Aquaculture – Industry Report

This content has been retrieved from IBIS World Industry Report 11251- Fish & Seafood Aquaculture in the US

March, 2015

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Industry performance

The Fish and Seafood Aquaculture industry comprises companies that farm aquatic animals or plants, in controlled environments, and sell them for human and animal consumption. Over the five years to 2015, the industry suffered competition and declining demand. Seafood is generally more expensive than other sources of protein such as chicken. Therefore, the decline in seafood consumption can be primarily attributed to lower income levels combined with rising prices of seafood during the recession.

On the other hand, the rising price of seafood has allowed revenue to grow despite a slowdown in the volume of seafood sold. This factor along with the recent fall in the price of fish feed, the primary input cost in industry production, have increased industry sales margins. As a result, industry revenue has grown at an annualized rate of 0.48% since 2011.

Since 2011, inexpensive products from importers have gained an increasing share of domestic demand. According to the International Trade Administration, the US imported an average of $1.9 billion in farmed seafood accounting for an estimated 4% of domestic demand. The majority of aquaculture product imports have come from Chile and Canada, which have both larger and more cost effective operations than in the United States.

Despite strong competition from imports, exports, especially to Asia, have been a major source of industry growth. According to data from the Food and Agricultural Organization of the United Nations, the quantity of seafood consumed in all of East Asia grows by 3.0% each year. Therefore, IBISWorld expects industry exports to grow at an annualized rate of 4.8% over the five years to 2015 to reach $138.0 million.

The declining productivity in the Fishing industry due to declining fish stocks and the Deepwater Horizon oil spill has also shifted demand towards the Fish and Seafood Aquaculture industry. Consequently, IBIS World estimates the industry will continue growing at an annualized rate of 1.1% over the five years to 2020.

According to IBIS World, the industry has the potential to grow at a much faster rate if government legislation is passed to allow aquaculture farms to operate in the open ocean, an activity that is currently banned.

Recent Performance

The Fish and Seafood Aquaculture industry has experienced slow growth over the past five years. Given that the vast majority of industry revenue is derived from sales of fish, mollusks and crustaceans that will be processed into food products, this industry's success is tied to levels of seafood consumption. Per capita seafood consumption in the US has declined over the past five years, putting strain on industry operators. Nevertheless, increases in the price of seafood, combined with a healthy export market, have stimulated industry revenue growth. In 2015, revenue is forecast to grow 0.4% to $1.5 billion. Unlike revenue, the number of domestic industry establishments declined by 28% to 3,093 total farms from 2005 to 2013. This is because the industry is

undergoing consolidation, with smaller farms going out of business or being acquired by larger, more technologically advanced and productive farms. Similarly, the number of industry employees is forecast to decline at an annualized rate of 2.4% over the same period to 10,928 total workers as labor intensive farms are increasingly replaced by more productive, more highly automated farms that make relatively less use of labor in their operations. See Appendix A for historical, national data.

Industry Outlook

After falling for a number of years, per capita seafood consumption is expected to stabilize over the next five years. The decline in per capita domestic seafood consumption is expected to stem as increases in domestic income encourage Americans to eat more expensive foods, including dining out at restaurants that serve seafood. In addition, demand for seafood in Asia will continue to drive strong export growth. Nonetheless, growth in the Fishing industry (IBISWorld report 11411), alongside continued competition from imports, will limit the industry's ability to meet all of this increase in demand.

Decline in fishing stocks, has allowed aquaculture expansion in many parts of the world as a substitute source of fish and shellfish. Global aquaculture productivity is improving as a result of the implementation of advanced technology and production techniques. As aquaculture grows globally and becomes increasingly cost effective, imports are anticipated to continue to grow. IBISWorld expects industry imports to grow at an annualized rate of 4.9% over the five years to 2020 to $2.4 billion.

While industry operators will continue competing with imports for domestic demand, exports are expected to help the industry to continue growing. Abroad demand, particularly in Asia, is expected to continue expanding at an annualized rate of 5.6% over the five years to 2020. Trends toward eating out and choosing healthy foods will also boost demand and buoy prices at the retail level. Despite increased domestic demand for industry products, the number of industry operators is expected to fall at an annualized rate of 0.9% over the five years to 2020 as smaller, less-profitable farms go out of business.

