Brief Communication

Development of super-Intensive land-based RAS for marine finfish farming

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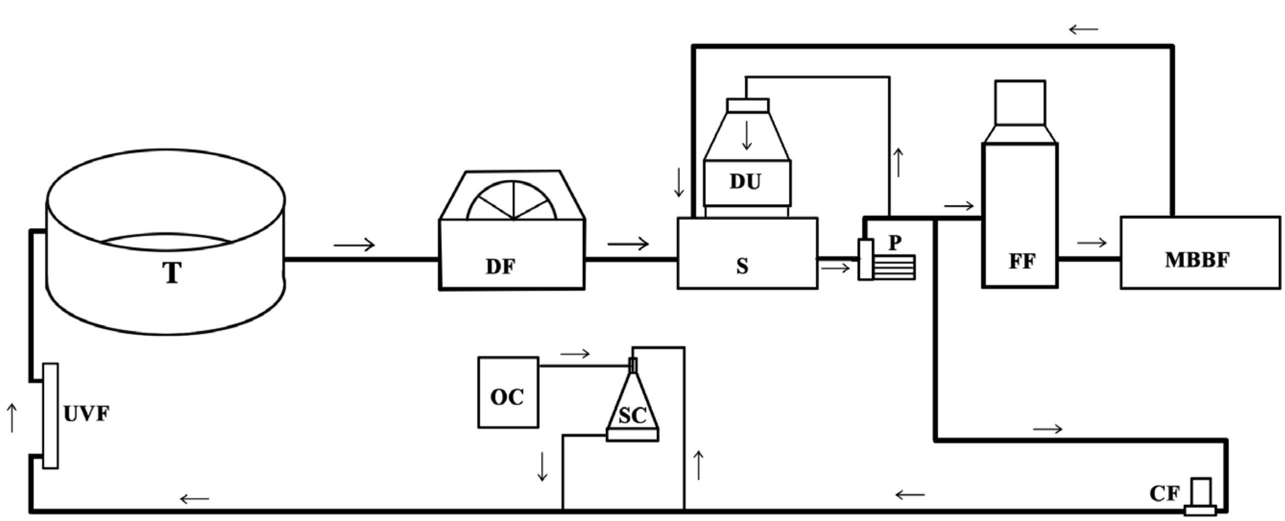
Around the world, most finfish mariculture production occurs within net cages. However, coastal net cage farming presents several significant drawbacks. More than 70% of the nitrogen provided as feed in these cages is lost into the open water, leading to environmental pollution. The widespread adoption of cage culture in coastal waters, particularly in backwaters and bays, inevitably results in substantial self-pollution. Cage farming also faces challenges related to parasitic and viral diseases and its vulnerability to natural disasters like high waves, strong winds, and floods, resulting in substantial crop losses. Globally, land-based Recirculating Aquaculture Systems (RAS) are gaining importance as an alternative method of mariculture, particularly for high-value finfish production. Land-based RAS offers numerous advantages, including the precise control of critical water quality parameters, efficient land and water utilisation, and maximised production. This production method is sustainable, environmentally friendly, and bio-secure. It provides flexibility in site selection and species cultivation, facilitates easy and complete harvesting, and allows year-round production planning. However, it is important to note that the high capital cost is a major obstacle to the widespread adoption of land-based RAS, which can only be overcome through intensive farming practices.

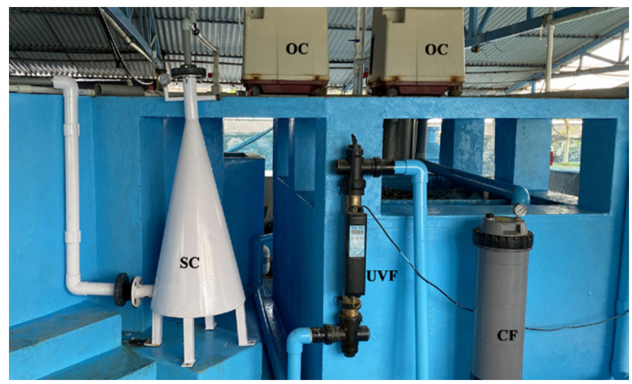
The Vizhinjam Regional Centre of the ICAR-CMFRI has established a dedicated facility to address this challenge and develop land-based super-intensive farming technology. This system comprises a 30-ton dual-drain tank with a balancing tank (T), a drum filter (DF), a foam fractionator (FF), a moving bed biofilter (MBBF), a degassing unit (DU), SUMP (S) a cartridge filter (CF), a UV filter (UVF), an oxygen concentrator (OC) and Speece cones (SC) or (down-flow bubble contactor). The flow of water from the



