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The Potential and Main Restrictions of Building Land-Based (RAS) Fish Farming Systems in the USA

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Abstract: Aquaculture is not sufficiently developed in the United States, especially compared to the global average. There is great potential for the construction of recirculating aquaculture systems (RAS), especially for the cultivation of salmon species. A major constraint on the development of aquaculture in the United States is the regulatory framework and obtaining permits. However, the economics of aquaculture are very promising, but projects are characterized by high capital costs.

Key words: aquaculture, RAS, land-based fish farming, the US fish market

1. Introduction

Let's start from what is Recirculating Aquaculture Systems (RAS). It is a technology that enables fish farming to be conducted in a sustainable and efficient way on the land. With the increasing demand for seafood and the pressure on wild fish populations, land based fish farming has become an attractive option to develop commercial aquaculture in the United States.

The United States imports 70-85% of its seafood [1], making it heavily reliant on foreign aquaculture production. Over half of the seafood imported into the US comes from aquaculture operations in other countries, for example salmon comes from Chile and Norway. Americans are the third-largest consumers of seafood in the world, creating a large market for aquaculture products.

Oysters and catfish are the two largest aquaculture species produced in the US [2]. The US produced in 2020 147 thousand tons of ousters with the consumption of 45 thousand tons. And for the catfish the production volumes in 2020 were 143 thousand tons with the consumption of only 78 thousand tons [3].

For Atlantic salmon and trout, the US produces only a small percentage of its consumption. In 2020 Atlantic salmon production was only 5% of the consumption that counts for 340 thousand tons per year. And the US produce 6% of the consumed trout with the consumption volumes of 250 thousand tons [3]. The growth of the population's prosperity increases the demand for red fish and stimulates investments in this industry.

The US aquaculture industry faces challenges such as regulations, environmental concerns, and competition from foreign producers. Cage aquaculture operations in the US are concentrated in coastal areas, particularly the Gulf of Mexico and the Pacific Northwest. Despite challenges, the US aquaculture industry has the potential for growth and to help meet the increasing demand for seafood [4].

RAS is a new technology that is currently in a developing state with a small number of operational projects around the world. However, we see a great potential for rapid development of RAS, as this technology has several advantages over fish farming in cages.

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There are many advantages of using the RAS technology comparing to the net pens or pool alternatives. RAS systems reuse up to 95% of the water [5], making them more efficient than pool or cage culture, which requires large amounts of water for replacement. RAS systems provide a more controlled environment, reducing the risk of disease transmission from wild populations, which can be a concern in cage or pool culture. RAS systems can efficiently remove and treat waste, reducing the environmental impact of aquaculture compared to pool or cage culture. RAS systems allow for more precise control over environmental parameters, such as temperature, dissolved oxygen levels, and feed delivery, resulting in higher growth rates and improved survival rates. RAS systems can be installed in a wide range of locations, including urban areas, where pools or net pens may not be feasible due to limited space or environmental constraints. Overall, RAS technology offers a more efficient, sustainable, and controlled approach to aquaculture compared to traditional pool or cages (net pens) technologies.

The vast potential of the market, which has traditionally relied on imports, presents an opportunity for new players to enter the market and specialize in farming and producing chilled salmon. The most suitable technology for the US market is currently land-based aquaculture systems for salmon farming. The leading solution providers for such technology are located in Denmark and Israel. Several companies have experienced high fish mortality rates or failed to reach their capacity once their projects were launched, emphasizing the importance of choosing the right farming technology and a proven concept when implementing new investment projects.

Building RAS systems in the USA involves several nuances that need to be considered before designing and planning the construction of RAS. Here are some of the key factors to consider when developing RAS systems in the USA: regulations and permits, what fish to grow and RAS economics.

2. Regulations and Permits

In press we read about many RAS projects that are launched for the development in the US. But then we see that majority of them stop for many years and don’t start construction. And usually, the main reason is getting permits.

The construction of RAS facilities in the USA is subject to federal and state regulations. It is important to obtain the necessary permits and comply with the regulations to avoid legal issues. The regulations vary depending on the state and type of facility being built, so it is crucial to research the specific requirements of the location where the RAS system will be constructed.