Industry profit margins are expected to expand marginally over the five years to 2020. Feed prices are anticipated to grow over the five years to 2020, but only at a slow annualized rate of 0.1%. Over the same period, the price of seafood is expected to grow at an annualized rate of 2.4%. In addition, while wages are anticipated to grow an annualized rate of 1.0% to $235.1 million over the five years to 2020, they are expected to decline as a percentage of industry revenue over the period. Finally, the number of industry operators is forecast to decline at an annualized rate of 0.9% over the five years to 2020 to 2,676 total companies. This represents a fall in the number of small, less-profitable farms operating in the industry. As a result of these expected trends, industry profit margins are anticipated to rise.

Domestic producers' ability to expand production and curb the flow of import penetration will continue to be major issues for the industry's future growth potential. Potential legislative changes could have a massive effect on the industry; proposed legislation would increase the amount of water available with which to operate aquaculture farms, making the US more competitive in the global market while driving domestic enterprise growth. A number of acts, such as the now dead National Sustainable Offshore Aquaculture Act of 2011, have been debated in Congress in recent years. These proposals have sought to open US coastal waters from three to 200 nautical miles to industrial fish farming operations, which are currently limited to within three miles of the US coastline. If passed, the area made available for aquaculture would be significantly larger than the entire land

area of the United States. However, historical stagnation in the implementation of such legislation makes coastal aquaculture unlikely in the near term.

Health food products procured from aquaculture also offers a bright prospect for future industry growth. Aquaculture includes the production of algae known as spirulina, which is used in tablet form as a dietary supplement. Containing high amounts of protein for its plant-based nature, spirulina has been used in animal, human and in vitro research. Companies like Cyanotech Corporation produce spirulina tablets and market them as a "super food." Innovative products like these can help the industry earn additional revenue over the next five years.

Products and Markets

Supply Chain

Key buying industries

- Seafood Preparation – NAICS 31171. Most significant purchaser of fish, mollusks and crustaceans from aquaculture.
- Animal Food Production – NAICS 31111. Fish is commonly used as an ingredient for making pet food.
- Fish & Seafood Wholesaling – NAICS 42446. Demand of fresh, live, unprocessed fish and seafood.
- Supermarkets & Grocery Stores – NAICS 44511. Larger grocery stores and super markets may buy direct from the industry.
- Fish & Seafood Markets – NAICS 44522. Some of the larger markets may have the purchasing power to bypass wholesalers and buy direct from the industry.

Key selling industries

- Animal Food Production – NAICS 31111. Fish and seafood farms demand feed for each species.
- Pump & Compressor Manufacturing – NAICS 33391.This industry supplies oxygen and pump equipment used to divert fish through water.
- Computer & Packaged Software Wholesaling – NAICS 42343. Fish farms need to run specialist aquaculture-management software programs.
- Electronic Part & Equipment Wholesaling – NAICS 42369. Industry players require various electronic devices, such as temperature, humidity, pH and EC monitors.
- Farm, Lawn & Garden Equipment Wholesaling – NAICS 42382. Producers purchase nets, gauges, fittings and valves through these wholesalers.
- Electronic & Computer Repair Services – NAICS 81121. Maintenance and repair of electronic water-quality and monitoring equipment on fish farms is essential to keep operations going.
- Machinery Maintenance & Heavy Equipment Repair Services – NAICS 81131. Maintenance and repair of transport equipment, pumps and compressors on fish farms is also essential to keep industry operations going.

Key External Drivers

Demand from seafood preparation
Operators in this industry rely on the Seafood Preparation industry for demand for their products. The Seafood Preparation industry purchases fish and shellfish from the Fish and Seafood Aquaculture industry and further processes them to create prepared seafood products for retail, wholesale and consumers. Demand from seafood preparation is expected to increase somewhat in 2015, representing a potential opportunity for the industry.

Demand from fish and seafood wholesaling
Operators in the Fish and Seafood Aquaculture industry depend on demand from fish and seafood wholesalers. The Fish and Seafood Wholesaling industry purchases fresh fish, mollusks, crustaceans and other industry products and sells them on the market. Demand from the Fish and Seafood Wholesaling industry is expected to decline slightly in 2015, posing a potential threat to the industry.

Per capita seafood consumption
Per capita seafood consumption measures how many pounds of seafood the average American consumes in a year. Seafood includes all fresh, frozen and canned fish and shellfish. As people consume more seafood, demand for the industry's products increases. Per capita seafood consumption is expected to rise in 2015.

Price of seafood
The price of seafood has a significant effect on demand for seafood. When the price of seafood increases, consumers will opt to increase their purchases of substitutes like chicken or beef, at the expense of seafood. The price of seafood is expected to increase in 2015.

