CtrlAQUA

How quickly should we increase water salinity in RAS?

During smolt production in RAS, the water salinity is often increased from freshwater to brackish- or seawater. This can negatively impact the biofilter nitrification efficiency, leading to high ammonia or nitrite concentration – highly toxic to fish. To develop a strategy to increase the salinity safely, we studied the effect of rate of salinity increase on nitrification. The findings suggest that large salinity increments may be a better strategy than small salinity increments in RAS, provided the initial decrease in nitrification is acceptable.

Experimental design

We investigated the influence of the rate of salinity increase on nitrifying moving bed biofilm reactors (MBBR). Five treatments (C, S1, S2, S6, and S15) were run with different salinity change rates: 0 (control, always in freshwater), 1, 2, 6, and 15‰ day^{-1}, respectively. The study was performed on lab-scale MBBRs continuously operated at 12°C, pH 7.9 on synthetic medium. The MBBRs were filled with biofilm carriers from a freshwater RAS. The salinity in the reactors was slowly increased by increasing the salinity in the makeup water (by blending freshwater and seawater).

Nitrification performance at different salinities

At salinities higher than 12‰, the nitrification performance decreased with salinity in all treatments. The ammonia oxidation capacity decreased linearly with salinity, with 50-90% reduction in seawater (Fig. 1A). Surprisingly, the smallest salinity increment (S1) had the greatest decrease (90%). This implies that we should only increase the salinity daily if the feeding rate is low, otherwise the ammonia/nitrite concentration may increase. Further, the nitrification performance decreased similarly in all treatments, suggesting that it was independent of the rate of salinity increase.
After seawater transfer, the nitrification performance

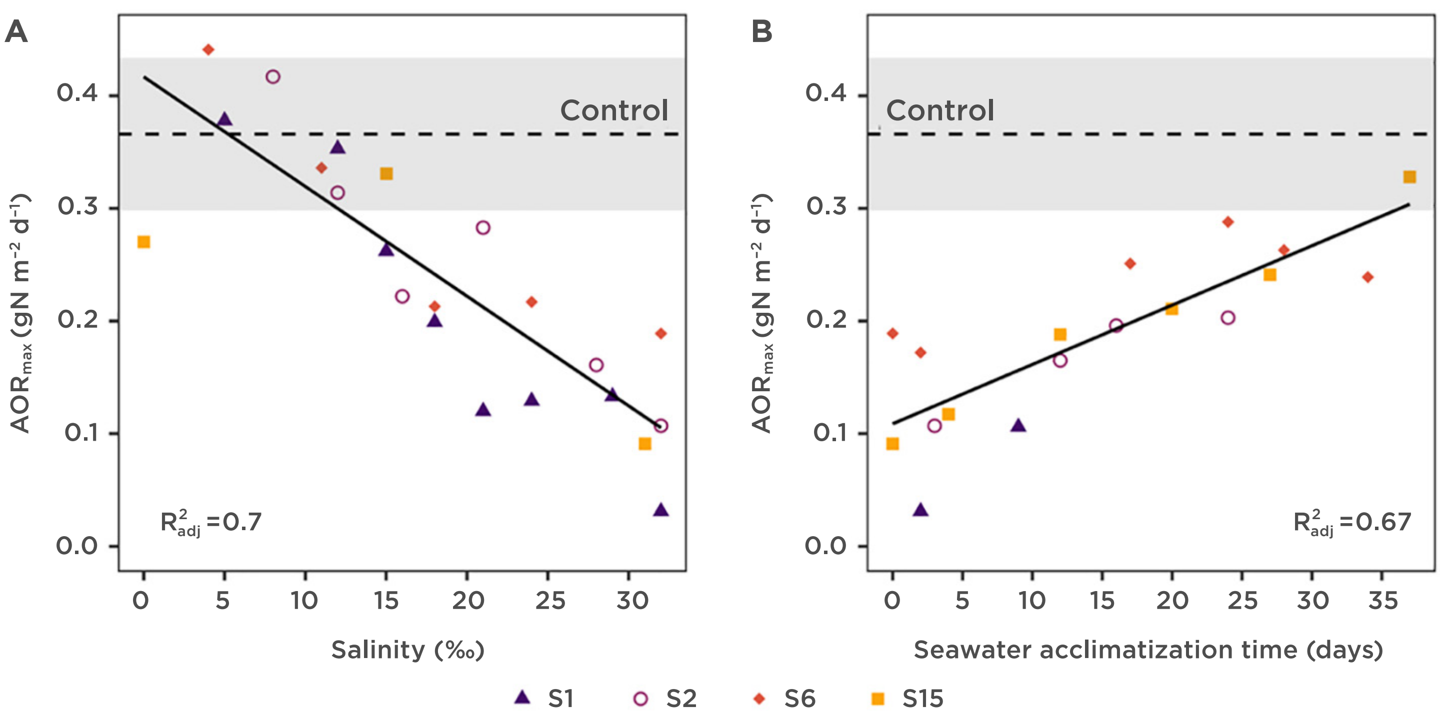

Figure 1: *The nitrification performance decreased linearly with salinity and increased linearly with acclimatization time in seawater, and was not significantly influenced by the rate of salinity increase. Graph: Linear regression analyses on ammonia oxidation capacity (AOR_{max}) from all treatments showing the correlation between A) AOR_{max} and salinity and B) AOR_{max} and seawater acclimatization time.*

