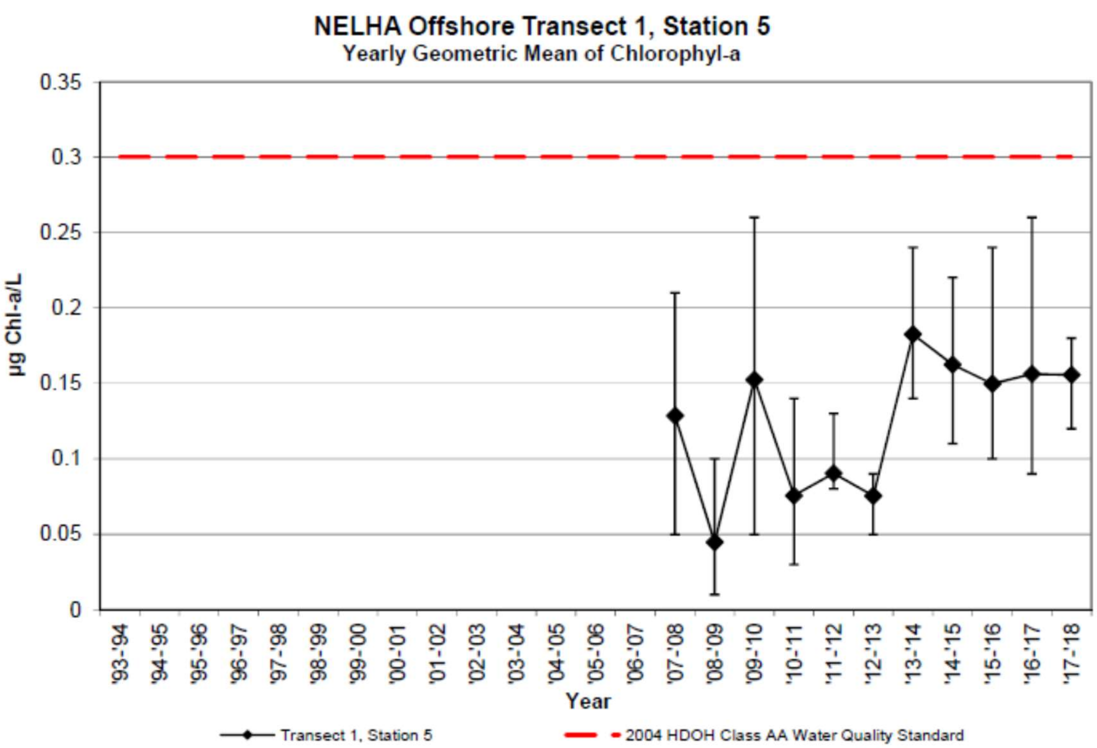
Yearly Geometric Mean of Nitrate + Nitrite
µg N/L
Year
Transect 1, Station 5
2004 HDOH Class AA Water Quality Standard


NELHA Offshore Transect 1, Station 5
Yearly Geometric Mean of
Total Dissolved Nitrogen
µg N/L
Year
Transect 1, Station 5
2004 HDOH Class AA Water Quality Standard


NELHA Offshore Transect 1, Station 5
Yearly Geometric Mean of Total Ammonia
µg N/L
50
40
30
20
10
0
'93-'94
'94-'95
'95-'96
'96-'97
'97-'98
'98-'99
'99-'00
'00-'01
'01-'02