Trade-weighted index
The Trade-weighted index measures the value of the US dollar with respect to major foreign currencies. As the trade-weighted index rises, the US dollar appreciates with respect to these currencies, simultaneously increasing the price of US goods abroad while decreasing the price of foreign goods in the US. International trade plays a large role in this industry. Therefore, an increase in the trade-weighted index tends to damage industry export revenue, while expanding import competition. The trade-weighted index is expected to increase in 2015.

Price of feed
Fish feed represents the largest purchase cost for operators in the Fish and Seafood Aquaculture industry. Increases in the price of feed, which includes fish feed, serve to raise industry input costs. The price of feed was rising steadily from 2010 to 2013 as the expansion in global feed demand outstripped supply. However, the Environmental Protection Agency's loosened ethanol quotas for corn and other crops in 2013, substantially reducing demand for feed inputs. As a result, the price of feed is forecast to fall substantially in 2015.

Products

According to the 2013 Census of Agriculture, the majority of industry revenue is derived from sales of food fish[vii] (see Table 1). The National Fisheries Institute in 2012, indicated that the top 10 most consumed fish and seafood in the US per capita were:

Table 1. Aquaculture Sales by Type of Product, 2005 and 2013

	2005	2013	% Change
	$ millions		
Food fish	672.4	732.1	+9
Mollusks	203.2	328.6	+62
Crustaceans	53.4	84.9	+59
Ornamental fish	51.3	41.5	-19
Baitfish	38.0	29.4	-23
Sport fish	18.1	23.8	+32
Miscellaneous	56.0	131.4	+135
Total	1,092.4	1,371.7	+26

Source: USDA NASS, 2013 Census of Aquaculture.

Shrimp (26%), Canned Tuna (16.4%), Salmon (13.8 %), Tilapia (10.1%), Pollock (8%), Pangasius (5%), Crab (3.6%), Catfish (3.4%) and Clams (2.4%). These types represent about 90% of the seafood consumed in the US. Wholesalers obtain these items from maritime fishing and inland fish farms[i]. Therefore, potential farmers should consider these trends when determining what to farm.

We were unable to find historical data indicating production amounts for farming, landings, imports and exports for Perch and Walleye. Therefore, market size and demand estimates were not calculated for these species.

2013 US Market Size and Unfulfilled Domestic Demand

We were unable to find estimates of market size for individual species of fish and seafood. Therefore, using currently available data from 2013, we estimated market size by calculating the total species available in the US (Imports + Commercial Landings + Farmed) and subtracted exports to derive the total domestic sales value by species in 2013. We then compared this to the estimated national market size for all seafood and fish in the US (($33,178,533,000 + $5,490,498,000 + 169,689,000) - 4,843,145,000 = $33,995,575,000), and found the market segment percentage these species hold.

Unfulfilled domestic demand was calculated by subtracting the total US production (Farmed + Landings) from the previously calculated US Demand (See Table 2).

2013 Market Size by Species			
	Salmon	**Shrimp**	**Trout**
Imports[ii]	$2,353,815,000	$5,314,845,000	$79,844,000
Landings[iii]	$756,576,000	$565,268,000	$761,000
Farmed[iv]	$76,987,000	$43,214,000[v]	$110,203,000
Exports[vi]	$619,261,000	$112,260	$7,693,000
US Demand for Edible and Non-Edible Seafood and Fish by Species((Total US Production + Imports)-Exports)	$2,568,117,000	$5,923,214,740	$183,115,000
Percent of Total Fish and Seafood Demand	7.55%	17.42%	0.54%
Unfulfilled Domestic Demand (Total Domestic Demand - Domestic Production)	$1,734,554,000	$5,314,732,740	$72,151,000

2014 Potential US Market Size

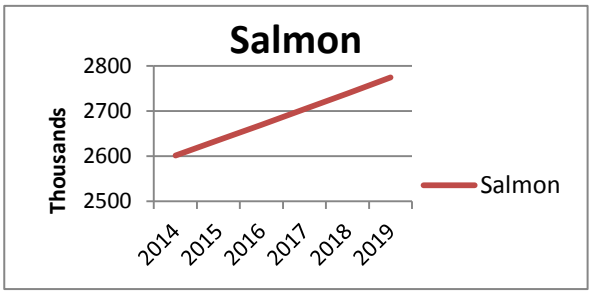
According to IBISWorld, consumer spending and health perceptions are expected to drive demand for seafood over the next five years. IBISWorld estimates an annualized growth rate of 1.3% for the seafood wholesaler industry through 2019, meaning increased demand for fish production. In 2014, the greatest product segment belonged to fresh fish and seafood, making up 50% of total fish consumed in the United States. Therefore, inland fish farms could increase access to fresh fish and seafood for wholesalers and consumers not located near the coast. Additionally, IBISWorld reports 35% of the fish and seafood segment is made of frozen items. The convenience of frozen items has narrowed the share between frozen and fresh items.