The main permits that the companies need to obtain to start construction process includes:

- Discharge Permit — A permit may be required if the RAS system will discharge any wastewater or effluent into the waters of the state. That is usually the permit most difficult to obtain, mainly due to the ecological issues.
- Water Appropriation Permit — A permit may be required if the RAS system will withdraw water from a public water supply or other source.
- Aquaculture Registration or Permit — This permit is required for the operation of aquaculture facilities, including RAS systems.
- Construction Permit — A permit may be required for the construction of new facilities or modification of existing facilities.
- Zoning Permit — A permit may be required to ensure that the facility is in compliance with local zoning ordinances.
- Coastal Zone Management Permit — A permit may be required if the RAS system will be located in the Coastal Zone.
- Wetlands Permit — A permit may be required if the RAS system will be located in or near wetlands.

The regulatory requirements for obtaining permits vary from state to state, and even from city to city,

which can cause confusion and delays. One of the main reasons why companies face delays in obtaining building permits in the USA is the lengthy and unpredictable review process. During the review process, the project is evaluated for compliance with zoning laws, building codes, and environmental regulations, which can take several months or even years.

Another factor that contributes to the delays in obtaining building permits in the USA is the lack of transparency in the process. Companies may not always be informed of the status of their permit applications or the reasons for any delays, which can make it difficult to plan and budget for their projects. The complexity of the permit application process and the need to comply with numerous regulations can also lead to errors or omissions in the application, which can further delay the review process. In some cases, companies may need to hire specialized consultants, such as engineers or environmental experts, to assist with the permit application, which can add to the costs and time required to obtain the permit. Despite the challenges of obtaining building permits in the USA, it is essential for companies to ensure that their projects are compliant with regulations and meet the needs of the community, to avoid legal or reputational issues that can arise from non-compliance.

Buying an existing small aquaculture farm with all necessary permits in place can be an effective way to solve the permit problem and increase the speed of getting permits. However, there are some important factors that you should consider before making a purchase.

First, you should carefully evaluate the existing permits to ensure that they are valid and will transfer to you as the new owner. You should also check whether there are any restrictions or limitations on the permits, such as production quotas or environmental requirements.

Second, it is needed to thoroughly inspect the existing farm to make sure that it is in good condition and capable of producing the type and quantity of seafood that you are interested in. You should also consider the location of the farm and whether it is easily accessible to markets and transportation networks.

Finally, you should weigh the cost of purchasing an existing farm against the cost of obtaining permits for a new farm. While buying an existing farm may be more expensive upfront, it may ultimately save time and money in the long run by eliminating the need for permit applications and approvals.

Overall, buying an existing small aquaculture farm with all necessary permits in place can be a good option for those looking to enter the industry or expand their operations. However, it is important to conduct due diligence and carefully evaluate all aspects of the purchase before making a final decision.

3. What Fish to Grow

The choice of fish species to grow in a RAS depends on several factors, including market demand, availability of eggs, fingerlings or juveniles, growth rate, feed conversion efficiency, disease resistance, and overall profitability. But the most important is the market volume to sale fish.

In terms of economic feasibility, it is important to consider the production costs and the potential market value of the fish species. Some fish species that are commonly grown in RAS and have proven to be economically feasible include:

- Atlantic salmon. One of the most popular species in the US in terms of the demand. Consumption in 2020 was close to 340 thousand metric tons with local production only 17 thousand tons [3]. With imports close to 95% of the production it attracts many potential investors who are looking into this opportunity [4].
- Steelhead trout. The consumption in the USA is 250 thousand metric tons with production close to 15 thousand tons [3]. This specie is

well-suited for RAS production with technologies commercially proven. It is popular on the market and there is no problem to sell this fish.

- Tilapia: Tilapia is a warm-water fish that is easy to breed, grows quickly, and is relatively resistant to diseases. It is also popular at the consumer market in the US.
- Catfish: Catfish is a hardy fish that is well-suited for RAS production. But may require more processing before being sold in the market.