'02-'03
'03-'04
'04-'05
'05-'06
'06-'07
'07-'08
'08-'09
'09-'10
'10-'11
'11-'12
'12-'13
'13-'14
'14-'15
'15-'16
'16-'17
'17-'18
Year
Transect 1, Station 5
2004 HDOH Class AA Water Quality Standard


NELHA Offshore Transect 1, Station 5
Yearly Geometric Mean of Chlorophyl-a
µg Chl-a/L
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
'93-'94
'94-'95
'95-'96
'96-'97
'97-'98
'98-'99
'99-'00
'00-'01
'01-'02
'02-'03
'03-'04
'04-'05
'05-'06
'06-'07
'07-'08
'08-'09
'09-'10
'10-'11
'11-'12
'12-'13
'13-'14
'14-'15
'15-'16
'16-'17
'17-'18
Year
Transect 1, Station 5
2004 HDOH Class AA Water Quality Standard

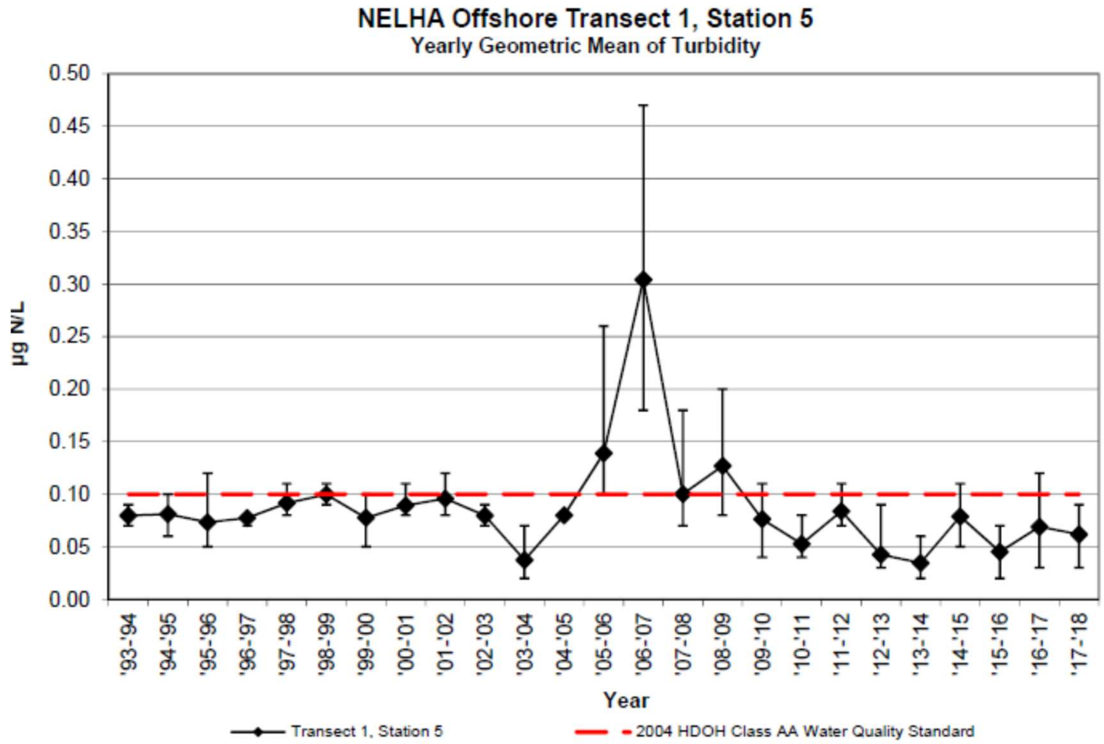
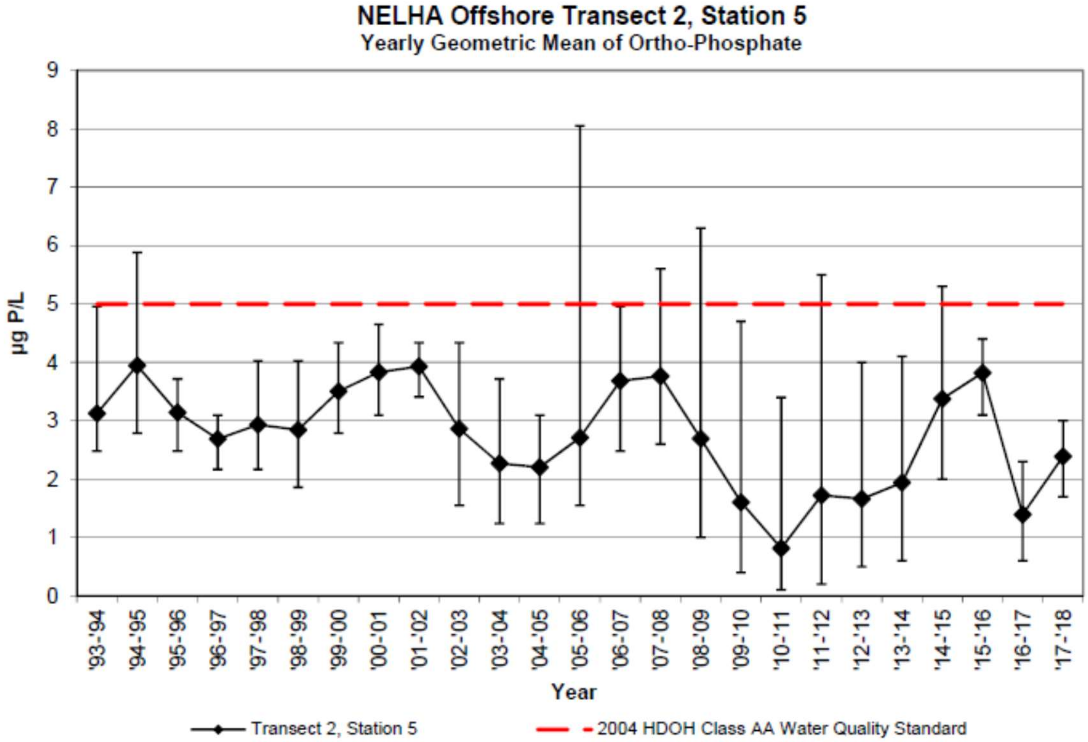


Figure A1. NELHA water sampling results for Transect 1 Station 5 from 1993 to 2018.


NELHA Offshore Transect 2, Station 5
Yearly Geometric Mean of Ortho-Phosphate
µg P/L
Year
'93-'94
'94-'95
'95-'96
'96-'97
'97-'98
'98-'99
'99-'00
'00-'01
'01-'02
'02-'03
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'09-'10