To calculate the potential market size for the next five years, we relied on IBISWorld's prediction of an annualized growth rate of 1.3% and the 2013 market size as calculated above per species (2013 Market Size * expected annualized growth rate)[vii]. However, this does not take into account fluctuations in demand between species. Because this is an average of all seafood and fish sales, it may not accurately represent the growth that will be seen by the individual species researched.

Salmon

2014	$2,601,502
2015	$2,635,321
2016	$2,669,581
2017	$2,704,285
2018	$2,739,441
2019	$2,775,053

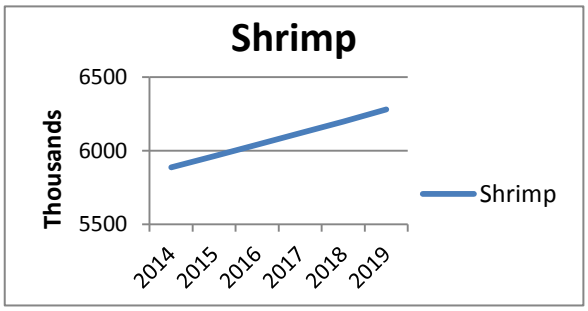
Figure 1. Estimated growth of market size for Salmon



Shrimp

2014	$5,886,610
2015	$5,963,136
2016	$6,040,657
2017	$6,119,185
2018	$6,198,735
2019	$6,279,318

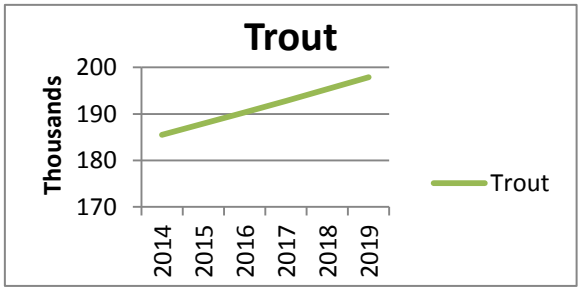
Figure 2. Estimated growth of market size for Shrimp



Trout

2014	$185,495
2015	$187,906
2016	$190,349
2017	$192,823
2018	$195,330
2019	$197,869

Figure 3. Estimated growth of market size for Trout



Demand Determinants

The primary determinant of demand for the Fish & Aquaculture industry's products is the level of fish and seafood consumption. When consumers eat more fish and seafood, there is a greater demand for the food fish, mollusks and crustaceans that the industry raise and which are used to produce fish and shellfish food products. Per capita seafood consumption has declined over the five years to 2015 as a result of a number of factors described below.

The price of seafood, which has grown over the past five years, impacts the level of seafood consumption, and therefore demand for the Fish & Aquaculture industry's products. As the price of seafood goes up, consumers are more likely to demand less seafood and instead opt to consume chicken, beef, pork and other similar food products. The price of fish and shellfish that are raised in US aquaculture establishments in comparison to the price of seafood that is either caught by the Fishing industry (IBISWorld report 11411) or is raised by aquaculture establishments abroad also affects demand for industry products. For example, according to the National Fisheries Institute, Americans are increasingly consuming pangasius, an inexpensive fish that is primarily farm-raised in Southeast Asia and then imported to the United States. The availability of pangasius and other similar inexpensive fish has shifted demand away from the Fish & Seafood Aquaculture industry's products.

Income levels are also important in determining the level of demand for industry products. Fish and Seafood products are generally more expensive than similar foods. Therefore, when income levels decline, there is typically a decrease in seafood consumption. Lobsters as well as oysters and other mollusk products are particularly expensive and are most often eaten in restaurants. As disposable incomes rise, consumers are more likely to visit restaurants and eat such seafood products. Demand for many non-edible products that are derived from the Fishing & Aquaculture industry are also highly dependent on income levels. Caviar and alligator products (such as alligator skin clothing) purchases depend highly on income levels, as does the quantity of ornamental, sport and bait fish that are purchased. Finally, income levels abroad affect industry demand through exports. As income levels rise in Asia, where seafood plays a large role in diets, demand for the industry's products will grow.

