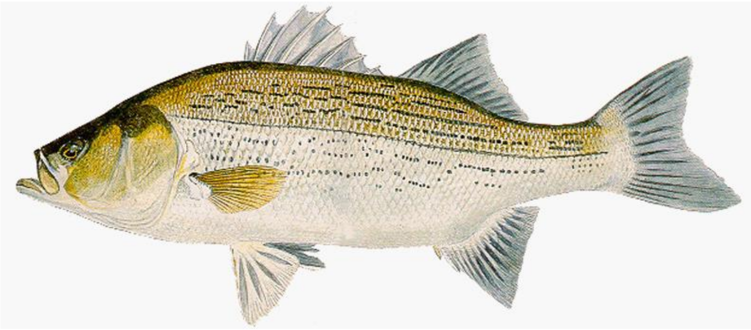
Monterey Bay Aquarium
Seafood Watch®

Hybrid Striped Bass

Morone chrysops X Morone saxatilis



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United States

Ponds and recirculating aquaculture systems

May 7, 2012

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Final Seafood Recommendation[1]

Hybrid Striped Bass raised in ponds from the United States present a final high overall score of 6.71, and therefore is ranked Green or Best Choice overall. Hybrid Striped Bass raised in recirculating systems from the United States present a final high overall score of 7.66, and therefore is ranked Green or Best Choice overall.

Hybrid Striped Bass

United States

Ponds

FINAL RANK	GREEN

OVERALL RANKING	
Final Score	6.71
Initial Rank	GREEN
Red Criteria	0
Intermediate Rank	GREEN
Critical Criteria?	NO

Criterion	Score (0-10)	Rank	Critical?
C1 Data	8.06	GREEN	n/a
C2 Effluent	8.00	GREEN	NO
C3 Habitat	7.37	GREEN	NO
C4 Chemicals	8.00	GREEN	NO
C5 Feed	3.98	YELLOW	NO
C6 Escapes	7.00	GREEN	NO
C7 Disease	7.00	GREEN	NO
C8 Source	10.00	GREEN	n/a
3.3X Wildlife Mortalities	-3.00	GREEN	NO
6.2X Introduced Species Escapes	-2.70	GREEN	n/a

[1] Hybrid striped bass are cultured in both ponds and recirculating aquaculture systems. The assessment for each mode of production gave such distinctly different scores that the Seafood Watch recommendation was separated into two final ranking score tables.

Hybrid Striped Bass

United States

Recirculating Systems, Water Re-use Systems

FINAL RANK	GREEN

OVERALL RANKING	
Final Score	7.66
Initial Rank	GREEN
Red Criteria	0
Intermediate Rank	GREEN
Critical Criteria?	NO

Criterion	Score (0-10)	Rank	Critical?
C1 Data	8.06	GREEN	n/a
C2 Effluent	9.00	GREEN	NO
C3 Habitat	8.03	GREEN	NO
C4 Chemicals	8.00	GREEN	NO
C5 Feed	3.98	YELLOW	NO
C6 Escapes	8.00	GREEN	NO
C7 Disease	8.00	GREEN	NO
C8 Source	10.00	GREEN	n/a
3.3X Wildlife Mortalities	0.00	GREEN	NO
6.2X Introduced Species Escapes	-1.80	GREEN	n/a

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

Executive Summary

The U.S. hybrid striped bass (*Morone chrysops × M. saxatilis*) is considered a premium quality food fish and is a popular sport fish in the U.S. (Jobling et al. 2010). The majority of hybrid striped bass (HSB) are cultured in earthen ponds throughout the western and southern regions of the U.S. and a total of 7,800,000 lbs. of HSB were produced in 2011 (Turano 2012). HSB are known to be a fast growing, resilient species; qualities that make them ideal for aquaculture (Kohler 2004).

- Data quality on HSB was generally good. Most information was readily available on government and non-profit organization websites. Feed ingredient data specific to HSB feeds was difficult to find and the industry could benefit from greater transparency in this category.
- The Environmental Protection Agency (EPA) together with various state agencies, regulate the discharge of effluents from commercial and private operations. HSB effluent research concluded that current pond methods do not have widespread, negative effects on the environment. This assessment concluded that 14% and 10% of total waste produced by HSB ponds and recirculating aquaculture systems (RAS) is discharged, respectively. Evidence of the adoption of new methods for managing effluent (use of settling basins, irrigation of farm crops) improved final scoring for ponds, but scores for HSB RAS were slightly better as RAS practices tend to discharge less effluent than ponds.
- Most ponds are constructed on lands already being used for agricultural purposes. These lands were cleared ~10 years ago, therefore the loss of habitat functionality and value of habitat was considered Low. Newly built HSB RAS do impact local habitats but on a smaller scale when compared to ponds. Overall habitat impact from ponds and RAS was considered minimal.
- Ponds are known to attract significant populations of birds. The U.S. Fish and Wildlife Service can issue a permit for the lawful capture, trapping, and taking of certain bird species. With these management practices in place and no evidence to suggest non-compliance on the part of HSB producers, the impact of predator/wildlife mortalities from HSB producers was Low.
- While chemical treatments may be used for a variety of purposes, the majority of those used in HSB production are listed as low-priority chemicals by the United States Department of Agriculture. The chemical use criterion score for HSB ponds and RAS was Low.
- The feed assessment for HSB production was Moderate. Greater transparency on the part of feed manufacturers on the amount and composition of feed ingredients used in HSB feeds could improve these values.

- The risk of escaped HSB from ponds and RAS was determined to be Low to Low-Moderate largely due to relatively low water exchanges. The risk of a negative impact from aquaculture escapes is also relatively low due to the widespread, deliberate stocking of HSB across the U.S. The industry relies heavily on the trans-water body movement of HSB fry and fingerlings from hatcheries to production farms. Evidence of biosecurity practices in place at both the source and destination facilities lowered the assessed risk of escapes and improved the scoring.
- Aquaculture has the potential to significantly impact local ecosystems through the transmission of disease, pathogens, or parasites. In an effort to address points of introduction, HSB producers have adopted best management practices specifically aimed at minimizing the movement of pathogens to and from HSB production sites. Therefore, the risk from disease, pathogens, or parasites was Low.
- Information from producers and available literature suggest that the amount of broodstock taken from the wild is generally minimal. The HSB fry are produced at hatcheries in the southeast region and research is ongoing to domesticate broodstock and provide a year-round supply of fry and fingerlings.

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Introduction

Scope of the Analysis and Ensuing Recommendation

Species—hybrid striped bass (*Morone chrysops* × *M. saxatilis*)[2]

Geographic coverage—United States

Production Methods—The majority of hybrid striped bass (HSB) aquaculture is done in freshwater, earthen ponds. HSB are also produced in recirculating aquaculture systems (RAS) and there are a few cases of production in retired coal mine lakes (Kohler 2004).

Species Overview

The farmed U.S. HSB (*Morone chrysops* × *M. saxatilis*) are predominately a cross between the freshwater female white bass (*M. chrysops*) and the anadromous male striped bass (*M. saxatilis;* Jobling et al. 2010). The reciprocal cross ("original cross"; *M. saxatilis* × *M. chrysops)* is also referred to as HSB. Both species and their hybrids have been introduced into rivers and reservoirs throughout the U.S. (Fuller 2012; Jobling et al. 2010; Kohler 2004). White bass females are readily available and produce viable eggs in captivity (Turano, NC Sea Grant, personal communication; McGinty and Hodson 2008; Morris et al. 1999). These favorable qualities explain why the *M. chrysops* × *M. saxatilis* cross are preferred by HSB producers.

HSB were first produced in the mid-1960s and initially stocked in reservoirs throughout the southeast U.S. (Fuller 2012; Hodson 1989). Hybrids have gained acceptance as a sportfish and stocking programs are ongoing (Kohler 2004). Both striped bass and white bass belong to the family Moronidae in the order Perciformes (Jobling et al. 2010; Hodson 1989). Striped bass are indigenous to the east coast of North America, while white bass are native to the Mississippi drainage (Kohler 2004).

HSB share similar physical characteristics to their parental species (Hodson 1989). The body is compressed slightly, with lateral stripes similar to striped bass, though the stripes are sometimes broken in the area behind the pectoral fin and below the lateral line (Hodson 1989). There are 8-9 spines on the dorsal fin and the caudal fin is forked with two pointed lobes (Hodson 1989). HSB are a carnivorous species and feed primarily on zooplankton until they are 100-125mm, after which time they switch to small fish (Hodson 1989). They grow rapidly; typical sizes range from 2 to 5 lbs. though HSB are generally harvested at 1.5 to 3.5 lbs. (Morris et al. 1999; Hodson 1989). HSB are a resistant species and survive in a range of environmental water conditions (Hodson 1989). Their optimum temperature is 25-27°C though they are

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[2] Hybrid striped bass refers to a variety of hybrids of freshwater bass with a striped bass. The sunshine bass (*M. chrysops* F × *M. saxatilis* M) is the hybrid typically used in aquaculture for food while the Palmetto bass (*M. saxatilis* F × *M. chrysops* M) is preferred for sport fishing stock enhancement (Green, USDA-ARS, personal communication).

known to tolerate temperatures ranging from 4 to 33°C. HSB are commonly cultured in freshwater but are tolerant of salinities as high as 25ppt (Hodson 1989), and possess several traits that make them an ideal species for aquaculture; they are fast growing, readily accept pelleted diets, and are generally resistant to disease (Kohler 2004).

Production Statistics

A total of 7.8 million pounds of HSB were produced in 2011 (Turano 2012). Of that total, 6.9 million pounds were produced in ponds in the West, Mid-Atlantic, and Southeastern regions of the U.S. (Turano 2012). A moderate 802,000 lbs. of HSB were produced in tanks, with production largely in the upper Midwest and Southeastern regions of the U.S. (Turano 2012). HSB are also produced in Germany, Israel, and Italy (Jobling et al. 2010). White bass, striped bass, and their hybrids have been introduced to Mexico, China, Taiwan, Russia, France, and Portugal (Jobling et al. 2010). Production values of these countries combined, totaled over 800,000 lbs. in 2009 (2007-2009 FAO stats). Production data show a 10% decrease in tank production from 2008 to 2011 and the subsequent shift to even more pond production (Turano 2012; Appendix B). The data also show that the production of HSB has decreased moderately in recent years (Appendix B).

