The Solutions for Condensed Space Issues in Sustainable Aquaculture

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Introduction

As the world's population grows at an exponential rate, the rate of seafood consumption follows along, enlarging the issues within our current fishing systems. According to the NOAA Fisheries, the average American consumed 16.1 pounds of seafood in 2018, yet the population has risen in the two years by 1.16%, accounting for an increase of almost four million people in the United States alone. This means that in 2020, the annual seafood consumption is 125,580,000,000 pounds, and in 2050, the predicted population of 9.8 billion will consume 157,780,000,000 pounds. At this rate, it is predicted that the human population and demand for seafood will outpace the growth of marine life so that the ocean will run out of fish by the year 2050. Thus, researchers have been working on sustainable aquaculture, which has the potential to launch as soon as the year 2030. Sustainable aquaculture is a form of cultivating marine life from the ocean and its natural ecosystems in order to sustain the growing population. The predicted issues with this project mainly focus on the problems that come with condensed space: concentrated waste, parasites for migrating fish, and the smothering of marine life on the seafloor. Researchers have been finding ways to dissolve these issues so that the future of sustainable aquaculture may become a reality quicker than expected.

The Challenge

With the amount of marine life that would have to be grown in a small amount of space, the main issue is the concentration of waste given off by those organisms. In a Japanese aquaculture production, it was shown that one ton of fish can give off 0.8 kilograms of Nitrogen and 0.1 kilograms of Phosphorus on average, which is the waste 73 people give off per day (1). Due to how little urine saltwater fish release, the concentration of ammonia and amino acids in their urine is incredibly strong, which would lead to issues for aquaculture production if it were to not have the correct filtration systems in place. If fish are subjected to a strong concentration of their liquid waste for an extended amount of time, they can develop urinary tract and kidney diseases, which can be fatal. A common disease is a proliferative kidney disease that is common in commercially-grown trout and salmon, which are extremely popular in seafood culture. Along with urine, solid fish waste is also a large issue, as the increasing concentration of solid waste in a tank would allow small particles of waste to block the gills, which poses a great threat to the lives of the fish. Solving for the issues of concentrated waste means growing healthy and toxic-free fish that is safe for the human population to consume. Otherwise, the production would lead to a spread of diseases through the fish, wrecking the food web as both marine life and human life are impacted by such diseases.

Another such issue that has risen to the surface is that when fish are grown in net pens in the ocean, parasites from the grown group can emerge. This poses a problem as the parasites could be contracted by migrating wild fish that swim near the net pens. One solution is to release pesticides and antibiotics into the net pens in order to eliminate the parasites and diseases. However, the discharge of these chemicals would severely impact local species, crippling their growth and habitat. Additionally, the parasitic bacteria have potential to evolve resistance to the pesticides, which would stunt our ability to treat the diseases contracted from eating diseased fish. One disease, fish-borne zoonotic trematodes, or more commonly known as FZT, can jump hosts from fish to land animals such as dogs, cats, pigs, and even humans. The World Health Organization has estimated that over 500 million people are at risk for infection of FZT and that the trematodes could lead to liver and intestinal diseases. Thus, the prevention of parasites in sustainable finfish aquaculture is an effort for healthy fish and people.

The creation of net pens in the open ocean means that those organisms are concentrated in one solitary area. This creates an effect on the seafloor that is known as smothering. The organisms on the ocean floor are unable to receive sunlight, which eventually leads to the deaths of marine plant life. Those who feed off the plants are then forced to migrate to another location, and the predators of those organisms must follow, otherwise they must face starvation. This creates a bare spot on the ocean floor that is devoid of life, negatively impacting the ecosystem in that area as plantlife diminishes and marine life disappears from sight. As the organisms in the net pen release waste, the plants that would normally convert their waste into food or ocean-safe chemicals are gone, meaning that the harmful waste is released into the ocean with no solution. The absence of marine life in the area normally leads to ocean dead zones, which contain a reduced level of oxygen in the water. If this were to happen, marine life would be further pushed away into the depths of the ocean as shallower waters become too toxic. The existence of shorelife would become a rarity, and ocean culture as a whole would be negatively impacted. As a myriad of problems emerge, the expansion of net pens becomes an environmental issue.

The beginning stages of sustainable finfish aquaculture had many flaws, including health risks for both the marine animals and humans, as well as the marine ecosystem, which would in turn affect land ecosystems and those that depend on marine life. As the aquaculture projects developed, scientists and aquaculture farmers experimented to find the best financially sustainable way to create the most seafood without impacting the environment or health of the fish.

Proposed Solution

There are two solutions with the most potential for what may become bigger producers of seafood in the future, and one is the idea of indoor farming. Indoor farming has already been launched, as the largest indoor fishery is currently Blue Ridge Aquaculture in Virginia. They are the largest producer of Tilapia, raising more than 4 million pounds every year in a facility less than three acres of land (2). The success of Blue Ridge was a phenomenal feat, proving that sustainable finfish aquaculture technology had advanced into allowing fisheries to raise millions of fish while situated on a small acreage.

Indoor farming solves for the issues of pollution from concentrated marine waste. The indoor farms are accommodated with Recirculating Aquaculture Systems, also known as RAS, which filter waste in the water, even leaving the water cleaner than how it entered the indoor habitats. Physical filters gather solid feces and leftover food, so that the system may turn such wastes into compost and raw material. Additionally, ozone treatment breaks down the organic solids while Ultraviolet light kills the pathogens that could be transmitted through the waste, leaving all toxic waste benign and ready to be composted back into the environment. For liquid waste, bio filters convert the urine into safe amounts of Nitrogen, lessening the toxicity of the concentrated urine. The final step includes the injection of pure oxygen into the filtered water as well as the removal of carbon dioxide. This system allows for a clean cycle of water that removes all issues of toxicity in concentrated waste, creating a no-harm water system that not only removes waste, but also leaves water cleaner than how it originally came (3). In order to also reduce the amount of waste, the system also calculates the feeding times of the fish as well as the amount of feed given out (4). This RAS technology has already been tested and automated, with multiple facilities already having this system integrated, helping the current seafood production.