Fortunately for the industry, factors like nutrition often override price with respect to the purchase of fish and seafood. Fish is generally perceived to be a healthier protein source than other meats, which has had a positive implication for the demand for seafood. However, health concerns can also have a negative impact on the demand for seafood. For example, the perception that fish often contain high levels of mercury has encouraged some consumers to limit their consumption of seafood.

Major Markets

Fish and seafood processors

Fish and seafood processors constitute the largest market for the Fish & Seafood Aquaculture industry's products. Processors are factories that take large numbers of fish, mollusks or crustaceans and prepare them for sale to retailers and wholesalers. Processors add value to fish and seafood products through activities such as scaling, peeling, salting, breading, smoking, freezing and canning of fish. The nature of downstream value adding allows aquaculture firms to concentrate on producing a high-quality product rather than spending valuable time on developing new product markets. This market has remained relatively stable as a portion of revenue over the past five years.

Wholesale distributers and retailers

Wholesale distributors, including brokers and live haulers, constitute the second-most important market for industry products. Wholesalers buy fish, crustaceans and mollusks directly from industry operators to be sold to retailers, consumers, processors and other buyers of fish and seafood. While only about 13.0% of food fish are sold to wholesalers, a majority of mollusks and crustaceans raised in aquaculture farms are sold to wholesalers. Retailers represent the third-most important source of revenue for industry operators, and include fish markets, supermarkets, sport fishing stores and pet stores, among others. Over the past five years, sales to retailers have grown as a share of industry revenue, while sales to wholesalers has fallen. This is primarily due to the

phenomena of wholesale-bypass, in which wholesalers are being increasing cut out of supply chains as improved logistics and communications have allowed retailers and producers to better facilitate direct sales arrangements.

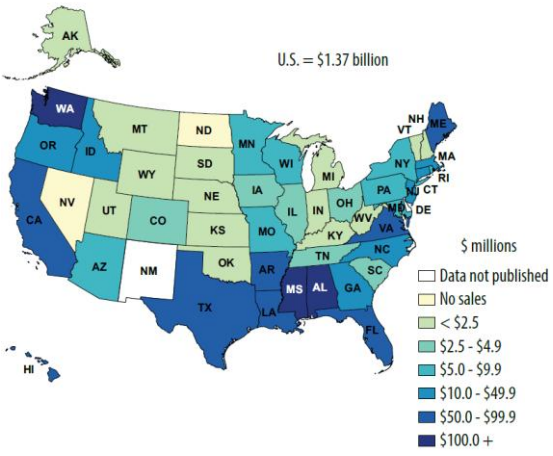
Competitive Landscape

Major players and exports

The Fish & Seafood Aquaculture industry is heavily concentrated in the Southeastern United States, which accounts for an estimated 57.6% of industry establishments. Catfish farming, the largest segment of industry activity, is done almost exclusively in Louisiana, Mississippi, Arkansas and other neighboring states. In addition, the region is home to large crustacean aquaculture operations. Louisiana is particularly well-suited to the farming of many types of fish, crustacean and mollusk species, and as a result accounts for an impressive estimated 16.3% of industry locations.

As the location to where the Mississippi river basin drains, the waters in Louisiana and surrounding states are particularly rich in food and nutrients for fish. These abundant resources allow farms in this region to support larger fish farms, which also yield more fish and shellfish products at lower unit costs. This has allowed for the development of some very large and efficient farms in the Southeast. For example, the Alabama company Southern Pride produces more than 80.0 million farm-raised catfish each year. However, the share of industry establishments has been in relative decline in Louisiana and the Southeast region as a whole over the past five years as catfish farming has slowly declined. At the same time, New England crustacean farming and salmon aquaculture in the Pacific Northwest has expanded.

Figure 4. Aquaculture Sales, by State, 2013

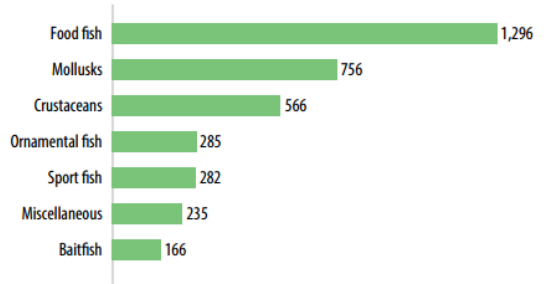


Source: USDA NASS, 2013 Census of Aquaculture.