Importance to U.S./North American market

HSB are the fourth largest fish farming sector in the U.S. (McGinty and Hodson 2008; Dunning and Daniels 2001). Virtually all HSB foodfish are sold within the U.S. and Canada (Ekstrom, Ekstrom Enterprises, personal communication; Freeze, Keo Fish Farm, personal communication; Turano, NC Sea Grant, personal communication). The export of HSB in the form of fry and/or fingerlings is roughly 30%−40% of all fry/fingerling production (Freeze, Keo Fish Farm, personal communication). HSB are most often sold directly from farms to wholesalers as whole fish, with costs ranging from $2.90 to $3.20 per/lb (Losordo et al. 2010).

Common and market names

Common names of HSB include: bass, wiper, rockfish, sunshine bass (*M. chrysops × M. saxatilis*), and palmetto bass (*M. saxatilis × M. chrysops).*

Primary product forms

HSB are most often sold directly from the farm to wholesalers as fresh, whole fish on ice (Gatlin, Texas A&M, personal communication; Freeze, Keo Fish Farm, personal communication; Jobling et al. 2010). There are some hybrid striped bass sold live to Asian markets in U.S. cities and Canada (Freeze, Keo Fish Farm, personal communication; Kohler 2004) and there are known frozen imports from Taiwan (Ekstrom, Ekstrom Enterprises, personal communication; Faucette, Colorado Catch, LLC, personal communication) though no data exists to substantiate such claims.

Analysis

Scoring guide

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

Criterion 1: Data Quality and Availability

Impact, unit of sustainability and principle

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

	Data Category	Relevance	Data Quality	Score
		Y / N	0 to 10	
A	Industry or production statistics	Yes	10.00	10.00
B	Effluent	Yes	10.00	10.00
C	Locations/habitats	Yes	7.50	7.50
D	Predators and wildlife	Yes	7.50	7.50
E	Chemical use	Yes	7.50	7.50
F	Feed	Yes	5.00	5.00
G	Escapes, animal movements	Yes	7.50	7.50
H	Disease	Yes	7.50	7.50
I	Source of stock	Yes	10.00	10.00
J	Other – (e.g. GHG emission)	No	Not relevant	n/a
			Total (0-10)	**72.50**

Final Data score (0-10)	**8.06**

Justification of Ranking

The lead agency for freshwater aquaculture in the U.S. is the United States Department of Agriculture (USDA 2010). The status of U.S. aquaculture production and general information can be found on the Food and Agriculture Organization of the United Nations National Aquaculture Sector Review (FAO- NASO) website. Several federal agencies have regulatory authority within the aquaculture industry and these include: the National Oceanic and Atmospheric Administration (NOAA), the U.S. Environmental Protection Agency (EPA), the National Marine Fisheries Service (NMFS), the U.S. Fish and Wildlife Service (FWS), U.S. Department of Agriculture (USDA), and the U.S. Food and Drug Administration (FDA). Each federal agency works with individual state agencies to ensure compliance from aquaculture producers. All of the aforementioned departments provide fact sheets and publications free to the public on their respective websites.

There are private sector associations such as the Striped Bass Growers Association, National Aquaculture Association and the U.S. Chapter, World Aquaculture Society that contribute significantly to the aquaculture industry by developing voluntary environmental codes of conduct and best management practices. Such codes and practices often follow guidelines found in the FAO Code of Conduct for Responsible Fisheries (FAO 1995). These and other aquaculture organizations also support the industry by sponsoring workshops and conferences. The HSB industry strives to create transparency and communication between producers, government agencies, research institutions and the general public.

Research institutions such as the North Central Regional Aquaculture Center (NCRAC), Southern Regional Aquaculture Center (SRAC), and the Stuttgart National Aquaculture Research Center (SNARC) work closely with federal/state agencies and producers in pursuing research projects specifically aimed at solving many of the industry's primary concerns. Fact sheets and publications are also available from the NCRAC and SRAC websites and the information is freely available and relatively recent.

Production Data

Good quality production data were readily available and up-to-date. Much of the production statistics came from presentations made at the World Aquaculture Society conference in 2012. These presentations were easily downloaded from the Striped Bass Growers Association website and the data was based on surveys from producers throughout the U.S. region (Turano 2012; Turano, NC Sea Grant, personal communication). Therefore, the score for industry/production statistics was 10 (High).

Effluent

Recent research has been conducted that specifically addresses effluents from HSB aquaculture (Eklund et al. 2012; Romaire 2012; Sydorovych and Daniels 2011). The most recent information on effluent regulations and policies can be found on the U.S. Environmental Protection Agency (EPA) website. The National Pollutant Discharge Elimination System is a system of permitting that regulates the discharge from point sources (i.e., storm drains). The EPA also has an interactive database that allows the public to view the compliance and enforcement status of facilities throughout the U.S. Nitrogen inputs from fertilizers can vary considerably from one farm to another and it is recommended that greater transparency be shown on the part of the EPA and state agencies. Since this was not a fault on the part of the HSB industry specifically, this did not adversely affect final scoring. Personal communications with producers confirmed that effluent data were being collected regularly by state and/or third party water quality labs. Taken together, the overall data quality score for effluent was 10 (High).

Habitat
In general, there was a lack of data on habitat conversion and function with respect to HSB production. The EPA has laws and regulations that apply to the establishment of animal feeding operations and to concentrated animal feeding operations but there is no category specifically dedicated to aquatic animal production facilities. Information related to habitat and farm siting management effectiveness and enforcement was unknown despite assurances that regulation occurs at the state level. The data quality score for habitat was 7.5 (Moderate-High).

Predator and Wildlife Mortality Rates and Population Impacts
The U.S. Fish and Wildlife Service (FWS) issues permits for the lawful capture, trapping, and taking of birds. These permits are species specific and aquaculture producers must list the exact species and number of birds of each species that are taken (Barras et al. 2007). It is recommended that the FWS publish recent data on predator/wildlife mortality rates and population impacts from the taking of birds. The score for predator/wildlife was 7.5 (Moderate-High).

Chemical Use
Despite the wealth of research on chemicals used in aquaculture operations, there remained a lack of data specific to the total amount and/or frequency of chemical treatments administered at HSB aquaculture sites. Most chemicals used by HSB producers are listed as low-priority by the USDA. Therefore, the score for chemical use was 7.5 (Moderate-High).

Feed Use
Feed manufacturers have the most up-to-date information on fishmeal, fish oil inclusion levels, and the source of plant and/or by-product ingredients used in HSB feeds. Unfortunately, much of this information remains proprietary and the assessor was unsuccessful in repeated attempts to contact the feed industry. Feed use estimates were determined from sources ranging from personal communications with producers and fish nutritionists (Ekstrom, Ekstrom Enterprises, personal communication; Gatlin, Texas A & M, personal communication) to fish nutrition research papers (Turano 2012; Turano, NC Sea Grant, personal communication). The score for feed data was 5 (Moderate).

Escapes
The quality of data regarding the escapes of farmed HSB was largely farm-specific. Hybrid striped bass are a non-indigenous species that have been deliberately stocked in water bodies throughout the U.S. Communication with industry professionals led to the conclusion that

most do not consider escapes of HSB to be an issue of concern because they have been introduced to most water systems. The score for escapes was 7.5 (Moderate-High).

Disease/Pathogens—outbreaks, mortalities, pathogen/parasite levels and treatments, biosecurity characteristics

The control of disease, pathogens, and parasites on aquaculture farms is typically state-regulated and there is variability among states in terms of the requirements put upon farms to properly monitor, report, and manage any outbreaks on their farms. It is worth noting that many HSB producers have taken it upon themselves to monitor their use of chemicals and have their water inspected by a third party to ensure that they meet water standards prior to discharge (Ekstrom, Ekstrom Enterprises, personal communication; Freeze, Keo Fish Farm, personal communication; Turano, NC Sea Grant, personal communication). Evidence of the aforementioned actions by HSB producers allowed for better scores in this category even though data to show chemical discharges is largely undocumented. Therefore, the score for disease/pathogens was 7.5 (Moderate-High).

Source of Stock—of farm stocks, use of wild fisheries for broodstock, larvae or juveniles

Information from producers and available literature suggest that the amount of broodstock taken from the wild is minimal to moderate. All HSB fry and fingerlings are produced in hatcheries independent from wild stocks. The final score for source of stock was 10 (High).

Criterion 1 Synthesis

Overall, the data quality for HSB industry was 72.5 to give a final score of 8.1 (High). Communication with HSB producers and researchers allowed for a more robust assessment of the industry.

Criterion 2: Effluents

Impact, unit of sustainability and principle

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

Full Assessment (Ponds)

Effluent Parameters	**Value**	**Score (0-10)**
C2.1a Biological waste (nitrogen) production per ton of fish (kg N ton^{-1})	90.57	
C2.1b Percentage of waste discharged from farm (%)	14.00	
C2 .1 Waste discharge score (0-10)		8.00
C2.2a Content of regulations (0-5)	4.00	
C2.2b Enforcement of regulations (0-5)	4.50	
C2.2 Regulatory or management effectiveness score (0-10)		7.20
C2 Effluent Final Score		**8.00**
Critical?	*No*	

Full Assessment (RAS)

Effluent Parameters	**Value**	**Score (0-10)**
C2.1a Biological waste (nitrogen) production per ton of fish (kg N ton^{-1})	90.24	
C2.1b Percentage of waste discharged from farm (%)	10.00	
C2 .1 Waste discharge score (0-10)		9.00
C2.2a Content of regulations (0-5)	4.00	
C2.2b Enforcement of regulations (0-5)	4.50	
C2.2 Regulatory or management effectiveness score (0-10)		7.20
C2 Effluent Final Score		**9.00**
Critical?	*No*	

The amount of waste or effluent produced by an aquaculture operation is a function of the production system, the species being farmed, and the management procedures/protocols in place. While there exists recent research of effluents from HSB farms (Eklund et al. 2012; Romaire 2012; Sydorovych and Daniels 2011), the lack of data made it necessary to conduct a full rather than a rapid assessment of effluents.

Justification of Ranking
Factor 2.1a- Biological Waste Production per Ton of Fish

Factor 2.1a is a measure of the amount of nitrogen waste produced per ton of fish produced. The following values must be known in order to make the calculation:

a) Protein content of the feed (%)
b) Economic feed conversion ratio (eFCR)[3]
c) Fertilizer nitrogen input per ton of fish produced (kg N t^{-1})
d) Protein content of harvested whole fish (%)
e) Protein nitrogen content factor= 0.16 (a fixed value based on the assumption that protein is 16% N)

The protein content of HSB growout feeds was estimated from protein content values in available literature and from industry professionals, to be ~40% (D'Abramo and Frinsko 2008; Dunning and Daniels 2001; Faucette, Colorado Catch, LLC, personal communication; Jobling et al. 2010; Ludwig 2004; Turano et al. 2007) and this was the value used for a) protein content of the feed (%).

