

Fish 2.0 Market Report: Aquaculture

An Investor Update on Sustainable Seafood



FISH2.0

Recirculating Aquaculture Systems: New Technology in a Thriving Industry

Aquaculture, the farming of aquatic organisms such as fish, crustaceans and plants, is the world's fastest-growing agriculture sector and produces more than 50% of the global seafood supply. The global aquaculture industry, currently valued at over \$144 billion, has consistently grown in terms of volume, increasing at an average of 8% annually in the last 20 years. In 2014, aquaculture overtook wild-caught fish as the leading source of seafood, and by the year 2020, the industry's value is expected to reach over \$200 billion—a 38% increase from today's figure. A confluence of demand factors such as global population growth and increased fish consumption has exponentially increased pressure on wild fish stocks, driving the need for seafood produced using sustainable aquaculture techniques.

One sustainable solution within the thriving aquaculture industry is a production method called Recirculating Aquaculture Systems (RAS). RAS, a land-based fish farming method, has the flexibility to be fully operational in any environment. It is self-contained and does not require direct water access, enabling abundant and fresh protein sources in a myriad of geographies where traditional aquaculture would be impossible. Businesses and policymakers are seeing value in RAS as a way to improve food access and gain a sustainable seafood supply. Specific opportunities for investors to engage in RAS include working with:

- **Companies improving current technologies.** Improvements in tank filtration and energy use will decrease overall system operating expenses and increase yields.
- **Businesses co-locating production with major markets.** Development of new RAS facilities in urban and export areas will create new local fresh supply sources for consumers.
- **Initiatives to scale production operations.** RAS set-up costs are higher than those for open-water aquaculture. However, investments to increase the size of operations facilities or otherwise create economies of scale in operating costs will allow existing RAS operations to improve profitability and returns to investors.
- **Efforts to expand the fish varieties grown in RAS environments.** Research into optimizing RAS for specific species will open new markets and increase distribution opportunities.

Aquaculture Is Meeting the Needs of an Expanding Global Seafood Market

Aquaculture is the fastest-growing agriculture sector in the world. Global population growth and an emerging middle class in developing economies are fueling increased demand for seafood, yet sustainable supplies of wild-caught sources are limited. These factors are contributing to the disparity:

- The volume of wild-caught fish, approximately 80 million tons, is expected to stagnate in the foreseeable future, as 87% of oceans are compromised: over 57% of the world's wild fish stocks are fully exploited, and another 30% are overharvested.

- The world's population has more than doubled in the past 50 years to over 7 billion, and the global consumption of fish per capita has increased from 10 kg per year to 19 kg per year.
- The global middle class, estimated at nearly 2.5 billion people, comprises the largest source of increased seafood demand, as this population seeks to consume fish as a healthful, affordable protein.



The confluence of these factors has exponentially increased pressure on wild fish stocks. Rising demand for seafood, coupled with the urgent need for sustainable supply, is expected to drive continued growth in the aquaculture industry.

Comparing Closed-Containment and Open Aquaculture Systems

Aquaculture systems exist both on- and offshore, and can be open or closed-containment. Open-water systems have historically been the leading method of aquaculture due to the moderate initial investment they require, their low operational expenses and their high degree of scalability. However, growing concern over the environmental impact of open systems has fostered an expanded interest in closed-containment systems.

From a technology standpoint, both types of systems offer a multitude of investment opportunities. Open-pen systems require better monitoring and disease control technologies. Closed-containment systems would benefit from developments in system design, water and energy use, and monitoring.

Below are general characteristics of each system.

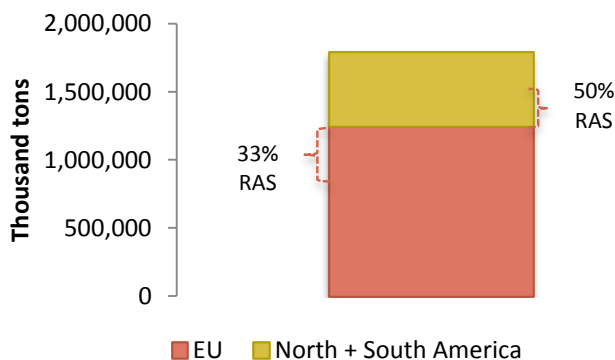
System Characteristics		Closed-Containment (including RAS)	Open
Example			
Inputs	Location	Anywhere	Oceans, lakes, rivers, ponds, estuaries
	Infrastructure	RAS, tanks, raceways	Cages, pens, racks, bags, ropes
	Set-up Costs	High	Moderate
	Species Farmed	Approximately 10	Over 100
Environment	Energy Use	High	Low (sourced from surrounding environment)
	Risk of Escapes	Low	High
	Waste Process	Filtered and removed from system	Released into surrounding body of water

RAS: A Proven Model That Is Growing in Popularity

Land-based aquaculture is anticipated to grow ninefold over the next 15 years, and within this market segment, Recirculating Aquaculture Systems (RAS), a form of closed-loop aquaculture, offers a significant industry opportunity to increase production sustainably.