Other coastal regions, while not as involved in the industry as the Southeast, have significant and growing aquaculture operations. The West, which accounts for an estimated 12.0% of industry establishments, produces a substantial amount of Atlantic salmon. The Mid- Atlantic, which accounts for an estimated 5.8% of industry establishments, is primarily focused on mollusk aquaculture. For example, Maryland is famous for its production of Chesapeake Bay oysters, while New Jersey is a significant producer of farm-raised clams. New England, which accounts for an estimated 7.8% of industry establishments, is an important region for crustacean and fish aquaculture.

The Fish & Seafood Aquaculture industry has a low level of concentration. The vast majority of industry operators are small individual fish or shellfish farms. While there are a number of large companies involved in the broader US seafood sector (which includes the Fishing and Fish & Seafood industries), most of them do not farm fish.

Figure 5. Number of Aquaculture Farms, by Type, 2013



Source: USDA NASS, 2013 Census of Aquaculture.

The majority of aquaculture in the United States is currently conducted in freshwater, partially due to restrictions over the building and operation of aquaculture farms in the ocean. As previously discussed, legislation concerning the possibility of the government issuing aquaculture licenses between 3 and 200 nautical miles offshore has been in discussion in Congress since 2007. The passage of such a law would greatly widen available waters for fish farming. Aquaculture in the ocean is more expensive and technologically complex than in freshwater due to the effect of currents and the distance of operations from land. It is likely that only larger companies with higher levels of available capital would be able to engage in such aquaculture, encouraging great involvement of such companies in aquaculture and increasing industry concentration.

Although there are not major players in the industry, IBIS World lists the following companies as having the greatest market share in the industry.

American Seafoods Group LLC
Estimated market share: Less than 1.0%
Seattle-based American Seafoods Group (ASG) is primarily engaged in fishing and fish processing operations, focusing on white fish, including Pollock, cod and sole. However, ASG operates in the Fish and Seafood Aquaculture industry through its Alabama-based subsidiary Southern Pride Catfish LLC, which it acquired in December 2002. Southern Pride breeds, harvests, processes and distributes catfish. Southern Pride began in 1986 with 38 employees processing more than 7.0 million pounds of farm-raised catfish. It is estimated that Southern Pride now employs 375 workers and processes 50.0 million pounds of farm-raised catfish each year. IBISWorld estimates that the company accounts for less than 1.0% of industry revenue, with an estimated $6.0 million in industry-specific revenue in 2015.

Flowers Fish Farm
Estimated market share: Less than 1.0%
Flowers Fish Farm was established more than 30 years ago on 11 to 12 acres of water in Dexter, MO. It is a family-owned and operated enterprise and one of the largest fish farms in Missouri, with more than 225 acres of water. Although the company primarily supplies channel catfish to fingerling and food fish producers, Flowers also breeds other species, such as white amur (grass carp), hybrid bluegill, fathead minnows, largemouth bass and crappie, in addition to servicing private ponds. As with most other companies in the industry, Flowers Fish Farm is not a public company and does not release financial data.

Key Success Factors

Success in the Fish & Seafood Aquaculture industry does depend on the quality of the fish or shellfish being raised, as poor-quality seafood cannot be sold. However, fish and shellfish are undifferentiated products that are purchased from aquaculture farms in large quantities, so that industry operators simply have to meet standard quality requirements when raising their product. Operators in this industry therefore compete primarily based on price. The industry is having difficulty raising prices to match increasing costs, putting strain on profit margins and highlighting the high level of competition in this industry. The following are considered competitive advantages in the industry:

- Use of techniques that produce higher-quality fish.
- Access to the appropriate water conditions is crucial to farming fish and seafood.
- Establishment of supply links in foreign countries, particularly in Asia helps ensure demand.
- Compliance with federal, state and county laws concerning water use and disposal.

- Access to production technology and an ability to adapt these to local conditions to improve output efficiency and industry know-how.

Competition between industry enterprises is also based on integration into downstream industries, reputation and experience, capacity, technology and product quality. The most successful industry players have vertically integrated to obtain captive markets and add value to the fresh product. This includes investing into fish and seafood wholesaling, retailing and processing. Also, aquaculture licenses are limited. Reputable industry operators familiar with managing authorities are more likely to receive license renewal.

Barriers to entry

The Fish & Seafood Aquaculture industry has low barriers to entry. Establishing a small catfish farm in the Southeast requires little capital investment. A plot of water or pond must be secured and fenced in and then filled with catfish. Small scale fish farm operations simply require the routine feeding and observation of fish as well as occasional maintenance in the event of damage to the fish enclosure. Oyster, clam and some other mollusk aquaculture farms do not even require feeding as these organisms feed simply by eating algae and other materials naturally found in water.

