Enhancing Water Quality Through Denitrification in a Recirculating Aquaculture System (RAS)

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BACKGROUND: An RAS was operated for 18 months to grow 70 California Yellowtail (*Seriola dorsalis*) for food production. Fish averaged 1.6 Kg during the last harvest in December 2025. Managing nitrogen was a major challenge. To promote Zero Water Discharge (ZWD), both nitrification and denitrification must be utilized. The purpose of this project is to evaluate denitrification to develop a ZWD RAS.

Figure 1. 3,000 L artificial marine RAS used to produce finfish. The system included: nitrification, oxygenation, solids separation, and foam fractionation.

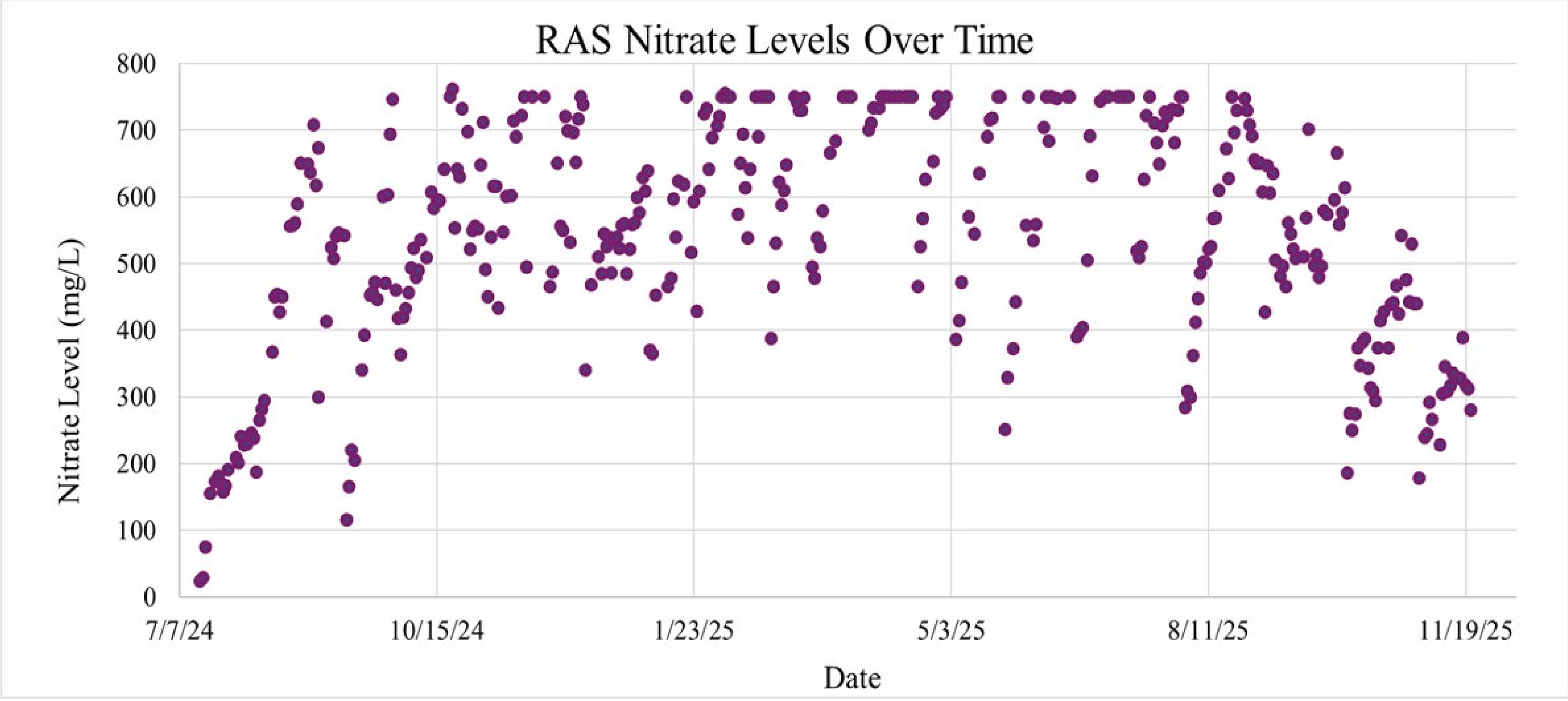


Figure 2. Elevated nitrate levels in the marine RAS due to lack of denitrification. Water exchange was required to lower NO3. The system operated from July 2024 to December 2025.

METHODS: Experiments were conducted using six 5-gallon buckets in a continuous flow mode. Treatments had three replications each. Samples were taken every 12 hours for 48 hours after the start of each trial. Initial trials measured different carbon additions and volumes of media. The carbon feed source was vegetable glycerin.