Based on available literature and recent communication with producers and/or researchers, the eFCR was determined to be 1.86 (see Criterion 5.1; D'Abramo and Frinsko 2008; Dunning and Daniels 2001; Ekstrom, Ekstrom Enterprises, personal communication; Gatlin, Texas A&M, personal communication; Jobling et al. 2010). Tank systems tend to have better eFCR than ponds (Losordo et al. 1998) but recent information to confirm this was unavailable.

In HSB pond production, hatchery ponds are fertilized with a mixture of organic (cottonseed meal, alfalfa hay, rice bran, animal manure; Green, USDA-ARS, personal communication; Ludwig 2004; Morris et al. 1999) and inorganic fertilizers (ammonium nitrate, urea, ammonium hydroxide, ammonium sulfate, phosphoric acid; Green, USDA-ARS, personal communication). These fertilizers provide food for phytoplankton. The phytoplankton provides food for rotifers which are in turn preyed upon by microorganisms such as copepods and cladocerans. It is these microorganisms that provide food for HSB fry and fingerlings during the first few weeks after stocking (Ludwig 2004). The type of fertilizer used, the amounts, and the frequency of application can vary considerably from one farm to the next. At this stage, fingerlings are typically graded and stocked into growout ponds. The growout ponds are not fertilized and juveniles feed on pelleted diets until they reach market size (Ekstrom, Ekstrom Enterprises, personal communication).

By estimating the HSB production from a growout pond to be ~6000 lbs/acre (Sydorovych and Daniels 2011) and that approximately 2.2 lbs N/acre was distributed as fertilizer in the initial fingerling pond (Green, USDA-ARS, personal communication), the fertilizer nitrogen input per

[3] eFCR= total feed inputs divided by the total harvested fish output over the entire production cycle. Ideally eFCR should be averaged over multiple production cycles and take seasonal differences into account (e.g. wet or dry season, age of fish). Where such data were unavailable, the analyst was cautious and used the best data available.

ton of fish produced was calculated to be 0.33 kg N t^{-1}. Finally, due to the lack of specific data, the protein content of harvested whole fish was determined to be 18%; a value supplied by Seafood Watch®. The biological waste (nitrogen) production per ton of fish was then calculated to be 90.57 kg N t^{-1}. The HSB RAS values for a) through e) were the same with the exception of c). The HSB RAS do not use fertilizers in their production; therefore the value for c) fertilizer nitrogen input per ton of fish produced (kg N t^{-1}) was 0. The biological waste (nitrogen) production per ton of fish for HSB RAS was 90.24 kg N t^{-1}.

Factor 2.1b- Production System Discharge

Factor 2.1b determined how much of the waste produced by HSB is actually discharged from the farm. It acts as a multiplier value for Factor 2.1a. While some ponds exchange 3%−10% of water/day, most HSB ponds are drained once per production cycle (1.5-2.5 yrs.), usually at harvest (Ekstrom, Ekstrom Enterprises, personal communication; Freeze, Keo Fish Farm, personal communication; Turano, NC Sea Grant, personal communication). Therefore, the initial score for ponds was 0.34. Ponds are drained for several reasons including: the prevention of cannibalism, control of snail populations, and to ensure that all fish are removed (Sydorovych and Daniels 2011; Romaire 2012). Effluents may be unintentionally discharged from ponds as over-flow from heavy rains (Sydorovych and Daniels 2011). Effluent nutrient levels can also vary seasonally depending on production practices (Daniels 2003). Some producers utilize a settling basin and/or vegetated ditches for the effluent water discharged from ponds (Ekstrom, Ekstrom Enterprises, personal communication), though retention time may vary from one farm to another. This practice allowed for an adjustment of -0.1. Additionally, some producers use a portion of effluent to irrigate the crops of local farmers (Ekstrom, Ekstrom Enterprises, personal communication; Freeze, Keo Fish Farm, personal communication; Turano, NC Sea Grant, personal communication) and this led to an additional adjustment of -0.1. With the two adjustments made, it was concluded that the percentage of waste discharged by the farm was 14%.

Results from a recent research study, concluded that current pond methods do not have widespread, negative effects on the environment but that producers should adopt environmentally responsible and sustainable production practices (Romaire 2012). In a study that investigated the economic feasibility of alternative effluent treatments, Sydorovych and Daniels (2011) found that retaining water in ponds after harvest instead of draining at the end of the production cycle, had the highest positive impact on yearly farm budgets and may reduce production costs without compromising fish yields (Sydorovych and Daniels 2011). The same study also showed that ponds have a natural capacity to assimilate waste through various biological and physical processes (Sydorovych and Daniels 2011). While Jim Ekstrom agrees that eliminating the draining of ponds saves the cost of pumping water, there is now the cost of piscides to eliminate unwanted fish. Additionally, Ekstrom has found that draining his ponds at the end of the production cycle increases survival, fish health, and overall FCR in his ponds (personal communication).

Information on HSB RAS effluents was scarce, though HSB RAS tend to be semi-closed, recirculating systems with at least one method in place for solids removal and biofiltration of soluble wastes (Losordo et al. 1998; Masser et al. 1999; Yanong 2012). The water re-use system at Colorado Catch utilizes tanks in a semi-flow-through system (Faucette, Colorado Catch LLC, personal communication). Effluent flows from the tanks to raceways where tilapias provide natural biofiltration. A portion of that water is oxygenated and returned to HSB tanks and the remainder is used to irrigate the surrounding farmland (Faucette, Colorado Catch, LLC, personal communication). The initial score for HSB RAS was 0.2 and an adjustment of -0.1 was made for the use of effluent water to irrigate crops. The percentage of waste discharged from HSB RAS was concluded to be 10%.

Criterion 2.2- Management of farm level and cumulative impacts

Criterion 2.2 measures the presence and effectiveness of laws, regulations and management controls to limit the total discharge of wastes from farms and the cumulative impacts of aquaculture effluent from multiple farms.

The most recent information on effluent regulations and policies can be found on the EPA website. The National Pollutant Discharge Elimination System (NPDES) is a system of permitting that regulates the discharge from point sources such as storm drains and discharge sites. State agencies often regulate aquaculture discharges under state law and the delegated authority under EPA NPDES rules. This is the case at Ekstrom Enterprises where the Texas Commission on Environmental Quality requires that the facility have an Aquaculture General Permit (Ekstrom, personal communication). This permit requires the conformity to certain facility designs, operating criteria, monthly analysis and reporting of discharges, and compliance with limitations on parameters such as biological oxygen demand, oxygen level, total ammonia nitrogen, and total suspended solids. The information found on the EPA website led to the answers to questions 1-5 in Factor 2.2a. The total score for Factor 2.2a- *Intent and content of effluent regulations and management measures* was 4 out of 5.

In addition to the NPDES permitting, the EPA monitors compliance by storing NPDES permits online from 2007 to 2010. Information on permitting, inspections, violations, compliance and enforcement status of facilities can be found on Enforcement and Compliance History Online (ECHO). This interactive database allows the public to view the compliance and enforcement status of facilities located throughout the U.S. The issuing of fines for non-compliance is typically regulated at the state level and can vary. Together this information led to the following answers to questions 1-5 in Factor 2.2b. The total score for Factor 2.2b Enforcement of effluent regulations and management measures was 4.5. The final criterion 2.2 score was calculated to be 7.2 out of 10.

Criterion 2 Synthesis

The overall impact from effluents discharged from HSB production is minimal. While pond practices such as annual draining and susceptibility to flooding lowered the scoring, evidence of the adoption of best management practices (BMPs) and biosecurity policies improved the assessment. Novel practices such as settling basins and the use of effluents to irrigate crops improved scoring even further. It was concluded that 14% and 10% of waste is discharged by HSB ponds and RAS, respectively. The EPA sets the regulations and guidelines with respect to effluents. The NPDES regulates effluent discharges from point sources such as storm drains and discharge sites. The ECHO interactive database allows for the public viewing of permits, inspections, violations, etc.

Criterion 3: Habitat

Impact, unit of sustainability and principle

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

Habitat Parameters		Value	Score (0-10)
C3.1 Habitat conversion and function			7.00
C3.2a Content of habitat regulations		4.50	
C3.2b Enforcement of habitat regulations		4.50	
C3.2 Regulatory or management effectiveness score (0-10)			8.10
C3 Habitat Final Score			**7.37**
Critical?	*No*		

This criterion assesses whether aquaculture operations are located at sites, scales, and intensities that maintain the functionality of ecologically valuable habitats.

Justification of Ranking

Factor 3.1. Habitat conversion and function

This factor measures the habitat impact while taking account of the ongoing functionality of affected habitats and the historic or ongoing nature of habitat conversion for aquaculture. Ponds have the potential to impact local habitats particularly if ponds are located in or around ecologically sensitive areas such as wetlands or mangroves. There is no evidence that HSB farms are located near such areas. The habitat type for most HSB farms was considered to be desert and dry scrublands (Low) in the west and riparian land and floodplains (Moderate) in the southeast where most HSB operations are located (Turano 2012). Many HSB ponds have been in operation for ~10yrs or more and are considered "historic" for the purposes of this assessment. Because the loss of habitat functionality occurred 10 years ago when the ponds were built, and the value of habitat was considered low, the score for HSB ponds was 7 to mean that there are moderate impacts to habitat functionality.

The HSB RAS are smaller in size compared to ponds. Therefore the loss of habitat functionality from RAS will be less than for ponds. This led to a HSB RAS score of 8 for criterion 3.1.

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

Criterion 3.2 measures the presence and effectiveness of regulatory or management controls and determines if the controls are appropriate to the scale of the industry. Criterion 3.2 also measures the confidence that cumulative impacts of farms sited in the habitats declared in

Factor 3.1 are at appropriate spatial scales. The EPA has laws and regulations that apply to animal feeding operations (AFOs) and concentrated animal feeding operations (CAFOs). There is no category specifically for aquatic animal production facilities. Therefore, information related to Factor 3.2a and 3.2b were largely unknown, though producers and researchers say they are regulated at the state level (Ekstrom, Ekstrom Enterprises, personal communication; Freeze, Keo Fish Farm; Turano, NC Sea Grant, personal communication). The scores for 3.2a (regulatory or management effectiveness) and 3.2b (siting regulatory or management enforcement) were each 4.5 to show that most every state has some form of regulatory management with respect to habitats. Therefore, the final score for 3.2 was 8.10.