'10-'11
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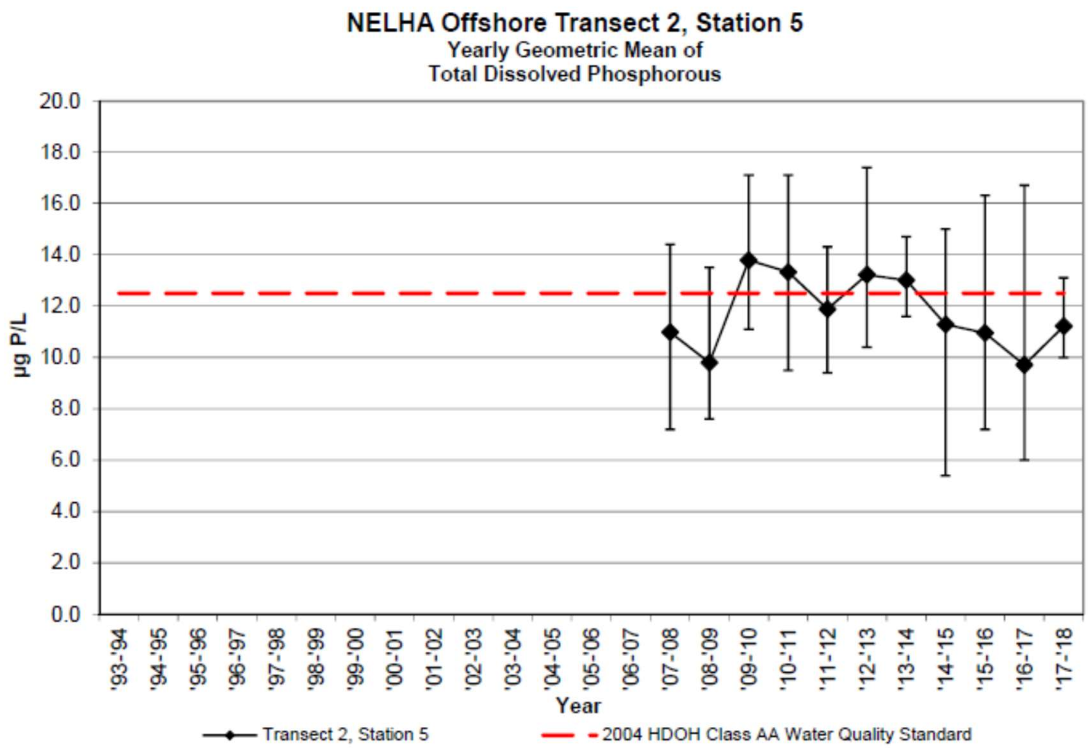
'16-'17
'17-'18
Transect 2, Station 5
2004 HDOH Class AA Water Quality Standard


NELHA Offshore Transect 2, Station 5
Yearly Geometric Mean of
Total Dissolved Phosphorous
µg P/L
Year
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'94-'95
'95-'96
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'08-'09
'09-'10
'10-'11
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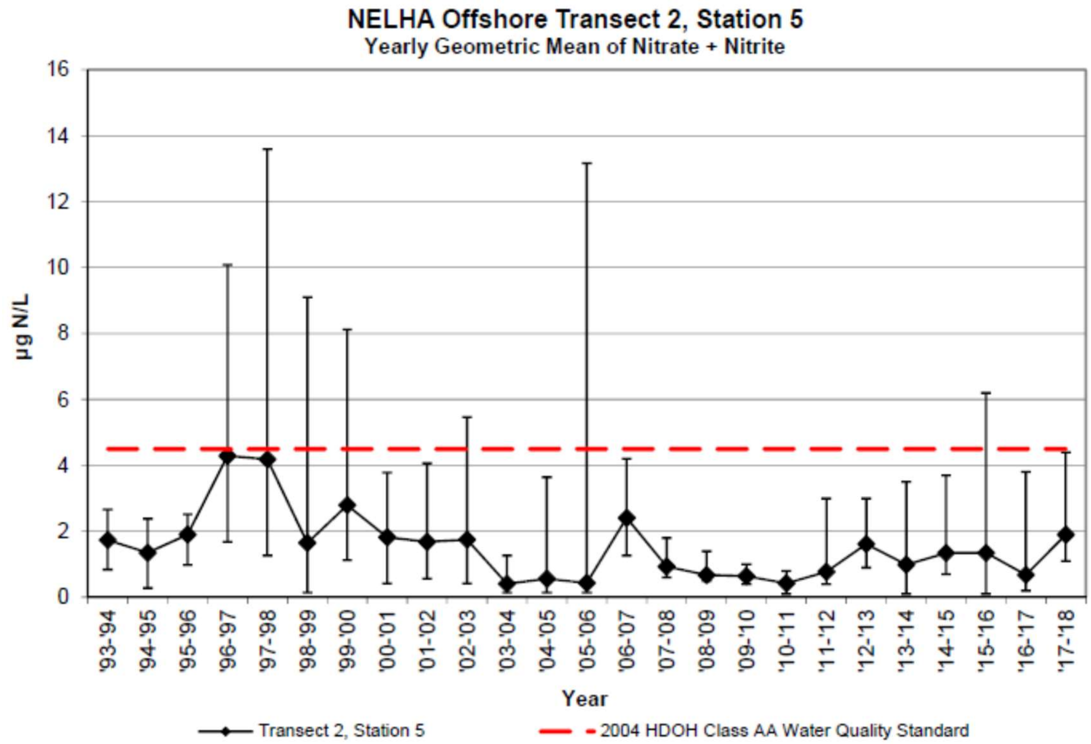