Flow Diagram of Super Intensive RAS Unit (T-tank, DF-drum filter, S-sump, P-pump, FF-foam fractionator, MBBF-moving bed biofilter, DU-degassing unit, CF-cartridge filter, OC-oxygen concentrator, SC-speece cone), UVF-UV filter.

Fish rearing tank of 35 t capacity

Filtration system



UV and O_2 injection

tank to the drum filter, as well as from the moving bed biofilter (MBBF) to the sump, is driven by gravity. All the equipment for the system was sourced locally. The dual-drain system removes concentrated waste through the central drain, while the side drain eliminates surface film and a portion of the circulating water. The balancing tank regulates the water flow through these drains. The drum filter effectively removes particles larger than 60 microns from the circulating water, and the foam fractionator targets dissolved and colloidal organic matter as well as particles smaller than 60 microns. The biological filter helps in the removal of ammonia through nitrification, and the degassing unit eliminates CO2 and other harmful gases. Subsequently, the cartridge filter removes any remaining particulate matter before the water enters the UV filter, efficiently eliminating parasites, bacteria, and viruses. The oxygen concentrator-Speece cone assembly maximises the dissolution of pure oxygen into the system water, sustaining high stocking densities. This system will be instrumental in developing and fine-tuning the super-intensive production mode, with the first trial's results being presented and discussed. The main component of the system, the rearing tank, had a diameter of 5 meters and a depth of 1.83 meters, with a total volume of 35 tons. During the culture period, the water level was maintained at 1.6 meters, resulting in a volume of 30 tons. A total of 1212 fingerlings of Silver pompano (*Trachinotus blochii*) with an average length of 85.33 mm (9.7 g) were stocked in the RAS. At the time of stocking, the water parameters were as follows: salinity 27 ppt, pH 8.18, temperature 28.6°C, and dissolved oxygen (DO) 5.04 mg/L.

The fish were fed with a feed (Nutrila) containing 40-42% protein, 6-10% crude fat, 3% fibre, and 12% moisture. During the first two months, the fingerlings were fed with a 1.8 mm pellet size. As the fish grew, the pellet size gradually increased to 2.5 mm during the third and fourth months, 3 mm during the fifth and sixth months, and 4 mm in the seventh month. This progression ensured the feed remained suitable for the fish at each growth stage. Initially, the fish were fed at 10% of their biomass, which was gradually reduced to 7% during the second month and further to 4.5% in the third month. During the third month, a technical issue occurred with the drum filter, resulting in the death of 12 fish due to waste accumulation, increased turbidity, and elevated ammonia (NH_3, 0.256 ppm) and nitrite (NO_2, 2.0 ppm) levels. Despite repairs, any increase in feed quantity led to high turbidity, indicating inadequate particulate matter removal by the filtration system, particularly the drum filter. Consequently, the feed quantity remained below

Harvesting pompano from the land-based super-intensive RAS

4 kg, even as biomass increased. This resulted in the feed percentage dropping from 4.5% in the third month to 1.7% in the seventh month.