Other fish species that are gaining popularity in RAS systems include barramundi, sea bass, and yellowtail kingfish. These fish also have high market demand and can grow quickly in RAS. Ultimately, the profitability of fish farming in RAS depends on various factors, including the initial investment, operating costs, and the price of fish in the market.

Ultimately, the choice of fish species for RAS production will depend on a variety of factors. And it is important to choose the right technology to farm.

4. RAS Economics

Advances in technology and increased demand for sustainable and traceable seafood are driving the growth of the RAS industry, with some projections estimating a global market size of over $1 billion by 2025. RAS systems require a higher initial capital investment compared to traditional open-pen fish farms, they can have lower operating costs and higher profit margins in the long run.

With the salmon/trout RAS systems the average Capital expenditures (CAPEX) that is needed to be invested is close to 24 mln USD for 1 thousand metric tons of fish grown [6]. CAPEX for RAS systems can include the construction and installation of the recirculating system, tanks, pumps, filters, and other equipment, as well as the cost of land and permits [7].

While RAS systems can have a higher initial CAPEX compared to traditional fish farms, they can also have a longer lifespan and lower maintenance costs, making them a sound long-term investment. There is also a need for a high working capital at least for the first fish growth till sales.

For 2,500 tons of salmon the need for the initial investment is close to 80 mn dollars that includes 60 million USD CAPEX, l0 million USD need for the working capital on the fish shift of fish and 10 million USD interest payments until the project will start generating revenue.

RAS systems can be more profitable due to the ability to produce fish year-round in controlled environments, reducing the risk of disease and environmental issues that can affect traditional fish farms. For the RAS fish farming EBITDA margin can reach 50-60% because of the less mortality, better feed conversion rates and ideal artificial conditions for the fish growth. The profitability depends on the cost of electricity, feed and technology used. Less use of pumps increases profitability and decrease complexity of the system. The fish can be grown to the size necessary for the consumers. And there is a need of purging before sales for a week. The fish is available all year round that with the specified size and that is extremely important with the sales.

The fish farming projects are characterized by long construction and growing periods. On average, construction takes about 2 years, and then it takes another 2 years for the fish to grow. Therefore, sales start only 4 years after the project is initiated. Fish farming projects are highly profitable in terms of operating profit, but due to high capital intensity and investment period, the average payback period for projects is more than 7 years.

There are other factors that should be considered before building the RAS system. That are water quality, energy and labor costs and financing.

Water quality is critical to the success of RAS systems. The USA has some of the strictest water quality regulations in the world, making it essential to ensure that the water source is suitable for the intended

fish species and meets the regulatory requirements. Additionally, since RAS systems recirculate water, it is necessary to monitor and manage the water quality to maintain optimal conditions for fish health and growth.

RAS systems require significant amounts of energy to operate the pumps, filters, and other equipment needed to maintain water quality. In the USA, energy costs can be high, so it is important to consider the efficiency of the system and the cost of energy when designing and building the RAS facility. Incorporating energy-saving technologies and practices can help to reduce operating costs and improve the system's economic viability.

Labor costs are another critical factor to consider when building RAS systems in the USA. The country has high labor costs compared to some other regions, so it is important to design the system to minimize labor requirements while ensuring optimal fish health and growth. Automation and technology can help to reduce labor costs, making the system more economically viable.

Building RAS systems can be expensive, and financing options may be limited. However, the US government offers several programs and incentives to support sustainable aquaculture development. Researching these options and identifying potential funding sources can help to make RAS projects more feasible and attractive to investors.

5. Advantages of the RAS Systems

The limitations of natural water bodies for fish farming can also include temperature, water quality fluctuations, pollution, seasonal variations, and natural disasters, such as droughts and floods. In addition, the availability of suitable land and access to water sources may be limited in certain geographic regions, further restricting the potential for aquaculture in those areas.

For some fish species, there are climatic limitations to their cultivation. For example, salmon and trout require cold water temperatures of up to 18 degrees Celsius for their growth. It is very difficult to maintain such temperatures throughout the year in natural sources.