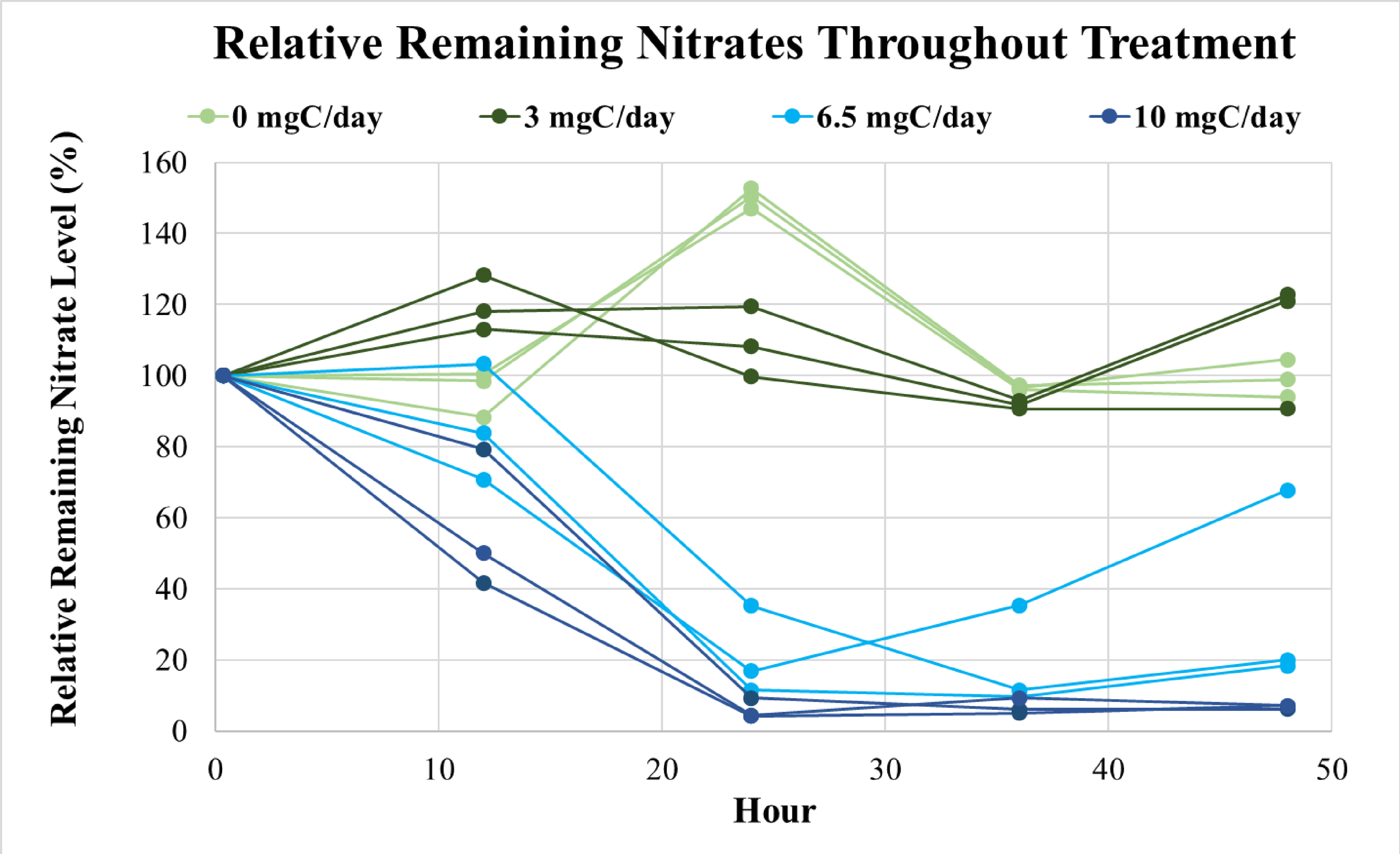
Table 1. Hydraulic Residence Time (HRT) was calculated for different media volume treatment (Vol / Flow rate).

Media Volume	Volume (L)	Flow Rate (L/Day)	HRT (Days)
4L	14.7	15.2	0.96
4L	14.5	16.6	0.88
6L	14.1	15.7	0.90
6L	14.2	15.7	0.90
8L	13.7	15.6	0.88
8L	13.5	15.4	0.88

Figure 4. Alkalinity and Nitrate levels were measured using the Hanna water quality test kit. Other parameters measured included: oxygen, pH, temperature and Oxidation Reduction Potential (ORP).

Figure 3. The test system contained consisted of six 5-gallon buckets, two volumetric pumps, and a feeder tank. Volumetric pumps were set to the same flow rate.

RESULTS: Nitrate reduction occurred at similar and sufficient rates when 6L of media were fed 6.5 g and 10 g per day. When no carbon was added little or no denitrification occurred. Different quantities of media hosting bacteria fed the same amount of carbon showed similar levels of nitrate reduction and oxidation potential.