Criterion 3 Synthesis

The majority of HSB farms are located in the western and southeastern regions of the U.S. with pond culture as the common production type. In general, the land used for HSB ponds was cleared for agricultural purposes ~10yrs ago and the loss to habitat functionality occurred long ago. Habitat and farm siting management effectiveness policies exist at the state level and the Habitat Criterion final score was 7.37 for HSB ponds and 8.10 for HSB RAS.

Criterion 3.3X: Wildlife and predator mortalities

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

This is an "exceptional" 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.

Wildlife and Predator Mortality Parameters		**Score (0 to -10)**
C3.3X Wildlife and predator score		**-3.00**
C3.3X Wildlife and Predators final score		GREEN
Critical?	*No*	

Justification of Ranking

Earthen ponds are exposed to the environment and are known to attract significant populations of birds (Barras et al. 2007). The predation by birds can represent a significant loss to producers in the form of: direct loss of fish, injuries sustained from bird strikes, and fish mortalities due to parasites and/or pathogens that birds bring to the ponds (Barras et al. 2007). In an attempt to manage this predation while preserving the bird populations, the U.S. FWS issues a permit for the lawful capture, trapping, and taking of certain bird species (Migratory Bird Permits- Subpart 21.47). All fish-eating birds are protected under the Migratory Bird Treaty Act (Barras et al. 2007). Bird populations are carefully monitored to ensure that fish producers do not take too many birds. With these management practices in place and no evidence to suggest non-compliance on the part of HSB producers, it is the opinion of the author that predator/wildlife mortalities are of Low-Moderate concern and a criterion penalty score of -3 was given.

Recirculating systems consist of either tanks or raceways in which the cultured fish and the water are contained within a facility or structure that is separate from the surrounding environment. If not properly sealed against nuisance pests such as mice, rats, possums, and raccoons there is the potential for significant wildlife mortalities as producers attempt to keep their facilities pest-free. To date, there is no evidence that such facilities are endangering wildlife through their practices therefore the impact by RAS systems on predator/wildlife mortalities is considered negligible (HSB RAS penalty score: 0).

Criterion 3.3X Synthesis
Earthen ponds are exposed to the environment and are known to attract significant populations of birds. The U.S. FWS issues a permit for the lawful capture, trapping, and taking of certain bird species. With these management practices in place and no evidence to suggest non-compliance on the part of HSB producers, it is the opinion of the author that predator/wildlife mortalities are a Low-Moderate and a criterion score of -3 was given.

Criterion 4: Evidence or Risk of Chemical Use

Impact, unit of sustainability and principle

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

Chemical Use Parameters		Score (0-10)
C4 Chemical use		**8.00**
C4 Chemical Use Final Score		**8.00**
Critical?	*No*	

Justification

Chemical treatments are used for a variety of purposes on an aquaculture farm. The following is a brief description of common chemicals used in aquaculture operations.

Herbicides

Herbicides are chemicals used by fish farmers to control algae or weeds. Common aquatic herbicides include: copper sulfate, diquat, fluridone, and glyphosate (Masser et al. 2006; Sydorovych and Daniels 2011). To control the spread of filamentous algae, aquatic dyes are often used (D'Abramo and Frinsko 2008). The dyes diminish light penetrating the water column and are effective in stifling algal growth (D'Abramo and Frinsko 2008). Fish farmers are usually very careful in the application of herbicides because a mass die-off of plant life from herbicide treatment will decrease dissolved oxygen levels and adversely affect the fish (Shelton and Murphy 2011). Most aquatic herbicides have water-use restrictions and must be evaluated for special application and licensing (Masser et al. 2006; D'Abramo and Frinsko 2008). The Southern Regional Aquaculture Center recommends the use of a combination of methods such as: grass carp (*Ctenopharyngodon idelld*), herbicide treatment, and mechanical seining/raking as the most environmentally safe way to manage aquatic weeds (Masser et al. 2006; Shelton and Murphy 2011). All aquatic herbicides should be registered and labeled for use by the EPA and USDA and it is understood that the applicator of the herbicide is responsible for the effects from the drift or movement of the chemical (Masser et al. 2006).

Disinfectants

Both pond and recirculating aquaculture operations use chemicals for the purpose of keeping their facilities biosecure. The use of disinfectants is, typically, the easiest way to control the spread of pathogens and/or parasites. Chemical disinfectants include: bleach, Virkon® Aquatic, iodine, isopropyl alcohol, and formaldehyde (formalin) (Yanong and Erlacher-Reid 2012).

Chlorine products such as sodium hypochlorite and calcium hypochlorite are typically used to treat incoming water before it enters a recirculating facility (Yanong 2012). The chlorine is removed with sodium thiosulfate before being introduced to the system. Broodstock and/or harvested, fertilized eggs are often treated with formalin to remove ectoparasites before being transferred into a hatchery (McGinty and Hodson 2008). Other chemicals such as 35% PEROX-AID® (hydrogen peroxide product) is FDA approved to kill specific pathogens in fish and fish eggs (Yanong and Erlacher-Reid 2012). Bacterial infections in HSB ponds are typically treated with copper sulfate, potassium permanganate, or formalin (Sydorovych and Daniels 2011). Chemical treatments must be carefully applied and closely monitored in recirculating systems as certain chemicals (copper sulfate, potassium permanganate) can disrupt the biofilter (Masser et al. 1999; Yanong 2012).

Piscicides/Sedatives

Piscicides are those chemicals used to kill unwanted fish. Aquaculture operations sometimes have undesirable fish in their ponds (Wynne and Masser 2010). These fish may be unintentionally introduced: 1) by humans, 2) during the filling of ponds with unfiltered water, 3) from drains during heavy rains (Wynne and Masser 2010), or 4) by birds (Ekstrom, Ekstrom Enterprises, personal communication). Rotenone is a chemical often used to remove unwanted fish from ponds before restocking (Wynne and Masser 2010). Products containing rotenone are considered restricted-use pesticides and may be applied only by a certified private applicator or by a licensed commercial applicator (Wynne and Masser 2010). Additionally, there exists a limited number of chemical sedatives used in aquaculture and these include: tricaine methanesulfonate (MS-222), carbon dioxide, benzocaine, and eugenol though none are approved by the FDA as immediate-release fish sedatives (Trushenski et al. 2012). Ease of handling and surgical procedures are just as few of the reasons for sedating fish on an aquaculture farm (Trushenski et al. 2012). Currently, MS-222 is the only sedative compound under limited approval by the FDA to temporarily immobilize fish (Trushenski et al. 2012).

Antibiotics/Vaccines

Research at SNARC in Stuttgart, AR have evaluated amoxicillin and florfenicol for the treatment of *Streptococcus iniae* infection in HSB (Darwish 2007; Darwish and Ismaiel 2003). Until recently, there were no antibiotics or vaccines approved for use in HSB production. However, in 2012 the FDA approved the use of Aquaflor for all warm water fish to treat Strepococcus and columnaris infections (Ekstrom, Ekstrom Enterprises, personal communication). The ARS Aquatic Animal Health Research Unit in Auburn, AL is working to develop fish vaccines (Elstein 2005) though, to date, none have been approved for HSB.

The risk of improper use of chemical treatments on HSB aquaculture ponds is considered to be of Low concern (Score: 8). Jim Ekstrom, owner of Ekstrom Enterprises, states that use of chemicals on his farm is restricted to only those approved by the FDA or EPA and that he uses no antibiotics on his fish (personal communication). Mike Freeze of Keo Fish Farm, relies on grass carp to control excessive plant growth on his farm (personal communication). Chemical treatments represent an added cost to production for producers and most agree that the

regular use of chemicals is not cost effective (Ekstrom, Ekstrom Enterprises, personal communication; Freeze Keo Fish Farm, personal communication).
The chemical use score for HSB ponds was 8 (Low Risk) because, even though the ponds are drained annually, there is no published evidence of impacts on non-target organisms or evidence of resistance to key treatments from the use of chemicals.

The chemical use score for HSB RAS was also considered to be Low Risk (score: 8). The HSB RAS has a low chemical risk score because only a small amount of water is required by RAS systems compared to ponds (Losordo et al. 1998), meaning a lower amount of chemically treated water can potentially enter the environment. Additionally, recirculating systems may have mechanisms in place to neutralize chemicals prior to discharge. An example of this is the use of chlorine-based chemicals for disinfection purposes. These chemicals are easily neutralized with sodium thiosulfate and the water is easily tested for residual chlorine prior to discharge

Criterion 4 Synthesis
Chemical treatments are used for a variety of purposes on an aquaculture farm. These purposes include: algal/weed control, disinfectants, and fish sedatives. Most chemicals used by HSB farmers (chlorine, sodium chloride, ice, etc.) are considered relatively harmless (Ekstrom, Ekstrom Enterprises, personal communication; Freeze Keo Fish Farm, personal communication). To date, there is no published evidence of impacts on non-target organisms or resistance to treatment from the use of chemicals in HSB pond or RAS production. The chemical use score for HSB pond and RAS production was 8 (Low Risk).

Criterion 5: Feed

Impact, unit of sustainability and principle

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

Feed Parameters (Ponds)	Value	Score (0-10)
C5.1a Fish in : Fish Out Ratio (FIFO)	2.02	4.96
C5.1b Source fishery sustainability score (0 to -10)		0.00
C5.1: Wild fish use		4.96
C5.2a Protein IN	74.40	
C5.2b Protein OUT	22.00	
C5.2: Net Protein gain or loss (%)	-70.43	2
C5.3: Feed Footprint (hectares)	15.79	4
C5 Feed Final Score		**3.98**
Critical? *No*		

Justification of Ranking

C5.1. Wild Fish Use

Criterion 5.1 measures the amount of wild fish used to produce farmed fish. This measurement is combined with a measure of the sustainability of the fisheries from which they are sourced. Factor 5.1a- Fish In (FI) to Fish Out (FO) ratio is a measure of the dependency on wild fisheries for feed ingredients. This is accomplished by estimating the amount of wild fish used in feeds to the harvested farmed fish. In order to estimate FI:FO, the following values were needed:

a) Fishmeal inclusion level (%)
b) Fish oil inclusion level (%)
c) Fishmeal yield
d) Fish oil yield
e) eFCR

Repeated, unsuccessful attempts to contact feed manufacturers made this assessment difficult and most values were estimated based on personal communications and published research. Feed composition data is considered proprietary by feed manufacturers and HSB feeds are formulated using a least-cost feed formulation, meaning that diet composition will change in response to fluctuating ingredient prices (Green, USDA-ARS, personal communication). The fishmeal inclusion level was estimated based on information gathered from personal communications (Gatlin, Texas A&M, personal communication; Ekstrom, Ekstrom Enterprises, personal communication; Turano, NC Sea Grant, personal communication). The average of the aforementioned % FM inclusion levels came to 26% FM. The fish oil inclusion level was estimated to be 5% (D'Abramo and Frinsko 2008; Gatlin, Texas A&M, personal communication; Turano, NC Sea Grant, personal communication). Because both fishmeal and fish oil yield were unknown, 24% and 5% were provided by Seafood Watch®, respectively. Finally eFCR was estimated at 1.5-2 (Ekstrom, Ekstrom Enterprises, personal communication), 1.8-2 (Gatlin, Texas A&M, personal communication), and 2 (Jobling et al. 2010), the average of which was 1.86. Therefore, the FI:FO ratio for fishmeal was 1.65, fish oil was 1.86, and the final FI:FO score was 1.86, leading to a final score of 5.35 out of 10.