The most important barriers to aquaculture are regulation. Fish farming operations could have potentially harmful environmental impacts in sensitive geographic areas. Often, a license can only be acquired by purchasing an existing operation. The licensing barrier may be reduced if measures to expand offshore aquaculture eventually pass. This legislation would open up more water for aquaculture operations and expand the potential number of aquaculture licenses.

When capital costs are coupled with the constrained growth prospects associated with import competitiveness, lenders are likely to regard the activity as a high risk. As a result, access to funds on favorable terms may not be possible. Competition from other aquaculture-producing nations such as Chile is fierce. Many countries have established contracts with overseas buyers, and their output is sufficiently large enough to operate on lower cost structures than their US counterparts.

Global competition

The US seafood sector has a relatively high level of industry globalization. Many of the major processors and marketers of US seafood have links to international producers or their own aquaculture operations in competing countries. For example, the ContiGroup Company's ContiLatin Division runs a shrimp farm and hatchery in Ecuador. The Fish & Seafood Aquaculture industry is comparatively much less globalized. There are no major foreign companies in this industry, with small independently owned aquaculture farms accounting for the vast majority of industry operators.

Despite the absence of foreign owned industry establishments, the Fish & Seafood Aquaculture industry is subject to a high level of industry globalization due to high levels of import competition and the importance of exports to industry revenue. While aquaculture is a relatively small industry in the United States, it can play an important role in the economies of some countries, such as Chile. As a result, foreign aquaculture farmers have been able to increasingly import their products to the United States. Industry imports are expected to grow at an annualized rate of 5.6% over the five years to 2015. Exports have also grown rapidly as industry operators have taken advantage of the explosion in demand for seafood products in East Asia. Industry exports are expected to grow at an annualized rate of 4.8% over the five years to 2015.

Operating Conditions

Capital Intensity

IBISWorld estimates that for every $1.00 spent on wages, industry operators spend $0.12 in capital investment making the industry low level capital intensive. On the other hand, the industry is labor demanding, with farm workers required to regularly feed the fish and shellfish and monitor them to ensure that breeding cycles are in order, water temperatures are suitable and that no damage has been done to the enclosures in which the farmed fish are being raised.

More advanced aquaculture enterprises use a relatively higher amount of capital in their operations. These operators invest in advanced tanks, cages and pumps that are better able to regulate optimal conditions in which to raise fish and shellfish.

Technology and systems

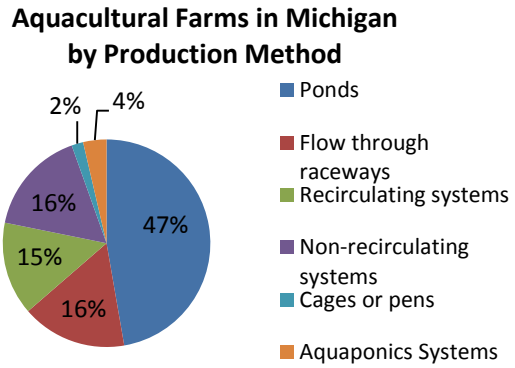
According to IBIS World, technological change in The Fish & Seafood Aquaculture industry is moderate. The main areas of investment are technologies that improve quality and productivity such as breeding and product geographic-information systems (GIS).

Breeding technology usually involves genetic modification that enhances an animal's resistance to disease, speeds up the reproductive process or increases meat yield. US fish farmers are behind some aquaculture nations with regard to breeding technologies. For example, Australian-based firm Clean Seas Tuna successfully bred southern bluefin in captivity for the first time in May 2009, and Japanese fish farmers successfully completed a third generation of regular bluefin tuna breeding in captivity in 2007. GIS technology is used to investigate and plan aquaculture developments. This technology combines data related to land elevations, proximity to water, temperature ranges, rainfall averages and soil types to enable better assessment of potential farm sites.

Production Systems and Methods

The 2013 Census of Aquaculture included the following methods for aquaculture production in the United States: ponds, flow-through raceways, recirculating systems, non-recirculating systems, cages or pens, aquaponics, cropland used for crawfish production, mollusks on bottom, mollusks off bottom (floating trays, racks and bags, long lines, string culture and rafts) and other productions methods.

Figure 6. Aquaculture farms in Michigan by Production Method. [viii]



Of these methods, the state of Michigan currently has Farmers using aquaponics, cages or pens, recirculating and non-recirculating systems, flow through raceways and ponds for aquacultural production. Pond production is the most highly used method of production in the state, used in 47% of Michigan farms. See Figure 6.