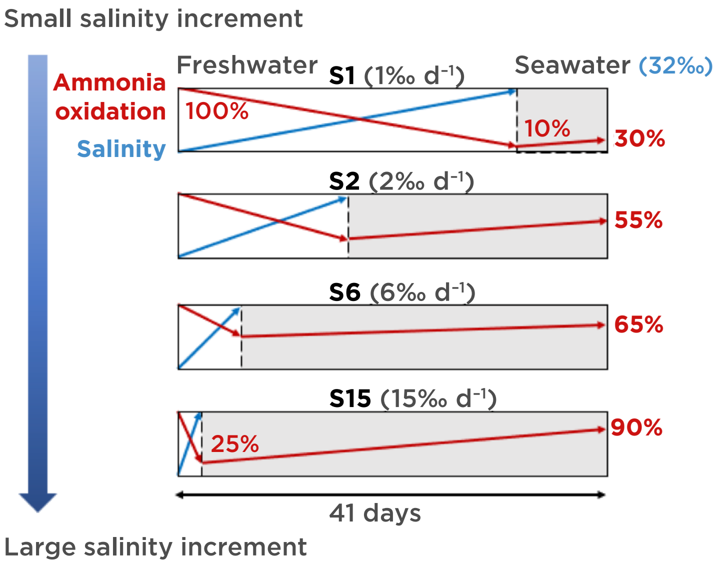

Figure 2: *Nitrification performance (as ammonia oxidation capacity, AOR_{max}) in biofilters switched from freshwater to seawater at different rates of salinity increase. After 41 days, S15 had the highest AOR_{max}, 90% of the freshwater control. By contrast, S1 had the lowest AOR_{max} (30% of control). This suggests that large salinity increments may be a good strategy for increasing salinity when the feeding rate is low.*

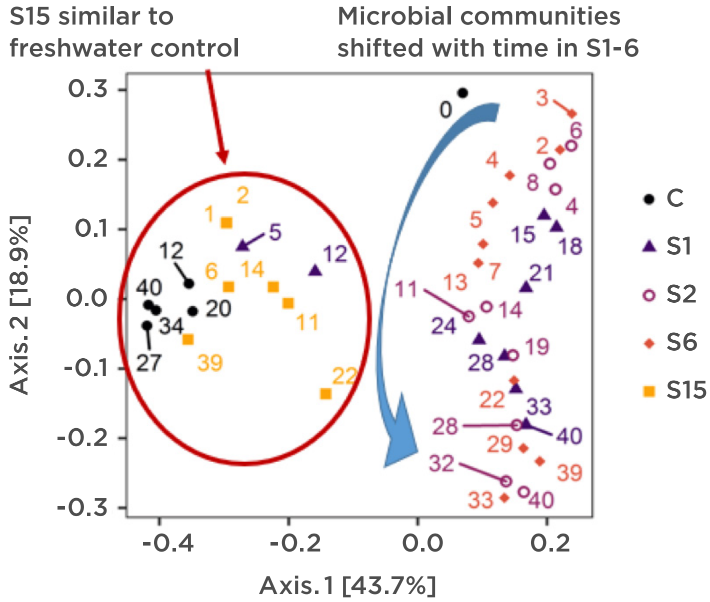

Figure 3: *The microbial community composition in the biofilm in treatment S15 was similar to the freshwater control, while it shifted with time in the other treatments. Graph: Ordination by principal coordinates analysis (PCoA) based on Bray-Curtis similarities in the biofilm. Labels indicate sampling day.*

improved with time. Moreover, the rate of recovery was similar for all treatments (Fig. 1B). At the end of 41 days, the 15‰ day^{-1} treatment (S15) had recovered to 90%, whereas the S1 had only recovered to 30% (Fig. 2). This suggests that large salinity increments are more practical than small increments in RAS.

Biofilm microbial community

In contrast to the nitrification performance, the microbial community composition in the biofilm did depend on the rate of salinity increase (Fig. 3). The microbial composition of the freshwater control and S15 were similar, suggesting that microbes in RAS biofilms can physiologically adapt to large salinity increments. In contrast, the microbial composition in the other treatments shifted with time. In biofilms with constantly changing salinity, microbes that are more capable of handling salinity variations may become dominant. Knowledge about the salt-tolerance of microorganisms is important for designing saline RAS biofilters, so that we can optimize and select the "right" bacteria.

Conclusion

Although the rate of salinity increase influences the biofilm microbial community, it does not significantly influence the nitrification performance when switching from freshwater to seawater. Therefore, when the feeding is low or there are no fish in RAS, large salinity increments can be a better strategy than small salinity increments.

About the research

- CtrlAQUA project EXPO/TREAT
- Partners: Nofima, Krüger Kaldnes and NTNU
- Lab scale moving bed biofilm reactors (MBBRs)
- Water salinity: freshwater (0‰) to seawater (32‰)
- Published article:
  Navada, S., Vadstein, O., Tveten, A.-K., Verstege, G.C., Terjesen, B.F., Mota, V.C., Venkataraman, V., Gaumet, F., Mikkelsen, Ø., Kamstra, A., 2019. Influence of rate of salinity increase on nitrifying biofilms. J. Clean. Prod. 238.

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