Factor 5.1b measured the sustainability of the fisheries providing fishmeal and fish oil. A negative adjustment is made to the FI:FO score for low sustainability of the fisheries. There is no penalty for using sustainable fishery sources. It is worth noting that feed manufacturers such as Skretting Inc. have a policy related to the procurement of fishmeal and fish oil. On the Skretting Inc. website there is a mandatory criteria that states that no marine product used in their feeds can be classified as Critically Endangered or Endangered by the IUCN. Most of the fishmeal/fish oil used in the HSB feeds come from the Gulf menhaden fishery (Ekstrom, Ekstrom Enterprises, personal communication, Faucette, Colorado Catch, LLC, personal communication, Freeze, Keo Fish Farm, personal communication). Gulf menhaden (*Brevoortia patronus*) are an ecologically important species in the northern Gulf of Mexico, supporting the second largest commercial fishery in the U.S. (Vaughan et al. 2007). Reduction factories along the Gulf process fish into meal, oil, and soluble products (Vaughan et al. 2007).

According to Fishsource (www.fishsource.com), the Gulf menhaden fishery scored ≥6 in management quality and 10 in fish stock assessment. The Gulf menhaden fishery is not overfished nor is overfishing occurring (updated: June 2012). Therefore the score for Factor 5.1b- Source fishery sustainability was 0 and the final score for 5.1 Wild Fish Use was 5.35.

C5.2. Net Protein Gain or Loss

Criterion 5.2 measures the net protein gained or lost during the fish farming process. Data on the amount of feed protein coming from sources unsuitable for human consumption can reduce the protein IN score as do data on the amount of crop ingredients used rather than fishmeal. Additionally, the use of non-edible byproducts of harvested fish can improve the protein OUT score.

The calculation for 5.2a protein IN and 5.2b protein OUT required the following basic data:

a) Protein content of feed
b) FCR
c) Protein content of whole harvested farmed fish
d) Edible yield of harvested farmed fish

The Seafood Watch® criteria allow the use of non-edible protein sources (such as processing by-products) to be discounted from the calculations and therefore improve final scores. The criteria also address the conversion of plant proteins to animal (fish) proteins if the data on their inclusion in feeds is available. Many alternatives to fishmeal and oil have been shown to be suitable for HSB (Blaufuss and Trushenski 2012; Gaylord et al. 2004; Metts et al. 2011; Rawles et al. 2010), but data on their inclusion in commercial feeds were not provided, so it was assumed (for the purposes of this assessment) that *all* protein HSB feeds come from edible sources.

From criterion 2.1a, the protein content of feed was 40% and FCR was 1.86 (criterion 5.1). The protein content of whole harvested farmed HSB was estimated to be 55% and edible yield of harvested farmed fish was 40% (Turano, NC Sea Grant, personal communication). The value for protein IN was estimated to be 74.40 and protein Out to be 22.00. The calculated net protein was -70.40% which represented a net protein loss for HSB production. The final criterion 5.2 score was 2 but could be improved if better data were provided by feed manufacturers.

C5.3. Feed Footprint

Criterion 5.3 is a measure of the global resources used to produce aquaculture feeds based on the global ocean and land area used to produce the feed ingredients necessary to grow one ton of farmed fish.

Factor 5.3a—Ocean area of primary productivity appropriated by feed ingredients per ton of farmed seafood

In order to calculate factor 5.3a, the following values were required:

a) Inclusion level of aquatic feed ingredients (%FM+%FO)
b) FCR
c) Average primary productivity (carbon) required for aquatic feed ingredients= 69.7 tC t^{-1} (fixed value)
d) Average ocean productivity for continental shelf area= 2.68 t C ha^{-1} (fixed value)

Using 31% for the inclusion level of aquatic feed ingredients and an FCR of 1.86, the ocean area appropriated was 15 ha t^{-1} of farmed HSB.

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

In order to calculate Factor 5.3b, the following values were required:

a) Inclusion level of crop feed ingredients (%)
b) Inclusion level of land animal products (%)
c) Conversion ratio of crop ingredients to land animal products= 2.88 (fixed value)
d) FCR of farmed fish
e) Average yield of major feed ingredient crops= 2.64 tons crops ha^{-1} (fixed value)

The inclusion level of crop feed ingredients and land animal products, was estimated to be 46% and 23%, respectively (Green, USDA-ARS, personal communication). The land area appropriated was calculated to be 0.79 ha t^{-1}. The total global area appropriated per ton of farmed HSB = ocean area (Factor 5.3a) + land area (Factor 5.3b) was 15.79 ha t^{-1} of farmed fish. The final scoring of criterion 5.3 was 4 and considered Moderate.

Criterion 5 Synthesis

Overall, the assessment of feed for the HSB industry is considered Moderate. The wild fish use score was 5.35 out of 10, indicating a relatively high amount of fishmeal (FM) and fish oil (FO) is used to produce HSB. The Gulf menhaden fishery (source of most FM and FO in HSB feeds) is well managed and not overfished. The net protein from HSB production was negative to indicate that a greater amount of protein is required to culture HSB than is actually produced. The measure of global resources (ocean and land area) used to produce the feed ingredients necessary to grow one ton of farmed fish was 15.79, an indication that the feed footprint from HSB feeds is Moderate. Greater transparency from feed manufacturers on feed ingredients used in HSB feeds may have improved final scoring.

Criterion 6: Escapes

Impact, unit of sustainability and principle

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

Escape Parameters	**Value**	**Score (0-10)**
C6.1a Escape risk		7.00
C6.1a Recapture and mortality (%)	0	
C6.1b Invasiveness		7.00
C6 Escape Final Score		**7.00**
Critical?	*No*	

Justification of Ranking

Factor 6.1a Escape Risk

The escape risk score (Factor 6.1a) considers the escape risk inherent in the production system. HSB pond aquaculture was initially determined to have a moderate escape risk system. HSB ponds are drained at harvest (Romaire 2012; Sydorovych and Daniels 2011) and some ponds exchange up to 3%−10% of their water per day as a way to manage water quality (Freeze, Keo Fish Farm, personal communication). Those HSB ponds located in low-lying areas are vulnerable to flooding events (Romaire 2012; Sydorovych and Daniels 2011). There is evidence to show that HSB pond producers have begun adopting certain prevention methods such as BMPs and biosecurity policies (Ekstrom, Ekstrom Enterprises, personal communication; Freeze, Keo Fish Farm, personal communication; Turano, NC Sea Grant, personal communication). Jim Ekstrom has the levees on his farm built 8 ft. above a natural grade to decrease the risk of flooding and has screens on all discharge drains (Ekstrom, Ekstrom Enterprises, personal communication). Both Jim Ekstrom and Mike Freeze have a biosecurity BMP policy in place to prevent the escape of farmed fish (Ekstrom, Ekstrom Enterprises, personal communication; Freeze, Keo Fish Farm, personal communication). Because HSB farmers have implemented these practices the HSB pond, the escape risk score was reduced Low to Low-Moderate (score: 7).

Hybrid striped bass RAS were determined to be of low escape risk. This was largely due to the inherently closed design of RAS and their being, generally, placed inland. The HSB RAS producers have much greater control over the discharges from their facility and tend to use multiple screens (in the tank and at the discharge site) to prevent escapes. The escape risk score for HSB RAS was Low to Very Low (score: 9).

The recapture and mortality score estimates the general recapture or mortality rate at the escape site of escapees. Information on the occurrence or numbers related to such an event was unknown and therefore the estimated recapture rate and estimated direct mortality rate were both 0%.

Factor 6.1b. Invasiveness

Factor 6.1b considers the potential for ecological disturbance from escapees. The native, non-native status, and/or the domestication and ecological traits of the farmed species play a role in the scoring. Even though the parental species (white bass, *Morone chrysops* and striped bass, *M. saxatilis*) are native and indigenous to parts of the U.S., HSB are non-native, non-indigenous and it is the palmetto bass that is predominately stocked into lakes and reservoirs throughout the U.S. (Kohler 2004). While established populations of HSB are known to exist (Hodson 1989), the regular restocking of HSB suggests that most populations of HSB are not *fully* established, that is, the HSB are not able to sustain viable populations without regular restocking. Hybrid striped bass may or may not be present in waterways near HSB production facilities. Since species introductions tend to be unsuccessful, a viable population of HSB is unlikely. Therefore, part B of the invasiveness factor was given a score of 2.

In part C of the invasiveness assessment, the score is based on the answers to 5 questions[4] specifically aimed at the potential ongoing impacts of escapees. With such widespread stocking of HSB, there is no evidence of a significant impact of farmed HSB on any wild species resulting from aquaculture; therefore, part C of the invasiveness factor was given a score of 5. Taken together the final score for factor 6.1b was 7.

Criterion 6 Synthesis

The escape risk score (factor 6.1a) was 7 for ponds and 9 for RAS. Evidence of BMPs and/or biosecurity procedures in regular practice improved the assessment score.

The invasiveness score (factor 6.1b) was 7 and based on the non-native status of HSB and the determination that farmed HSB are *not fully established in all areas where production occurs*. Establishment of escaped HSB is possible though no evidence of this exists. Due to the abundant, deliberate stocking of HSB, aquaculture's contribution to any potential impacts is considered to be minor and the final escape criterion score was 7 for ponds and 8 for RAS.

Criterion 6.2X: Escape of Unintentionally Introduced Species

A measure of the escape risk (introduction to the wild) of alien species <u>other than the principle farmed species</u> unintentionally transported during live animal shipments.