Every day, 5-10 % water exchange was given to maintain the water quality. However, due to the drum filter malfunctioning again during the 5th month, 80 fish died, with ammonia and nitrite levels rising to 0.414 ppm and 2.1 ppm, respectively. To manage the increased turbidity, daily washing and replacement of the cartridge were implemented. On June 6th, the drum filter stopped working entirely, necessitating emergency harvesting. Despite these instrumentation

Harvested pompano fishes

Table 1. Growth and feeding of Silver pompano *T. blochii*

	No. of fish	Average length(mm)	Average weight (g)	Feed %	Monthly feed consumption
Initial	1212	9.7	11.7564		
1st month	1212	29.75	36.057	10.00%	33
2nd month	1212	71.5	86.658	7.00%	73
3rd month	1200	189.1	140.38	4.50%	100
4th month	1120	201.5	183.8	2.90%	114
5th month	1120	237.1	224.9	2.20%	125
6th month	1120	251.3	240.7	1.80%	125
7th month	1120	279.5	303.5	1.70%	127

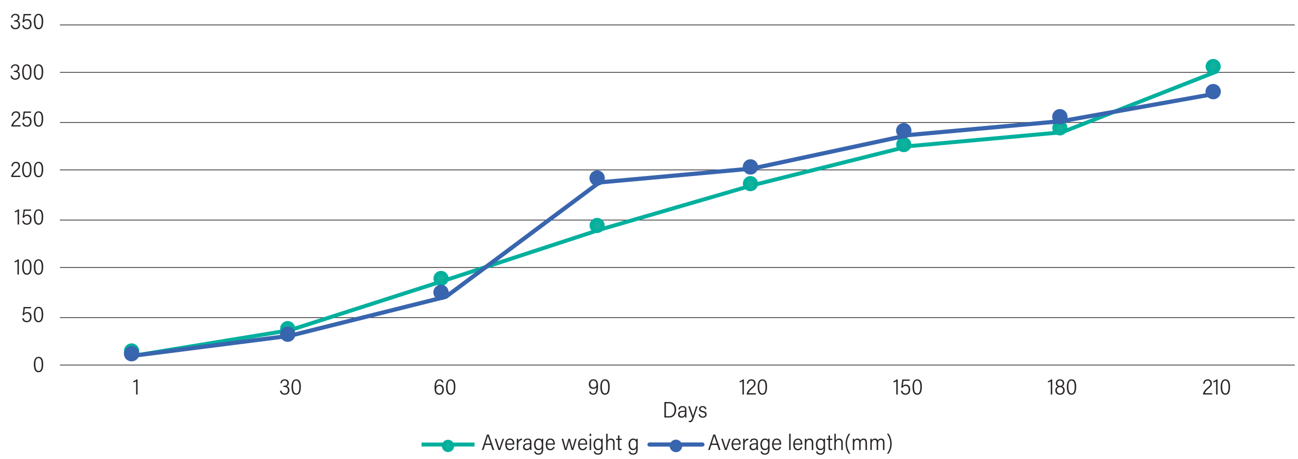


Fig. 1. Growth in length (mm) and weight (g) of Silver pompano over time in a super intensive RAS

challenges, we harvested 303 kg of fish with a survival rate of 92.40%. The average length and weight of the harvested fish were 279.5 mm and 303.5 g, respectively. The feed conversion ratio (FCR) calculated during the experiment was 2.4. The growth and feed are presented in Table 1 and Fig. 1.

Conclusion

The current production of 339 kg from a 30-ton tank, which is 11.3 kg/m^3 or equivalent to 172 tons per hectare, conclusively proves that production of more than 20-30 kg/m^3 is quite achievable with better equipment. The study highlights the importance of maintaining optimal water quality parameters and effectively managing organic waste in super-intensive RAS systems, as heavy organic load and consequent changes in water quality led to some mortality. Future research has to focus on improving waste management strategies, equipment selection, and system design to prevent similar issues. The development of super-intensive land-based RAS for marine finfish farming presents a promising alternative to traditional net cage mariculture. The experimental trial conducted at the Vizhinjam Regional Centre of ICAR-CMFRI demonstrates the potential for high-value finfish production with efficient resource utilization and sustainable practices. This study has yielded valuable data and insights into the operation of super-intensive land-based RAS. Despite challenges such as high capital costs and organic waste management, the benefits of land-based RAS make it a viable option for future mariculture development. Additionally, the importance of specially designed artificial feed in super-intensive systems cannot be overstated, as it plays a crucial role in optimizing fish growth, minimizing waste, and maintaining water quality. This research paves the way for more sustainable, productive, and economically viable marine aquaculture practices, promising a brighter future for the industry.