

SUPER-INTENSIVE RAS TRIAL YIELDS ENCOURAGING SHRIMP HARVEST AT OCEANIC INSTITUTE

Summary:

An intensive growout trial produced 5.7 kg/m² of market-size shrimp in 14 weeks in a recirculating aquaculture system using minimal water volume and only 0.34% daily water exchange. Alternative management strategies allowed the elimination of costly external biofilters and other system components used in previous trials, thereby reducing production costs.

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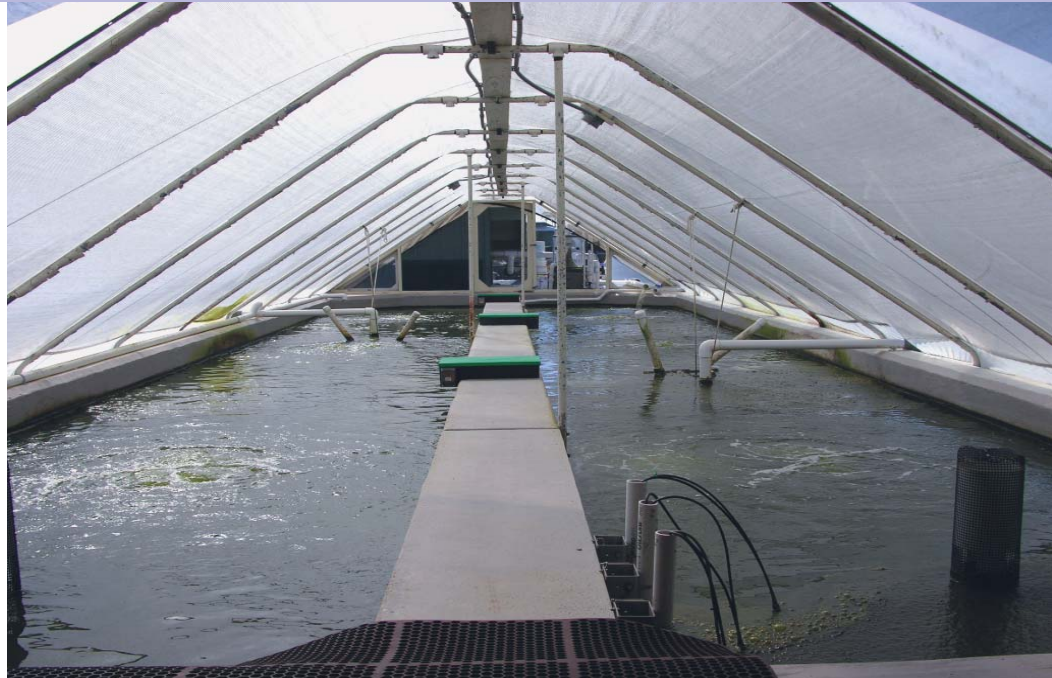
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Recirculating aquaculture systems (RAS) offer several advantages over traditional shrimp farming in coastal ponds. Water requirements are reduced significantly, thereby reducing the potential for pathogen introduction into the culture environment, and nutrient and biological pollution of the natural environment. In addition, an RAS can produce shrimp at an inland location away from sensitive coastal areas and closer to markets. However, higher capital and operating costs have been a barrier to the economic viability of RAS growout technology.

Recent research at the Oceanic Institute in Hawaii, USA, has focused on reducing production costs by simplifying recirculating system design, improving management strategies, and enhancing shrimp performance through selective breeding.

Growout Trial

In a super-intensive growout trial, shrimp representing 27 families from the Oceanic Institute selec-



This RAS at the Oceanic Institute is used for super-intensive shrimp production and to evaluate shrimp family performance.

tive-breeding program were tagged and stocked in a raceway-based recirculating system. The RAS consisted of a 75-m² concrete raceway with system components that included a foam fractionator, oxygen generator, and air stones. Clear ultraviolet-protected plastic sheeting was used to cover the raceway as a biosecurity feature to reduce pathogen introduction by airborne vectors. The cover also served as an effective thermal insulator to maintain desirable water temperatures.

Water use was minimized so that suspended particles, attached bacteria, and microalgae could be retained in the production system. This was important because shrimp reared in water with high concentrations of microalgae and microbial-detrital aggregates grow better than shrimp reared in filtered sea water. Also, suspended particles could serve as attachment sites for nitrifying bacteria.

A total of 22,600 juvenile shrimp with mean weight of 0.81 g were stocked in the RAS at an initial density of 300 shrimp/m². The shrimp were fed a commercial 35%-protein

feed in the morning by hand and by belt feeders for the remainder of the day and evening.

Shrimp Performance

After 14 weeks, 20,238 shrimp with a mean weight of 21 g were harvested from the raceway. Final survival was 89.5%, and mean growth rate was 1.44 g/week. The feed-conversion ratio was 1.49, with a final production of 5.7 kg/m² (7.5 kg/m³).