[4] Do escapees have significant impacts on any wild species by: 1) competing for food or habitat, 2) providing additional predation pressure, 3) competing for breeding partners or disturbing breeding behavior of the same or other species, 4) modifying habitats (e.g., by feeding, foraging), or 5) are there other, unknown impacts on species or habitats?

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

Escape of Unintentionally Introduced Species Parameters	**Value**	**Score (0 to -10)**
C6.2Xa International or trans-waterbody live animal shipments %		1.00
C6.2Xb Biosecurity of source/destination	n/a	7.00
C6.2X Escape of unintentionally introduced species final score	n/a	**-2.70**

Justification of Ranking

Factor 6.2Xa International or trans-waterbody live animal shipments
HSB production is reliant on the trans-waterbody movement of juveniles. Most HSB farms obtain fingerlings from the handful of hatcheries located largely in the southeast region of the U.S. (Hodson 1989; Jobling et al. 2010). These hatcheries distribute fingerlings directly to farms, RAS facilities, and research institutions throughout the U.S. and overseas (Freeze, Keo Fish Farm, personal communication). Therefore, the assessment to determine the HSB industry’s reliance on animal movement was high, meaning that 80%−90% of HSB production is reliant on the trans-waterbody movements of HSB fingerlings. Factor 6.2Xa the international or trans-waterbody live animal shipments was a score of 1.

Factor 6.2Xb Biosecurity of source/destination
While it can be argued that the dominant risk of introducing non-native organisms during live shipments of HSB is associated with deliberate restocking activities, the risk of aquaculture contributing to the spread of such organisms as snails, pathogens, or unwanted fish during transport (Hill 2008) is a concern for many. There is also the potential for introduction and/or amplification of disease, pathogens, or parasites in the water used to transport broodstock or fingerlings onto hatcheries and production farms (Birkbeck et al. 2011). One method for reducing the risk of unintended organisms being transported from one farm site to another is through biosecurity policies. Biosecurity is any set of methods, practices, or procedures that minimizes the risk of 1) introducing an infectious pathogen or organism to a facility and 2) spreading the disease to the animals of that facility or to other farm sites (Yanong and Erlacher-Reid 2012). Biosecurity has become an issue of importance in the aquaculture industry as producers become aware that biosecurity can minimize fish exposure and susceptibility to disease (Yanong and Erlacher-Reid 2012).

This assessment considered the biosecurity practices at both the source (hatchery) and destination (pond or RAS). Hatcheries are generally a series of earthen ponds with a 3%−10% water exchange rate per day (Freeze, Keo Fish Farm, personal communication). These ponds are drained at harvest and the ponds are potentially vulnerable to flooding events. These characteristics would have been reason to give a score of 4 but because of the biosecurity practices in place such as: 1) using sterile well water to fill ponds and for transport of HSB fingerlings 2) subjecting HSB fry to a saline dip to remove parasites before stocking 3) having the farm inspected prior to the transport of HSB fingerlings, and 4) having a biosecurity plan in place (Freeze, Keo Fish Farm, personal communication), the score was increased to Low-Moderate (score: 6).

Once HSB arrive at the intended aquaculture facility, the biosecurity practices at the given site can increase or decrease the risk of unintended species leaving the site and entering the environment. The management of these facilities, compliance with regulations, BMPs, and hazard analysis critical control points (HACCP) policies all help to prevent escapes (Hill 2008; Hill 2009). The biosecurity risk at HSB ponds was determined to be Low-Moderate because even though earthen ponds are drained at the end of a production cycle (1.5- 2.5 years) and are vulnerable to flooding events, they generally have at least one biosecurity practice in place to prevent escapes. These biosecurity practices include pond levees built above the flood zone (Ekstrom, Ekstrom Enterprises, personal communication) and BMPs for employees and husbandry practices (Ekstrom, Ekstrom Enterprises, personal communication; Freeze, Keo Fish Farm, personal communication). The HSB RAS were also given a score of 6 since such facilities are known to have multiple BMPs in place and tanks are drained at the end of a production run.

Criterion 6.2X Synthesis

The HSB industry relies heavily on the trans-waterbody movement of HSB fry and fingerlings. The biosecurity risk at the hatchery and farm were both considered Low-Moderate largely due to the evidence confirming the use of BMPs, and biosecurity policies. Therefore, the risk of introducing species during farm operations is considered to be relatively low compared to the deliberate restocking operations and the final score for 6.2X was a small penalty of -2.70.

Criterion 7. Disease; Pathogen and Parasite Interactions

Impact, unit of sustainability and principle

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

Pathogen and Parasite Parameters		**Score (0-10)**
C7 Biosecurity		7.00
C7 Disease; pathogen and parasite interactions final score		**7.00**
Critical?	*No*	

Justification

Aquaculture has the potential to significantly impact local ecosystems through the transmission of disease, pathogens, or parasites. The level of impact is a function of the type of production system utilized, the intensity of production, and the level of biosecurity practices in place.

HSB are generally resistant to disease (Kohler 2004) and it is believed that the stress of handling is what compromises their immune system (Ludwig 2004; Acerte et al. 2009). Common infections in HSB include: *Streptococcus* sp. (Plumb 1997; Ostland et al. 2006), *Ichthyophthirius multifilis* (causes ich disease; McGinty and Hodson 2008), *Mycobacterium marinum* (found in newly acquired white bass broodstock; Ostland et al. 2006), *Flavobacterium columnare* (columnaris; D'Abramo and Frinsko 2008), and *Photobacterium damselae* subsp. Piscicida (Acerete et al. 2009). A well known parasite, the yellow grub, *Clinostomum* sp. infects HSB raised in earthen ponds. Though the grub does not harm the HSB, their presence usually renders the fish unsellable (Kohler 2004). The nematode, *Eustrongylides ignotus,* was first reported in 2009 and is known to cause disease in aquatic birds (Mitchell et al. 2009). The *E. ignotus* infections in HSB likely come directly from ponds or from feeding on infected intermediate hosts such as oligochaetes and forage fish (Mitchell et al. 2009). Such diseases can cause significant mortalities and considerable economic loss to producers (Ostland et al. 2006). The source of mycobacterial infections may come from the water, pre-infected fish or in the ingestion of macro or microbiota (Bozzetta et al. 2010). Disease, pathogens, or parasites may be transported along with fish, moved from one facility to another, or moved between cultured and wild stocks (Birkbeck et al. 2011; Hill 2011).

The United States Department of Agriculture—Animal and Plant Health Inspection Service (USDA-APHIS) provides many services to the aquaculture industry in the form of lab diagnostics and testing, disease surveillance, and outbreak response and investigation.

Criterion 7- Biosecurity

HSB ponds have the potential to inadvertently transmit diseases, pathogens, or parasites to wild populations in a number of ways. The control of disease, pathogens, and parasites on aquaculture farms is typically state-regulated and there is considerable variability among states in terms of the requirements put upon farms to properly monitor, report, and manage any outbreaks on their farms. The water discharged from ponds at the end of the production cycle has the potential to introduce any number of infecting organisms into the wild. And once a pond is infected, disease can then be spread via aquatic birds that fly from one water body to another, potentially carrying the disease or parasite externally (feet, feathers) or internally (ingested fish). In an effort to address these and other points of introduction, several producers have adopted BMPs specifically aimed at addressing issues of biosecurity. Mike Freeze of Keo Fish Farm uses sand filtered well water for the transport of fry and fingerlings. The farm is regularly inspected by USDA-APHIS veterinarians, who check for viruses, diseases, and parasites on a regular basis (Freeze, Keo Fish Farm, personal communication). Part of the management plan at Ekstrom Enteprises is the biosecurity of any fingerlings stocked at the facility (Ekstrom, Ekstrom Enterprises, personal communication). These practices include the disinfection of all transfer equipment prior to (and after) the movement of fingerlings from the shipping container to the facility, and the quarantine of fingerlings prior to stocking in ponds (Ekstrom, Ekstrom Enterprises, personal communication). As a general practice, hybrid producers monitor dissolved oxygen and other water quality parameters regularly, and turn on aerators as necessary to reduce the susceptibility to stress-related disease outbreaks in their fish ponds (D'Abramo and Frinsko 2008). Using the assessment scale as a guide, the concern over disease, pathogens, or parasites on HSB farms was considered Low to Low-Moderate for the following reasons:

1) HSB farms discharge pond water on an annual basis. This water has the potential to carry pathogens to local waterways.
2) HSB farms have biosecurity regulations in place though the ponds are open to the introduction of local pathogens and parasites.
3) Regulations and/or best practice standards are said to exist but enforcement across all HSB farms is unknown.
4) While there are no known reports of disease-related mortalities, or amplification of pathogens or parasites in local ecosystems near HSB farms, there are no data to show that "independently audited, scientifically robust limits are in place and that levels are consistently below those limits over multiple production cycles."

Recirculating aquaculture systems (RAS), by their nature, have a much lower risk of introducing or amplifying the wild population with disease, pathogens, or parasites. Most RAS replace less than 5%−10% of the system volume per day and typically conduct a complete water exchange after each production cycle (Masser et al. 1999). The rest of the water is recirculated multiple times through the system. It is important to note that while HSB RAS exchange a greater percent of water per day than do ponds, the overall volume of water is much smaller. The RAS also have the ability to treat the water, reducing pathogen loads, prior to discharge. The HSB reared in RAS are biologically intensive (roughly 0.5lb fish/gal or greater) therefore, biosecurity and effluent management must be in place to keep any vectors to contamination at a minimum. Since the water is continuously recirculated and production is intensive, RAS tend to have very stringent biosecurity standards in place. Depending on the individual system, discharges from RAS are treated before release, thereby minimizing or eliminating any introduction of diseases or parasites to local waterways (Losordo et al. 1998). The concern over disease, pathogen, or parasite interaction in HSB RAS was considered low for the following reasons:

1) The production practices do increase the likelihood of pathogen amplification, but RAS have the ability to control the spread of disease by closing the infected tank (s) and treating the fish/water to control the spread of disease. They also have the ability to treat the recirculating water, bringing about better biosecurity opportunities.
2) RAS are not known to amplify pathogens or parasites above background levels though independently audited data are unavailable.