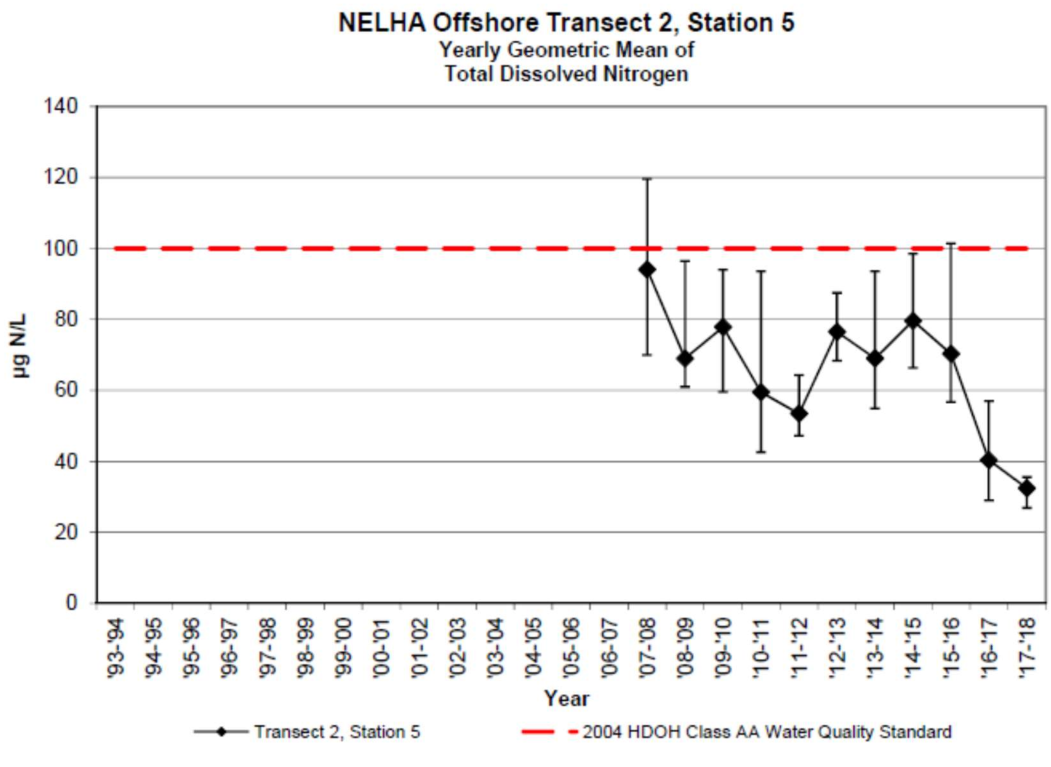
'15-'16
'16-'17
'17-'18
Transect 2, Station 5
2004 HDOH Class AA Water Quality Standard


NELHA Offshore Transect 2, Station 5
Yearly Geometric Mean of Nitrate + Nitrite
µg N/L
Year
Transect 2, Station 5
2004 HDOH Class AA Water Quality Standard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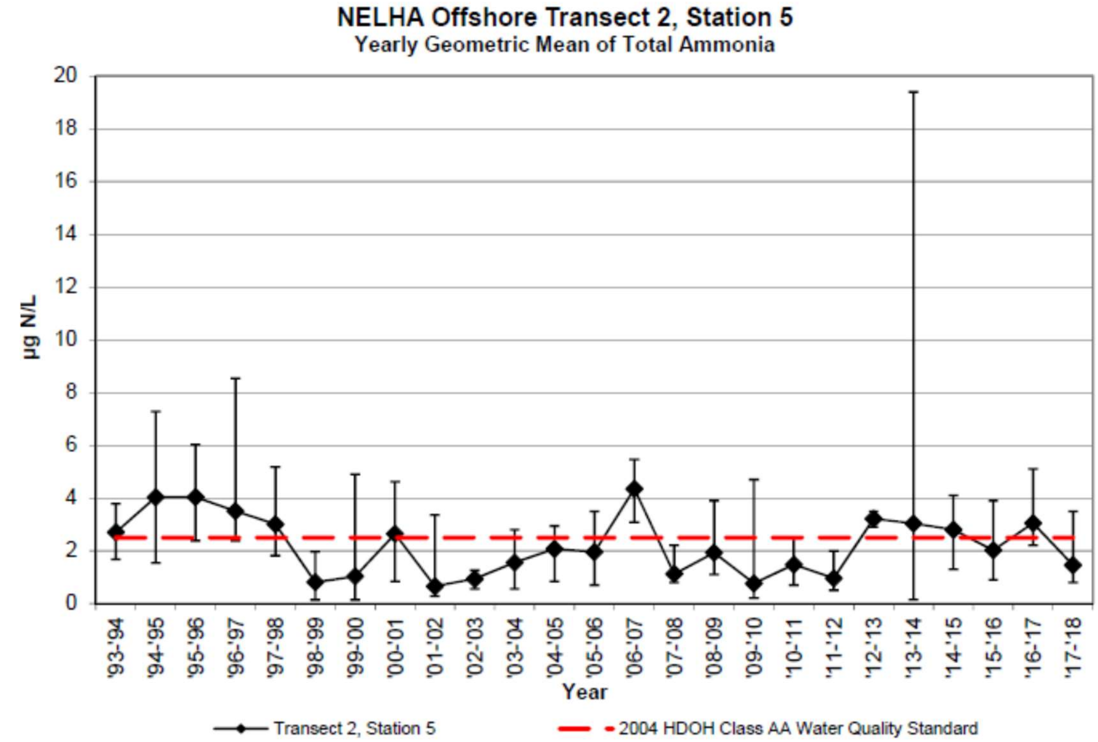
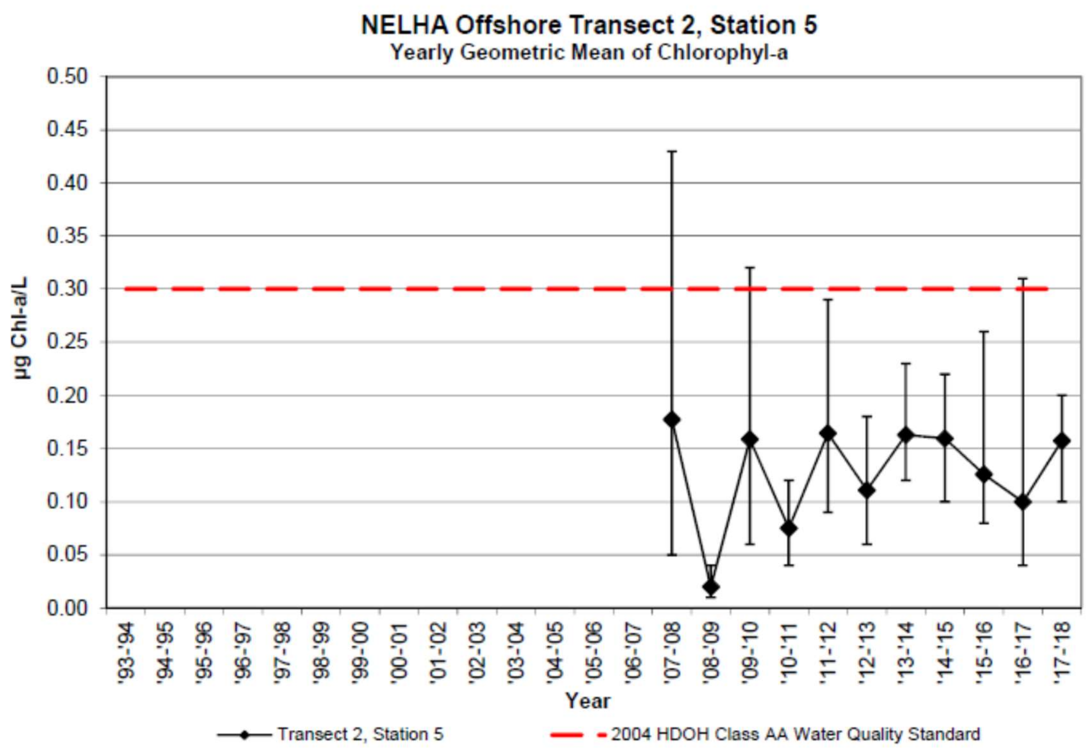
Yearly Geometric Mean of
Total Dissolved Nitrogen
µg N/L