Batch weights by family at stocking and individual harvest weights were measured to evaluate family performance. Seven shrimp families exhibited growth performance of 1.5 g/week or more and at least 85% survival during the 14-week trial. One family had a mean weight gain of 24.7 g (1.8 g/week growth) and survival of 99.5%. Furthermore, 243 individuals (2.7% of the tagged shrimp harvested) exhibited growth rates of 2 g/week. This group included representatives from 18 of the 27 families. Clearly, selective breeding will continue to play a significant role in ensuring good shrimp performance in these production systems.

Water Quality

One hundred sixty l of water were used to produce 1 kg of shrimp. Water lost to evaporation and the removal of protein fractionator sludge was replaced at a rate of 0.34%/day.

The high mean water temperature of $28.8^{\circ}\text{C} \pm 0.1$ S.E. throughout the 14-week trial supported rapid shrimp growth and could be attributed, in part, to the plastic cover that acted as a thermal insulator. The mean dissolved oxygen (D.O.) concentration was $5.48\text{ mg/l} \pm 0.07$ S.E. With few exceptions, D.O. concentrations were maintained above 5.00 mg/l throughout the trial.

Mean total ammonia nitrogen concentration was $0.99\text{ mg/l} \pm 0.21$ S.E. (Figure 1), while mean nitrite concentration was $2.32\text{ mg/l} \pm 0.18$ S.E. Ammonia and nitrite removal was accomplished by in situ microbes in the water column and attached to surfaces. No external biofilters were used during the trial.

Nitrifying Bacteria

The initial fill water for the RAS was clear well water devoid of particles upon which nitrifying bacteria could attach. This likely accounted for the variable concentrations in total ammonia nitrogen and nitrite nitrogen observed throughout most of the trial. However, low and stable concentrations of these inorganic nitrogen species were observed during the last three weeks of the trial, when shrimp biomass was high.

On day 58, the mean total bacterial count using a highly sensitive "DAPT" DNA stain was 3.9×10^8 cells/ml. Fluorescence in situ hy-

bridization techniques indicated that nitrifying bacteria of the genus *Nitrospira* were present at a concentration of 1.2×10^8 cells/ml and represented 31% of the total count.

Water analysis conducted on day 91 showed a total suspended solids concentration of $1,365\text{ mg/l}$. The particles provided significant surface area upon which nitrifying bacteria could attach. In addition, photoautotrophs were present in the water column, and mean net oxygen production was $3.1\text{ mg oxygen/l/hour}$. Data on RAS microbes suggests there is functional redundancy in terms of ammonia and nitrite removal, where photoautotrophs, nitrifying bacteria, and heterotrophic bacteria all play important roles.

Evolving Performance

Results from this trial reflected advances over previous Oceanic Institute research. Water exchange, for example, was significantly less than previous trials with 1.00-2.00% daily exchange. Alternative management strategies allowed the elimination of costly external biofilters and other system components – aspirator-type aerators, degassing columns, and artificial substrates – and reduced production costs.

Feed conversion and survival also improved over previous trials, in which feed-conversion ratios were typically greater than 2 and survival ranged 70-85%. Although super-intensive trials at the Oceanic Institute have been conducted using stocking densities as high as 700 shrimp/m^2 , the moderate stocking density used in this trial may provide a more consistent, reproducible result.

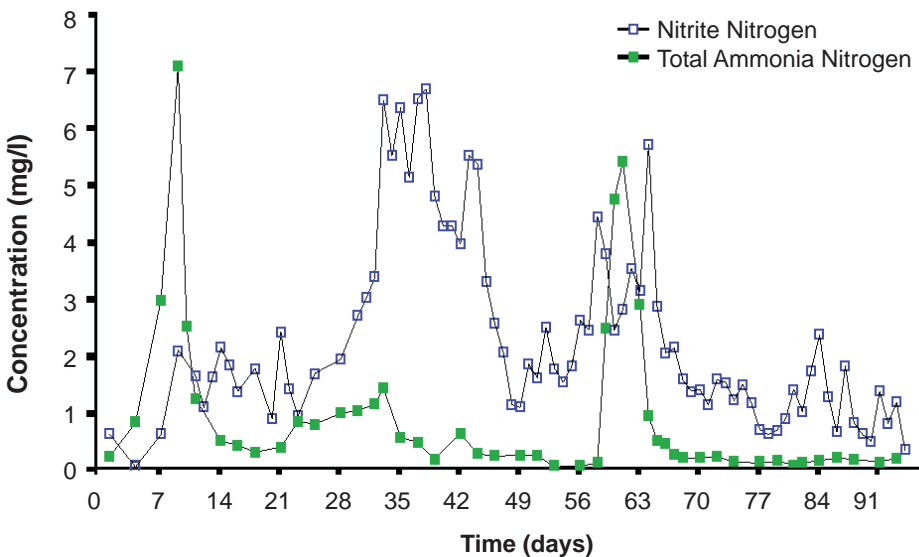


Figure 1. Nitrite nitrogen and total ammonia nitrogen concentrations.