Criterion 7 Synthesis

Aquaculture has the potential to significantly impact local ecosystems through the transmission of disease, pathogens, or parasites. The level of risk is typically a function of the type of production system utilized, the intensity of production, and the level of biosecurity practices in place. The risk of pathogen transmission from HSB ponds was considered to be Low to Low-Moderate (score: 7) due to the annual discharge of pond water, the biosecurity regulations and BMPs in place—though enforcement is largely unknown—and the lack of independently audited data showing low disease levels over multiple production cycles. The risk of pathogen transmission from HSB RAS was considered Low (score: 8) due to the nature of RAS recirculating the majority of their water, the ability of RAS to control disease outbreaks by closing parts of a system and treating the water/fish before discharging.

Criterion 8. Source of Stock – Independence from Wild Fisheries

Impact, unit of sustainability and principle

- Impact: the removal of fish from wild populations for on-growing to harvest size in farms
- Sustainability unit: wild fish populations
- Principle: aquaculture operations use eggs, larvae, or juvenile fish produced from farm-raised broodstocks thereby avoiding the need for wild capture.

Source of Stock Parameters	Value	Score (0-10)
C8 Percent of production from hatchery-raised broodstock or natural (passive) settlement		100
C8 Source of Stock Final Score	n/a	**10.00**

Justification

HSB are produced in hatcheries by multiple distributors throughout the U.S. region (Gatlin, Texas A&M, personal communication). The domestication of broodstock continues to be a high research priority for the HSB industry (Kohler 2004).

The national domestication program for HSB is ongoing with researchers from the U.S. Department of Agriculture–Agricultural Research Service, the Harry K. Dupree Stuttgart National Aquaculture Research Center (USDA-(?)SNARC), and the North Carolina State University (NCSU) working closely with producers at Keo Fish Farm, Keo, AR and Nature's Catch in the selective breeding of broodstock (Freeze, Keo Fish Farm, personal communication; Fuller 2011; Sullivan 2011). The SNARC facility has white and striped bass broodstock that have been reared in captivity for 9 and 5 generations respectively, and foundation stocks of striped bass and white bass are provided by NCSU (Green, USDA-SNARC, personal communication). Genetic research at SNARC focuses on the characterization of genetic and phenotypic traits important in the production of HSB (Green, USDA-SNARC, personal communication). It is the hope that such information will allow researchers to develop a selection program for white bass with the goal of producing a superior performing HSB (Green, USDA-SNARC, personal communication). The Pamlico Aquaculture Field Laboratory at NCSU has white bass broodstock that have been domesticated for over 7 generations and are transferred from research institutions to commercial hatcheries (McGinty and Hodson 2008).

Hatcheries rely on wild-caught or domesticated broodstock or both. In 2008, NCSU was the sole provider of domesticated white bass and striped bass to private industry (McGinty and Hodson 2008). At Keo Fish Farm, the broodstock are domesticated and additional broodstock are only obtained for a specific purpose such as genetic research (Freeze, Keo Fish Farm, personal communication). An annual permit obtained from the Arkansas Game and Fish Commission allows Keo Fish Farm to obtain wild striped bass/white bass from the Arkansas River (Freeze, Keo Fish Farm, personal communication). There is no evidence to suggest that this or any such practice by HSB producers is having a negative impact on wild fish stocks.

According to the U.S. Geological Survey, the striped bass fishery is not considered overfished (Fuller 2012) and the white bass populations are sustainably abundant (Fuller 2012). Therefore the final score for criterion 8 − source of stock was a 10.

Criterion 8 Synthesis

Information from producers and literature suggest that the amount of broodstock taken from the wild is minimal and, when taken, is done largely for research purposes. All HSB fry and fingerlings are produced in hatcheries independent from wild stocks.

Overall Recommendation

The overall final score is the average of the individual criterion scores (after the two exceptional scores have been deducted from the total). The overall ranking is decided according to the final score, the number of red criteria, and the number of critical criteria as follows:

– **Best Choice** = Final score ≥6.6 AND no individual criteria are Red (i.e. <3.3)

– **Good Alternative** = Final score ≥3.3 AND <6.6, OR Final score ≥ 6.6 and there is one individual "Red" criterion

– **Red** = Final score <3.3, OR there is more than one individual Red criterion, OR there is one or more Critical criteria

Criterion	Score (0-10)	Rank	Critical ?
C1 Data	8.06	GREEN	n/a
C2 Effluent	8.00	GREEN	NO
C3 Habitat	7.37	GREEN	NO
C4 Chemicals	8.00	GREEN	NO
C5 Feed	3.98	YELLOW	NO
C6 Escapes	7.00	GREEN	NO
C7 Disease	7.00	GREEN	NO
C8 Source	10.00	GREEN	n/a
3.3X Wildlife mortalities	-3.00	GREEN	NO
6.2X Introduced species escape	-2.70	GREEN	n/a

OVERALL RANKING	
Final Score	6.71
Initial rank	GREEN
Red Criteria	0
Intermediate Rank	GREEN
Critical Criteria?	NO

FINAL RANK	GREEN

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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Supplemental Information

Appendix A:

FROM: Joseph J. Prusacki
Director, Statistics Division
USDA - National Agricultural Statistics Service

Renee Picanso
Director, Census and Survey Division
USDA – National Agricultural Statistics Service

SUBJECT: Proposed 2013 Census of Aquaculture

The United States Department of Agriculture's (USDA) National Agricultural Statistics Service (NASS) is currently preparing for the 2012 Census of Agriculture. As part of its Census of Agriculture Program, NASS routinely conducts special studies to gather more detailed information on specific agricultural production. These studies, known as census follow-ons, are conducted in the years following the census of agriculture and include a sub-group of respondents that meet the criteria for the special study.

NASS is keenly aware of industry and data user needs for sound statistical data to make informed policy decisions. As a result of the previous census of aquaculture being suspended due to budget constraints, NASS has made this census follow-on a priority. In fiscal year 2014, NASS intends to conduct the 2013 Census of Aquaculture. However, its execution is subject to sufficient budget appropriations.

About the Census of Aquaculture

The target population for the 2013 Census of Aquaculture is any commercial or non-commercial place from which $1,000 or more of aquaculture products were produced and either sold or distributed during the census year. Commercial operations will qualify with sales greater than or equal to $1,000. Non-commercial operations are those that produce an estimated value of

$1,000 or more of aquaculture products, but release or distribute their production for purposes of restoration, conservation, or recreation. Examples of non-commercial operations include: federal, state, and tribal hatcheries.

Tentative Schedule for the 2013 Census of Aquaculture Activity

	Date
Initial Mail Out	December 2013
2nd Mail Out (exclude Catfish States)	January 2014
Phone & Field Follow-Up (Catfish States)	January 2014
Catfish Production Release	January 31, 2014
Phone & Field Follow-Up (Non-Catfish States)	February - March 2014
Trout Production Release	February 28, 2014
Publication Released	TBD

Appendix B:

Table 1: Total Production of HSB (*Morone chrysops* × *M. saxatilis*) produced in the U.S. in 2007[1] and 2011[2].

Production Type	Total Production (lbs.) 2007	2011
Ponds	8.6 mil	6.9 mil
Tanks	2.5 mil	802K
Cages	155K	77K
Total	11.2 mil	7.8 mil

U.S. Region	West		Upper Midwest		Southeast		Northeast		Mid-Atlantic	
Production Type	2007	2011	2007	2011	2007	2011	2007	2011	2007	2011
Ponds	3.4 mil.	3.1 mil.	0	0	2.2 mil.	1.3 mil.	4K	100	3.0 mil.	2.5 mil.
Tanks	1.6 mil.	355K	0	0	522K	220K	400K	227K	0	0
Cages	0	0	155K	77K	0	0	0	0	0	0
Total	5.0 mil.	3.4 mil.	155K	77K	2.7 mil.	1.5 mil.	404K	227K	3.0 mil.	2.5 mil.

[1]Data from state aquaculture extension programs and survey of major producers (Carlberg et al. 2007).

[2]Data from a survey of 51 HSB farms (Turano 2012).

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About Seafood Watch®

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

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

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

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

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

Guiding Principles

Seafood Watch™ defines sustainable seafood as originating from sources, whether fished[5] or farmed, that can maintain or increase production in the long-term without jeopardizing the structure or function of affected ecosystems.

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

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

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

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

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

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

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

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

Data Points And All Scoring Calculations

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

C1 - Data

	Data category	Relevance Y / N	Quality 0-10	Score
A	Industry/farm statistics	*Yes*	10.00	10.00
B	Effluent	Yes	10.00	10.00
C	Locations/habitats	Yes	7.50	7.50
D	Predator and wildlife	Yes	7.50	7.50
E	Chemical use	Yes	7.50	7.50
F	Feed	Yes	5.00	5.00
G	Escapes, animal movements	Yes	7.50	7.50
H	Disease	Yes	7.50	7.50
I	Source of stock	Yes	10.00	10.00
J	Other – (e.g. energy use)	No	Not relevant	n/a
			Total	**72.50**

C1 – Data Final Score = __ 8.06

______ (range 0-10)

C2 - Effluent

Rapid Assessment? No
Score — (0-10)

Full Assessment? Yes
C2.1 Waste discharged per ton of fish

Factor 2.1a – Biological Waste Production Per Ton of Fish		**Units**	**Value**
a)	Protein content of feed	%	40.00

b)	Economic Feed Conversion Ratio (eFCR[6])		1.86
c)	Fertilizer nitrogen input per ton fish produced	kg N t^{-1}	0.33
d)	Protein content of harvested whole fish	%	18.00
e)	Protein nitrogen content factor (fixed value)	*%*	*0.16*
nitrogen input per ton of fish produced = (a x 0.16 x b x 10) + c		kg N t^{-1}	119.37
harvested nitrogen per ton of fish produced = (d x 0.16 x 10)		kg N t^{-1}	28.80
waste N produced per ton of fish = nitrogen input - harvested Nitrogen		kg N t^{-1}	**90.57**
Factor 2.1a = _______ kg N t^{-1}		kg N t^{-1}	**90.57**

Factor 2.1b – Production System Discharge	Value (0-1)
Basic (unadjusted) Production System Discharge Score	0.34
Adjustment 1	-0.10
Adjustment 1	-0.10
Adjustment 1	0
Factor 2.1b - Discharge Score	**0.14**

C2.1 Score:
waste discharged = waste produced x production system discharge score
waste discharged per ton of fish = 2.1a x 2.1b = ___15.82____ kg N ton^{-1}
Criterion 2.1 Score = ___8.00___ (range 0-10. See scoring table in criteria)

C2.2 – Management of Farm Level and Cumulative Impacts

Scoring Answers: Yes = 1; Mostly = 0.75; Moderately = 0.5; Partly = 0.25; No = 0

Factor 2.2a Intent and Content of Effluent Regulations and Management Measures	Score (0-1)
1 – Are effluent regulations or control measures present that are designed for, or are applicable to aquaculture[7]?	1.00
2 – Are the control measures applied according to site-specific conditions and/or do they lead to site-specific effluent, biomass or other discharge limits?	0.75
3 – Do the control measures address or relate to the cumulative impacts of multiple farms?	0.75
4 – Are the limits considered scientifically robust and set according to the ecological status of the receiving water body?	0.75
5 – Do the control measures cover or prescribe monitoring of all aspects of the production cycle including peak biomass, harvest, sludge disposal, cleaning etc?	0.75

[6] eFCR = Total feed inputs divided by total harvested fish output over the entire production cycle. It should, ideally, be averaged over multiple production cycles and take account of seasonal differences (e.g., wet or dry season, age of fish). If these data aren't readily available, be precautionary with the best data available.