Based on information from the National Aquaculture Association, Table 2. represents the different production methods preferred for the species listed, and Table 3. provides descriptions of the production methods used for aquaculture.

Production Methods by Species

Species	Production Method
Atlantic Salmon	Net Pens
Hybrid Striped Bass	Ponds, Cages and Tanks
Sturgeon	Indoor or Outdoor Tanks, Cages, Large Pools and Ponds
Tilapia	Ponds, Tanks and Recirculation Systems
Trout	Raceways
Yellow Perch	Ponds and Intensive Tank Culture
Freshwater Prawns	Sectioned Ponds and Recirculation Systems

Table 2. Aquaculture Production Methods by Species.[ix]

Production Systems

Production Method	Description
Ponds	Ponds are one of the earliest forms of aquaculture and can be used to raise freshwater, saltwater and brackish water species. Major species raised in ponds are catfish, tilapia, shrimp, carp and hybrid striped bass.
Raceways	A raceway is a flow through system that diverts water from a stream, river, well or spring. The water passes through system and is treated before returning to the water body of origin. The water quality must be the same or better before discharged to the receiving waters. This type of production is strictly regulated by the federal government and requires a federal permit. Trout are frequently raised in raceways.
Recirculating Systems	Water is treated and reused in a recirculating system. This type of system is conducive to producing almost any type of fish. Recirculating systems are closed systems and help to address environmental concerns like fish escapes and wastewater discharge. They can also be located anywhere and produce saltwater fish inland. They are expensive to operate due to the large use of electricity.
Net Pens or Cages	These systems enclose fish in a pen or cage in offshore coastal areas or freshwater lakes. Location of net pens is highly regulated to deal with waste production and mesh size is regulated to prevent escapes. Salmon are most often produced in these systems.
Aquaponics	Aquaponic systems merge hydroponics and aquaculture. These are closed, sustainable systems, as water is filtered from the aquaculture portion through the plants to remove nutrients the plants need to grow. The water is further treated and returned to the aquaculture portion of the system.

Table 3. Aquaculture Production Methods and Descriptions.[x]

Appendix A. Historical National Industry Data.

	2007		2008		2009		2010		2011		2012	
	Production Value	% of Total Production	Production Value	% of Total Production	Production Value	% of Total Production	Production Value	% of Total Production	Production Value	% of Total Production	Production Value	% of Total Production
Landings	$4,204,652,788	77.77%	$4,394,112,311	78.17%	$3,930,115,285	77.11%	$4,524,214,633	77.91%	$5,370,260,938	80.07%	$5,126,890,170	80.60%
Farmed	$1,201,870,000	22.23%	$1,226,929,000	21.83%	$1,166,720,000	22.89%	$1,282,972,000	22.09%	$1,336,967,000	19.93%	$1,233,823,000	19.40%
		% of Domestic Sales		% of Domestic Sales		% of Domestic Sales		% of Domestic Sales		% of Domestic Sales		% of Domestic Sales
Total US Production	**$5,406,522,788**	32.57%	**$5,621,041,311**	42.18%	**$5,096,835,285**	439.62%	**$5,807,186,633**	109.97%	**$6,707,227,938**	19.88%	**$6,360,713,170**	19.48%
		% of Total Sales		% of Total Use		% of Total Use		% of Total Use		% of Total Use		% of Total Use
Imports	$28,777,119,000	173.36%	$28,456,612,000	213.55%	$13,124,171,000	1132.00%	$14,807,678,000	280.41%	$30,816,746,000	91.35%	$31,127,597,000	95.35%
Exports	$17,584,263,000		$20,751,865,000		$17,061,628,000		$15,334,182,000		$3,789,423,000		$4,843,145,000	
Demand for Domestic Edible and Non-Edible Seafood and Fish Sales ((Total US Production + Imports)- Exports)	**$16,599,378,788**		**$13,325,788,311**		**$1,159,378,285**		**$5,280,682,633**		**$33,734,550,938**		**$32,645,165,170**	
		% Demand		% Demand		% Demand		% Demand		% Demand		
Unfulfilled Demand (Total Domestic Demand - Domestic Production)	$11,192,856,000	67.43%	$7,704,747,000	57.82%	-$3,937,457,000	-339.62%	-$526,504,000	-9.97%	$27,027,323,000	80.12%	$26,284,452,000	80.52%

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