When growing fish in cages, the growing period is usually 1.5 to 2 times longer compared to RAS. At the same time, the risks of farming significantly increase. In natural water bodies, there are diseases, and fish must be vaccinated. There are also predators such as seals and birds that can negatively affect fish growth. Additional stresses can impact the growth and survival of fish in natural conditions and when grown in cages.

RAS overcomes many of these limitations by providing a controlled and optimized environment for fish growth, which allows for year-round production in a variety of geographic locations. By reducing reliance on natural water bodies, RAS also minimizes the impact on the environment and helps to conserve natural resources.

Furthermore, RAS can be designed and optimized for the specific needs of each fish species, allowing for improved feed conversion rates, growth rates, and fish health. This can lead to higher yields and improved profitability for fish farmers, while also providing a more sustainable source of fish for consumers.

Recirculating aquaculture systems (RAS) offer several advantages [8] over traditional cage and pond culture for fish farming, including:

- Water Quality Control: RAS allows for precise control over water quality parameters, such as temperature, dissolved oxygen, pH, and nutrient levels, providing a stable and optimal environment for fish growth.
- Disease Control: RAS offers a controlled environment that can significantly reduce the risk of disease outbreaks, allowing for a higher level of biosecurity and fish health.
- Reduced Environmental Impact: RAS minimizes the environmental impact of fish farming by recycling and treating water, reducing waste discharge, and minimizing the use of antibiotics and other chemicals.

- Higher Production Density: RAS allows for higher fish production densities than traditional farming methods, maximizing the use of space and increasing the efficiency of fish production.
- Reduced Land Use: RAS allows for the production of fish in areas where land is limited or expensive, making it a viable option for urban or land-constrained areas.
- Year-round Production: RAS enables fish farming year-round, regardless of weather conditions or seasonal fluctuations, leading to a more consistent and reliable fish supply.
- Reduced risks: RAS farms greatly reduce the risk of escapes or disease transmission to wild fish population.
- Location: RAS technology allows to locate farms closer to consumers, lowering the costs of transportation.

Overall, RAS provides a more sustainable and efficient approach to fish farming compared to traditional pond and cage culture, making it an increasingly popular method for fish production [9].

The number of full-sized large RAS facilities in the world with cultivation volumes exceeding 1,000 tons is currently very small. Projects with volumes of 2,500 and 5,000 tons are just beginning to be launched. One of the largest RAS facilities in the world is probably Atlantic Sapphire in Florida. They have already built facilities for growing almost 10,000 tons, but they have not yet reached their planned capacity and have faced a number of difficulties due to the technology.

At the same time, there are already a large number of RAS operating in the world for growing smolts and for growing fish up to 1 kg, and this is already a well-developed technology.

6. Conclusion

The construction of a full-size RAS requires significant investment in both capital and operational costs. Additionally, fish farming in RAS is a relatively new and developing industry that requires specialized knowledge and expertise in the fields of fish biology, water chemistry, and engineering.

There are also some challenges associated with fish farming in RAS, such as maintaining water quality, managing disease outbreaks, and reducing energy consumption, which can increase the operating costs. As a result, many farmers may not be willing to invest in a full-sized RAS, especially if they are not confident in their ability to operate and manage the system efficiently. As a result, many companies and farmers may focus on producing smolt in RAS as a way to reduce the impact of disease outbreaks and improve fish health before transferring them to sea cages or ponds.

As the demand for sustainably-produced fish continues to grow, and technology advancements continue to improve the efficiency and profitability of RAS, we may see more full-size RAS being built in the future. As technology and know-how continue to develop, it is expected that the cost of RAS construction and operation will decrease, making it a more accessible option for farmers and investors. As a result, the number of large-scale RAS facilities is likely to increase in the coming years, leading to more sustainable and profitable fish farming practices.

In conclusion, building RAS systems in the USA requires careful consideration of several factors, including regulations, water quality, energy and labor costs, and financing. By understanding these nuances and incorporating them into the design and construction of RAS facilities, aquaculture entrepreneurs can take advantage of the opportunities offered by this sustainable and efficient fish farming technology.

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