[7] Designed for, or applicable to aquaculture – as opposed to regulations designed for fisheries, agriculture or other activity or industry that are poorly related to the needs of aquaculture regulation. Aquaculture certification standards would be 'yes.'

Total = (0-5)	**4.00**

Factor 2.2b Enforcement of Effluent Regulations and Management Measures	Score (0-1)
1–Are the enforcement organizations and/or resources identifiable and contactable, and appropriate to the scale of the industry?	1.00
2 – Does monitoring data or other available information demonstrate active enforcement of the control measures?	1.00
3 –Does enforcement cover the entire production cycle (i.e. are peak discharges such as peak biomass, harvest, sludge disposal, cleaning included)?	0.75
4 – Does enforcement demonstrably result in compliance with set limits?	0.75
5 – Is there evidence of robust penalties for infringements?	1.00
Total = (0-5)	**4.50**

C2.2 score = (2.2a x 2.2b)/2.5
C2.2 effluent management score = ___7.20____ (range 0-10)

C2 - Effluent Final Score = ___8.00____ (final score derived from matrix table – see criteria document)
Critical? No

C3 - Habitat

C3.1 Habitat Conversion and Function

C3.1 Habitat Conversion and Function		Score
Habitat maintains functionality	(score 7-10)	7.00
Habitat lost functionality	(score 0-6)	
Habitat value (if necessary)	(high, moderate, low)	Low

C3.2 – Farm Siting Management Effectiveness
Scoring answers: Yes = 1; Mostly = 0.75; Moderately = 0.5; Partly = 0.25; No = 0

Factor 3.2a Regulatory or Management Effectiveness	Score
1 – Is the farm location, siting and/or licensing process based on ecological principles, including an Environmental Impact Assessments requirement for new sites?	0.75
2 – Is the industry's total size and concentration based on its cumulative impacts and the maintenance of ecosystem function?	0.75
3 – Is the industry's ongoing and future expansion limited to an appropriate scale and/or to appropriate locations, and thereby preventing the future loss of ecosystem services?	1.00
4 – Are high-value habitats being avoided for aquaculture siting? (i.e. avoidance of areas critical to vulnerable wild populations; effective zoning, or compliance with international agreements such as the Ramsar treaty)	1.00

5 – Do control measures include requirements for the restoration of important or critical habitats or ecosystem services?	1.00
Factor 3.2a score Total = (0-5)	4.50

Factor 3.2b Siting Regulatory or Management Enforcement	**Score**
1 – Are enforcement organizations or individuals identifiable and contactable, and are they appropriate to the scale of the industry?	1.00
2 – Does the farm siting or permitting process function according to the zoning or other ecosystem-based management plans articulated in the control measures?	1.00
3 – Does the farm siting or permitting process take account of other farms and their cumulative impacts?	1.00
4 – Is the enforcement process transparent – e.g., public availability of farm locations and sizes, EIA reports, zoning plans, etc?	0.75
5 – Is there evidence that the restrictions or limits defined in the control measures are being achieved? (see example[8])	0.75
Factor 3.2b score Total = (0-5)	4.50

C3.2 siting management score = (3.2a x 3.2b)/2.5 = ___8.10___ (range 0-10)

Final Habitat Criterion Score = [(2 x Criterion 3.1) + Criterion 3.2]/3
C3 - Habitat Criterion Final Score = ___7.37____ (Range 0-10)

C3.3X Predator and Wildlife Mortalities

Exceptional Criterion (i.e. negative score)

3.3X - Predator and Wildlife Mortalities	**Score**
Selected score (0 to -10)	**-3.00**

Critical? No (3.3X - Predator and wildlife mortalities is Critical if score = -10)

C3.3X Predator and Wildlife Final Score = ___-3.00___ (0-10)

C4 – Chemical Use

C4 - Evidence or Risk of Chemicals Use Score	**Score**
Selected score (0-10)	**8.00**

Critical? No

[8] For example, if mangrove cover is supposed to be maintained at greater than 60%, is there evidence that this is achieved? Or are Allowable Zones of Affect reactively monitored?

C4 Chemical Use Final Score = ____8.00___ (0-10)

C5 - Feed

C5.1 – Wild Fish Use

Factor 5.1a – Fish In : Fish Out Ratio (FIFO)		Units	Value
a)	Fishmeal inclusion level	%	26.00
b)	Fish oil inclusion level	%	5.00
c)	Fishmeal Yield from wild fish	%	24.00
d)	Fish oil yield from wild fish	%	5.00
e)	Economic FCR	-	1.86
FI:FO Fishmeal		-	2.02
FI:FO Fish oil		-	1.86
FI: FO final value		-	2.02
FI:FO Score		-	**4.96**

Factor 5.1b - Source Fishery Sustainability	Score
Selected score (0-10)	**4.96**

C5.1 Wild Fish Use score = FIFO score + [(FI:FO value x Sustainability Score) / 10]
C5.1 score = ___4.96_____ (0-10)

C5.2 – Net Protein Gain or Loss

5.2 – Net Protein Gain or Loss		Value	Score
a)	Protein content of feed	%	40.00
B)	eFCR	-	1.86
c)	Protein content of whole harvested farmed fish	%	55.00
d)	Edible yield of harvested farmed fish	%	40.00
Optional data if available (all additional data leads to improved scores)			
e)	Percentage of feed protein from sources unsuitable for human consumption (e.g. fish, animal or crop by-products or other processing wastes)	%	0
f)	Percentage of feed protein from crop ingredients suitable for human consumption	%	0
g)	Percentage of the non-edible byproducts from harvested farmed fish used for other food production	%	0
Protein IN = [a – (a x (e + (0.286 x f)) / 100)] x eFCR		Kg t^{-1}	74.40
Protein OUT = (c / 100) x [(d + (g x (100-d)) / 100]		Kg t^{-1}	22.00
Net protein gain or loss = (Protein OUT – Protein IN) / Protein IN		%	-70.43

net protein gain = ________ % (indicated by positive result)
OR
net protein loss = -70.43_____% (indicated by negative result)

C5.2 net protein gain or loss score = ___2.00____ (range 0-10. See scoring table in criteria)
Critical? No

C5.3 – Feed footprint

Factor 5.3a – Ocean Area		**Units**	**Value**
a)	Inclusion level of aquatic feed ingredients	%	31.00
b)	eFCR	-	1.86
c)	Average primary productivity (carbon) required for aquatic feed ingredients	$t\ C\ t^{-1}$	69.70
d)	Fish oil yield from wild fish	%	
e)	Average ocean productivity for continental shelf area	$t\ C\ ha^{-1}$	2.68
Ocean Area Appropriated = [(a x 0.01) x b x c] / d		$ha\ t^{-1}$	15.00

Factor 5.3b – Land Area		**Units**	**Value**
a)	Inclusion level of crop feed ingredients	%	46.00
b)	Inclusion level of land animal products	%	23.00
c)	Conversion ratio of crop ingredients to land animal products	-	2.88
d)	eFCR	%	1.86
e)	Average yield of major feed ingredient crops	$t\ ha^{-1}$	2.64
Land Area Appropriated (per ton of fish) = [(a + (b x c)) x 0.01 x d] / e		$ha\ t^{-1}$	0.79

total global area appropriated per ton of farmed fish = ocean area + land area
total area = ___15.79___ ha ton^{-1} of farmed fish
C5.3 feed footprint score = _____4.00___ (range 0-10. See scoring table in criteria)

Final Feed Criterion Score = [(2 x 5.1 score) + 5.2 score + 5.3 score] / 4
C5 - Feed Final Score = _____3.98____ (0-10)
Critical? No

The Feed Criterion is Critical if:

- Wild Fish Use score is zero
- Net Protein Gain/Loss Score is 0, OR
- FI:FO value >3 AND Net Protein score <=1.

C6 - Escapes

C6.1 – Escape of Principle Farmed Species

Factor 6.1a Escape Risk Score	Score
Escape Risk Score (0-10)	7.00
Recapture and mortality score (0-1)	0
Escape Risk Score = Escape Risk Score + [(10-Escape Risk Score) x RMS]	

Factor 6.1b – Invasiveness	Value (0-5)
Part A – Native species	**0**
Part B – Non-native species	**2.00**
Part C – All species	**5.00**
Invasiveness score = (Part A or B) + Part C	

C6.1 Escape final score = ____7.00____ (0-10) (selected from matrix table – see criteria document)
Critical? No

C6.2X - Escape of Unintentionally Introduced Species

Factor 6.2Xa - International or trans-waterbody live animal shipments	Value	Score
% of production dependent on trans-water body live animal shipments	**1.00**	

Factor 6.2Xb - Biosecurity of source and destination (for introduced species)	Value (0-10)
Biosecurity score of the source of animal movements	**7.00**
Biosecurity score of the farm destination of animal movements	**7.00**
Factor 6.2Xb Score (highest score of source or destination biosecurity)	

C6.2X score = [(10 - 6.2Xa) x (10 - 6.2Xb)] / 10 = -__2.70____ (range 0 to -10)
C6.2X - Escape of unintentionally introduced species Final Score = - _2.70____
Note – this is a negative score that will be subtracted from the overall final score total of the other criteria.

C7 - Disease

C7 – Pathogen and Parasite Interaction Risk	Score
Selected score (0-10 or critical)	**7.00**

C7 – Disease Final Score = ___7.00____

C8 – Source of Stock

C8 – Independence from Wild Capture Fisheries	Value
% of production from hatchery-raised broodstock or natural (passive) settlement	**100**

C8 – Source of Stock Final Score = ____10.00____ (range 0-10. See scoring table in criteria)