Year
Transect 2, Station 5
2004 HDOH Class AA Water Quality Standard


NELHA Offshore Transect 2, Station 5
Yearly Geometric Mean of Total Ammonia
μg N/L
Year
'93-'94 '94-'95 '95-'96 '96-'97 '97-'98 '98-'99 '99-'00 '00-'01 '01-'02 '02-'03 '03-'04 '04-'05 '05-'06 '06-'07 '07-'08 '08-'09 '09-'10 '10-'11 '11-'12 '12-'13 '13-'14 '14-'15 '15-'16 '16-'17 '17-'18
0 2 4 6 8 10 12 14 16 18 20
Transect 2, Station 5
2004 HDOH Class AA Water Quality Standard


NELHA Offshore Transect 2, Station 5
Yearly Geometric Mean of Chlorophyl-a
μg Chl-a/L
Year
'93-'94 '94-'95 '95-'96 '96-'97 '97-'98 '98-'99 '99-'00 '00-'01 '01-'02 '02-'03 '03-'04 '04-'05 '05-'06 '06-'07 '07-'08 '08-'09 '09-'10 '10-'11 '11-'12 '12-'13 '13-'14 '14-'15 '15-'16 '16-'17 '17-'18
0.00 0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50
Transect 2, Station 5
2004 HDOH Class AA Water Quality Standard

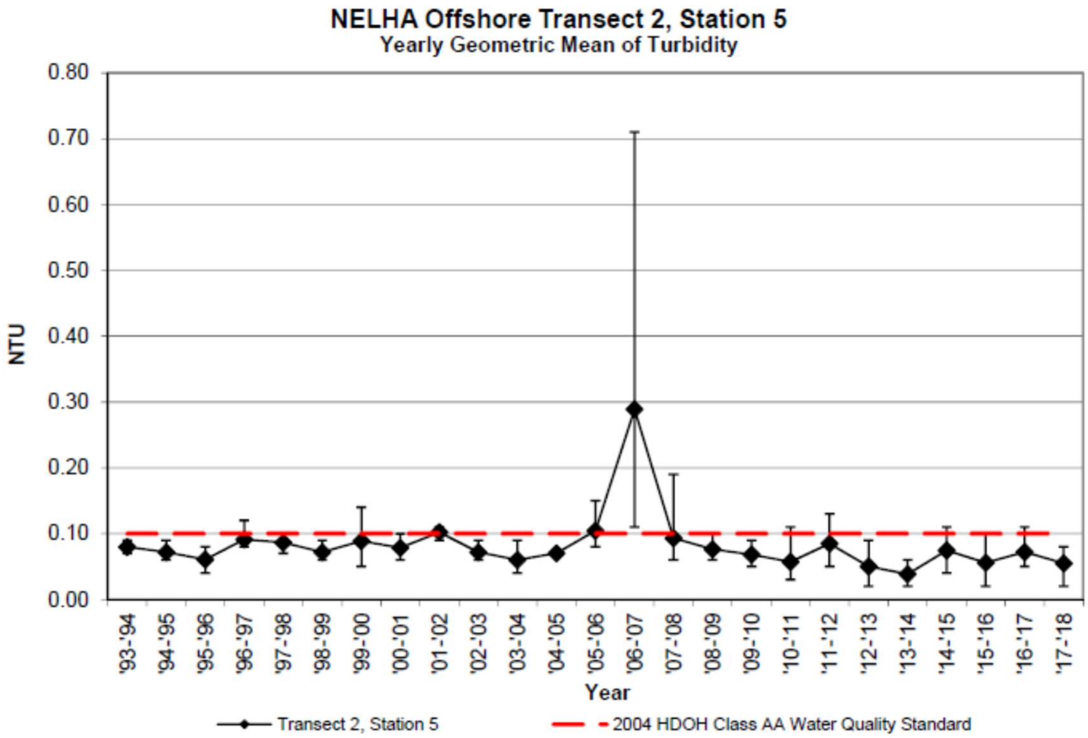


***Figure A2*.** NELHA water sampling results for Transect 2 Station 5 from 1993 to 2018.