- RAS enables fish farming in any location, under any climate conditions. It is especially well suited to certain segments of aquaculture, such as Atlantic salmon smolt, rainbow trout and European eel, because it supports salinity adaptation.
- According to the Freshwater Institute, over 50% of Atlantic salmon smolts (juvenile fish reared in hatcheries) in North and South America, plus the Faroe Islands, are now produced in RAS (see Figure 1).
- Norway is increasing its RAS adoption, with one-third of all salmon smolt production, totaling 22,000MT, coming from these systems. Since 2011, the country has constructed 6–8 systems a year in anticipation of increased demand for salmon smolts.

Figure 1. Global Salmon Aquaculture Production*



* Salmon smolts produced in North and South America and the European Union (including Norway) account for 99% of the species' global aquaculture supply.

- On the other side of the Atlantic, RAS is gaining traction with certain species: most US-produced tilapia (total less than 20,000MT a year) comes from RAS operations.

Global Expansion of Seafood Markets

RAS technology unlocks immense opportunities for businesses and consumers alike to access a fresh, healthful protein source.

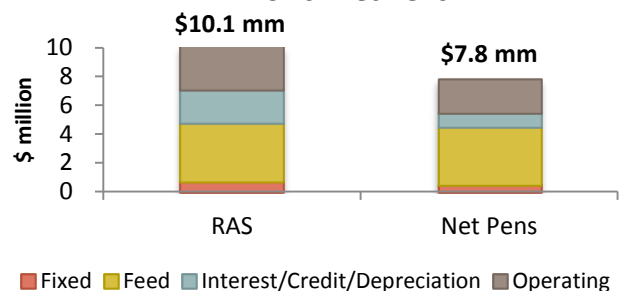
- As opposed to open aquaculture methods that require the ocean or direct freshwater sources, RAS is a self-contained tank system that enables efficient water use, environment control and extreme flexibility in terms of location. RAS can function fully in urban areas and even in desert environments.
- The location flexibility RAS provides can enable more cost-effective and convenient distribution than water-based aquaculture affords. Farmers can place an RAS next to major transport hubs or, conversely, in areas with limited infrastructure, thus reducing distribution expenses and opening up new markets.

Cost Challenges

While RAS has many benefits, this method of fish farming is not without its challenges, the most significant being cost:

1. Land-based systems can require three times as much initial investment in equipment as open-water farms.
2. Climate control and continuous water recirculation require significant energy use.
3. Technical complexity can increase operational and maintenance costs.
4. Figure 1 shows a general cost comparison between a RAS and an open-water net pen system.

Figure 2. Total Cost Comparison: RAS vs. Net Pens



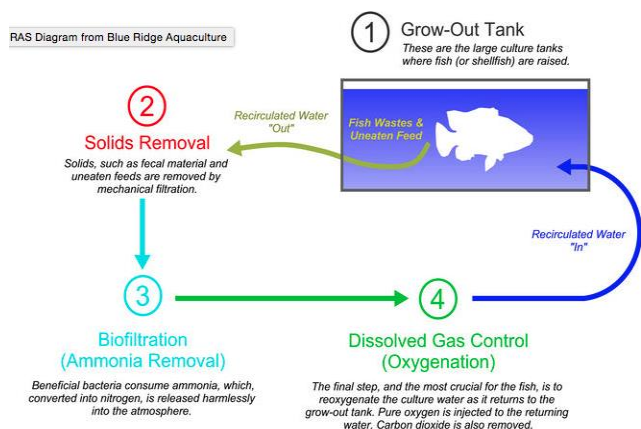
However, this cost gap is beginning to close. Cost savings technologies, production efficiencies and increased distribution opportunities, attained by co-locating facilities with markets, are piquing investors' interest in RAS. In addition, these systems have demonstrated fewer negative environmental impacts than open-water ones.

Identifying Good RAS Investment Opportunities

High efficiencies, consistent yields and first-rate products characterize a successful RAS. To this end, the focus areas for investment in RAS center on the following:

- 1. Technology Improvements.** Investments in technology, specifically those that lower energy costs or improve water quality, will improve fish health and lead to productivity and efficiency (see Figure 3).
 - Energy savings: Pump and filtration efficiencies can reduce overall RAS operational costs. Investors are developing energy reuse and conversion technologies.
 - Quality enhancements: Oxygen and biofiltration technologies can improve overall fish production and quality.

Figure 3. Areas for Technology Improvement Investments in RAS



- 2. Co-locating Production with Major Markets.** RAS allows placement of fish farms close to transport hubs, creating a favorable cost structure for growing and selling the fish.
 - Placing RAS in areas with poor infrastructure permits more direct go-to-market operations.
 - RAS enables landlocked and inland populations to access an affordable, healthful protein source.

- 3. Scaling Production Operations.** Vertically integrating operations throughout the value chain from “egg to plate” makes scale and cost savings possible.
 - Integrating systems vertically to include both hatchling and grow-out facilities reduces the risk of disease, ensures a year-round supply and allows breeding for desired traits.
 - RAS systems offer a high degree of control from both a location and a grow-out environment perspective. This control offers great potential to improve production and distribution efficiencies through scaling.

- 4. Expanding Fish Varieties for RAS Environments.** There are opportunities to expand the variety of species that are farmed in RAS, which could lead to the development of higher-value products and more consistent supply in segments of the global aquaculture market.
 - Approximately 10% of all aquaculture species are currently farmed in RAS. This leaves ample scope to expand the pool of options.
 - Production of additional fish species in RAS will require more research into such areas as determining specific water quality needs and system design requirements for each type of fish.

Key Sources:

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