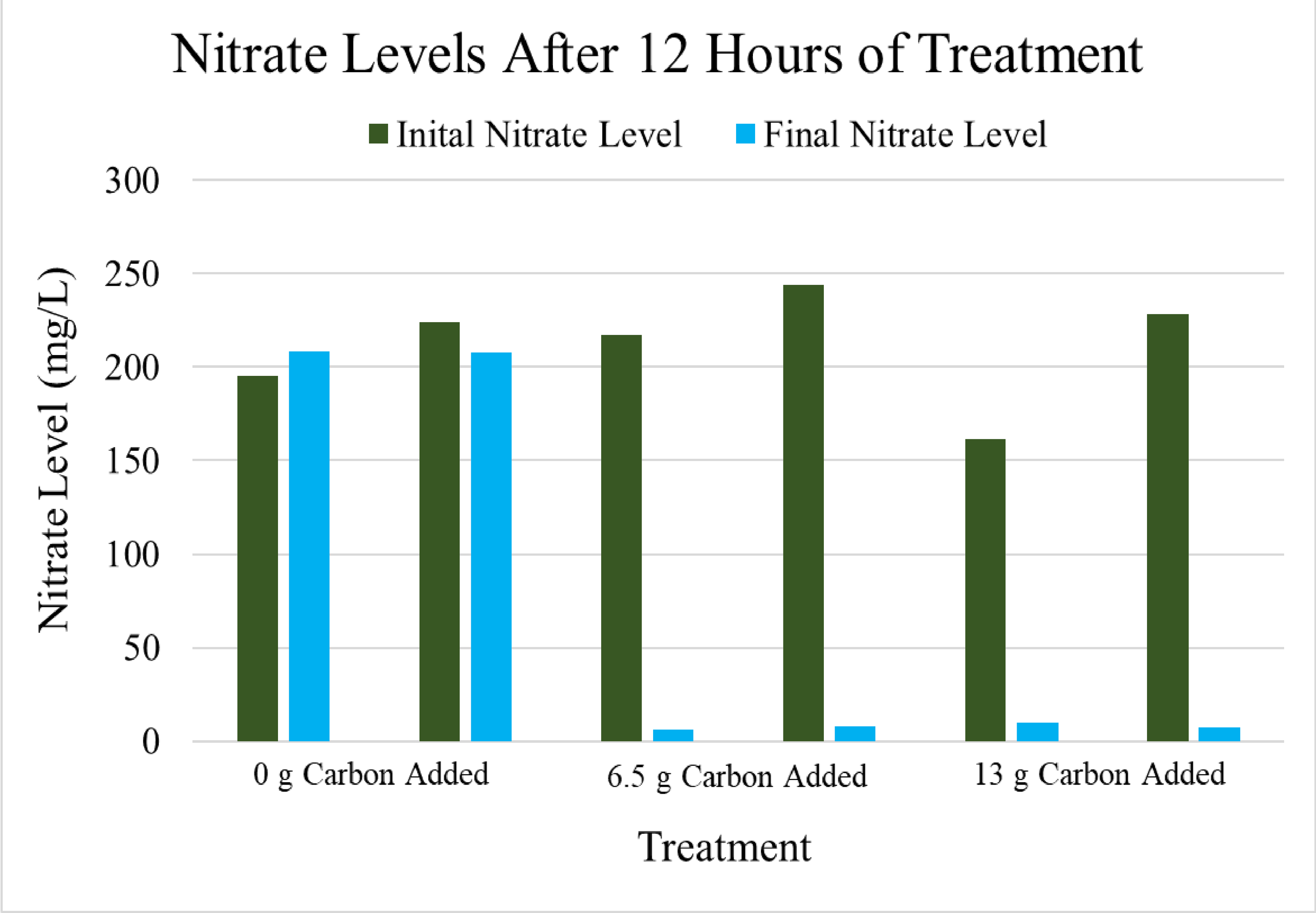


Figure 6. Comparison of relative remaining nitrate levels revealed that 80-95% reduction was achieved when fed 6.5 or 10 g C/day. While a feed rate of 3g C/day did not have a significant reduction.

Figure 5. Preliminary range-finding trials indicated that when no carbon source was provided, little to no denitrification occurred. Similar nitrate reduction occurred when 6.5 g and 13 g of carbon source were added.

Table 2. Four, six and eight Liters of media were compared in nitrogen trials, with all showing similar levels of denitrification and ORP values.

Hours	Nitrate Level (mg/L)			Oxidation-Reduction Potential	
	4 L	6L	8 L	4L	8L
0	180	240	180	231	231
12	230	225	223	47	-52
24	7	56	9	-120	-123
36	20	25	37	-122	-205
48	29	46	10	-112	-107

CONCLUSIONS AND FURTHER RESEARCH: Trials indicated that sufficient denitrification occurred when 6.5g of a vegetable glycerin carbon source were added at a water flow rate of 15 L/day containing 200 mg/L NO_3. The HRT of this experiment was close to 24 hours. Future trials will include changing the HRT to optimize denitrification potential and evaluating continuous carbon addition.

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