The facilities that use indoor farming also have no risks of transmitting locally grown fish parasites to those migrating nearby. Keeping the fish in an enclosed space allows for the farmers to clean and filter the water, removing all toxic waste, and eliminate all risks of parasite migration. Indoor farming also means that there is no marine environmental impact, since there is no natural seafloor that is in danger of being smothered. Essentially the fish grown in these indoor facilities have no negative impact on the environment, and only help accommodate for the world's growing hunger for seafood.

Another solution is Integrated Multi-Trophic Aquaculture, also known as IMTA's, which is the cultivation of multiple species of organisms on farms. IMTA has been successful in multiple regions of the world, such as Kona, Hawaii; Bahía de La Paz, Mexico; and off the coast of Ashdod, Israel (5). Most IMTA farms are located underwater, although it is not uncommon for some farms to be on land. These underwater platforms could be situated with groups of mussels and kelp, allowing for the natural recycling of waste that would have no negative impact on the ecosystem. Unlike indoor farming, outside IMTA aquaculture has a larger potential for error: no control over water. Because farmers are unable to filter the water, the natural organisms that lurk near the platforms would convert the waste for them. The mussels would extract the waste from the cages and the kelp would absorb the dissolved inorganic waste (6).

The expansion of sustainable farming means that the main brunt of the world's fish production would originate from these eco-friendly facilities, which would in turn also eliminate the indirect harms of mass fishing. One such example is bycatch. When fishermen use large nets to catch mass amounts of fish, they also entangle other marine animals in their nets as bycatch, such as sea turtles, dolphins, sharks, etc. The large nets also tend to have weights at the bottom which drag along the ocean floor and damage the plant life and coral ecosystems that thrive at the bottom. These nets can decimate endangered species, as if the nets are discarded or detached in water, fish can get caught in the nets and die (7). The damage that could result from a ghost net is irreparable and could severely damage the marine ecosystem and life that depends on it. As sustainable aquaculture expands and researchers further their work on it, technology advances so that sustainable finfish aquaculture becomes the main producer of fish, and harmful fishing techniques die out.

Conclusion

The idea of sustainable aquaculture has been a topic for many years, yet as the world's population only shows signs of exponential growth, these ideas have only been established into reality. Indoor farming and IMTA have both been developed and started. The only obstacle that stands in the way between the present and the future of sustainable farming is time. As time goes on, more and more sustainable farms will be created, slowly leaning the world's production away from harmful nets, bottom trawling, use of explosives, and cyanide fishing. The future proves to be bright, since many sustainable farms have already been established around the world and have shown immeasurable results.

Sustainable aquaculture is a concept that becomes more and more crucial to expand upon as the world's population increases daily, and the progress in the projects shows the potential of aquaculture. As it avoids detrimental effects to the environment and aids in the world's seafood production, sustainable aquaculture can only be affirmed as an inherently good idea, and the scientists are turning the idea into reality.

Bibliography

1. Bittel, Jason. “A Single Discarded Fishing Net Can Keep Killing for Centuries.” *NRDC*, 28 Aug. 2019, www.nrdc.org/onearth/single-discarded-fishing-net-can-keep-killing-centuries#:~:text=Gear%20can%20malfunction%20and%20detach,%2C%20though%2C%20is%20the%20weather.

2. Buck, Bela H., et al. “State of the Art and Challenges for Offshore Integrated Multi-Trophic Aquaculture (IMTA).” *Frontiers*, Frontiers, 24 Apr. 2018, www.frontiersin.org/articles/10.3389/fmars.2018.00165/full#:~:text=Integrated%20multi%2Dtrophic%20aquaculture%20(IMTA)%20is%20the%20co%2D,kelps)%2C%20which%20may%20feed%20on.

3. Dauda, Akeem Babatunde, et al. “Waste Production in Aquaculture: Sources, Components and Managements in Different Culture Systems.” *Aquaculture and Fisheries*, Elsevier, 20 Nov. 2018, www.sciencedirect.com/science/article/pii/S2468550X18300352#:~:text=Solid%20wastes%20are%20regarded%20to,suspended%20and%20total%20dissolved%20solids.

4. Government of Canada, Fisheries and Oceans Canada. “Integrated Multi-Trophic Aquaculture.” *Government of Canada, Fisheries and Oceans Canada, Communications Branch*, 31 Oct. 2019, www.dfo-mpo.gc.ca/aquaculture/sci-res/imta-amti/index-eng.htm.

5. Merritt, Jennifer. “Tons of Tilapia: Va. Indoor Fish Farm Largest in World.” *Lancaster Farming*, 22 Jan. 2011, www.lancasterfarming.com/news/southern_edition/tons-of-tilapia-va-indoor-fish-farm-largest-in-world/article_c4a4a46c-da05-5f29-8e63-f9eca423d85d.html#:~:text=Blue%20Ridge%20Aquaculture%20(BRA)%20in,in%20the%20form%20of%20tilapia.

6. "Recirculating Aquaculture System (RAS) Design." *Innovasea*, Innovasea, www.innovasea.com/land-based-aquaculture/ras-design/.

7. *What Is Recirculating Aquaculture?*, Blue Ridge Aquaculture, www.blueridgeaquaculture.com/recirculatingaquaculture.cfm.