Management of bioreactors in RAS for Atlantic salmon

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27th October 2022

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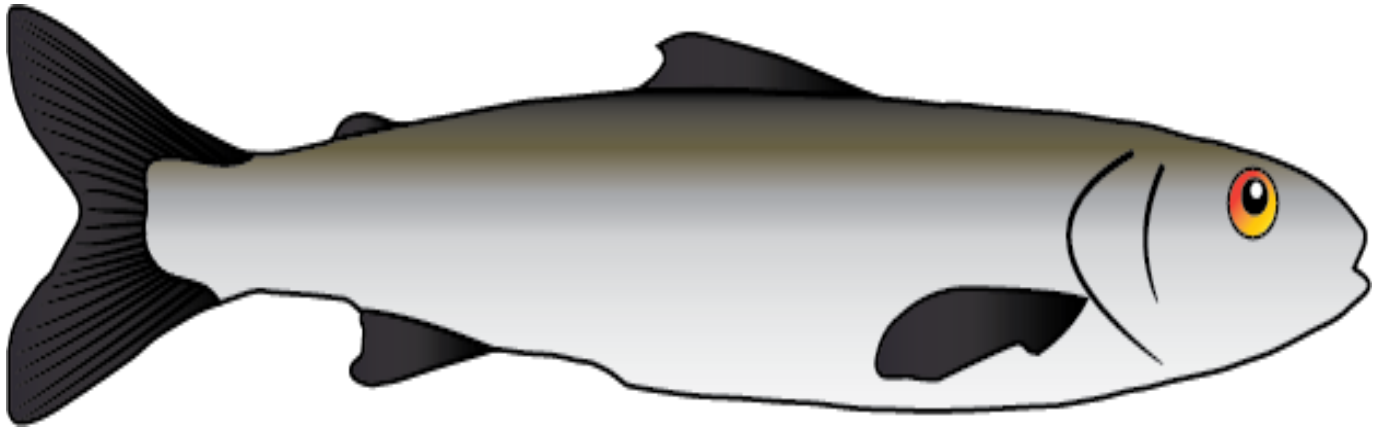
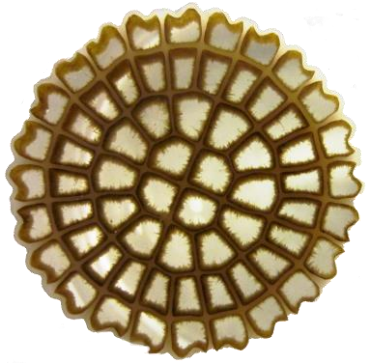
Who lives in the RAS?



Who else lives in the RAS?

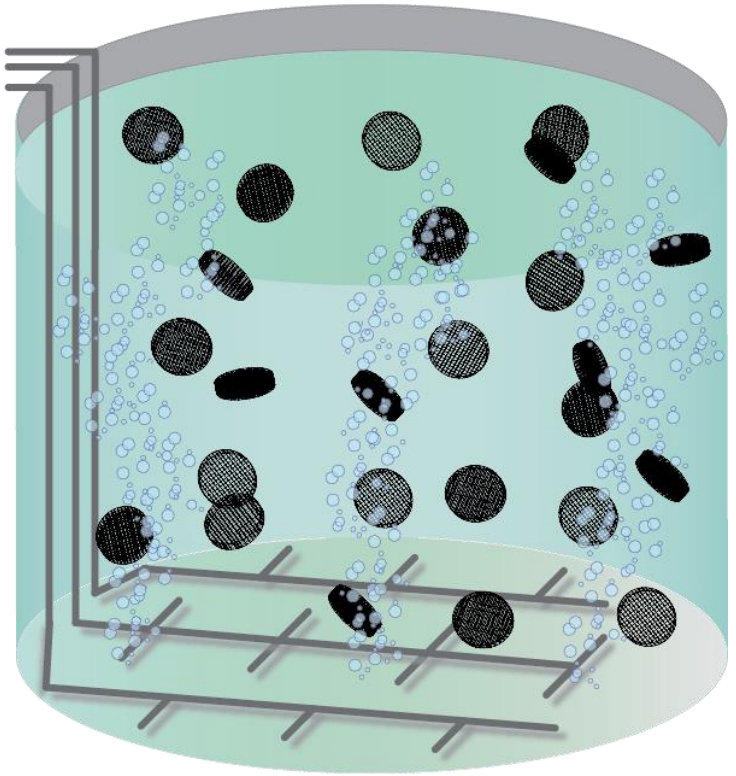
A microbial community -Not just nitrifiers!



Biofilm carrier

Nitrification

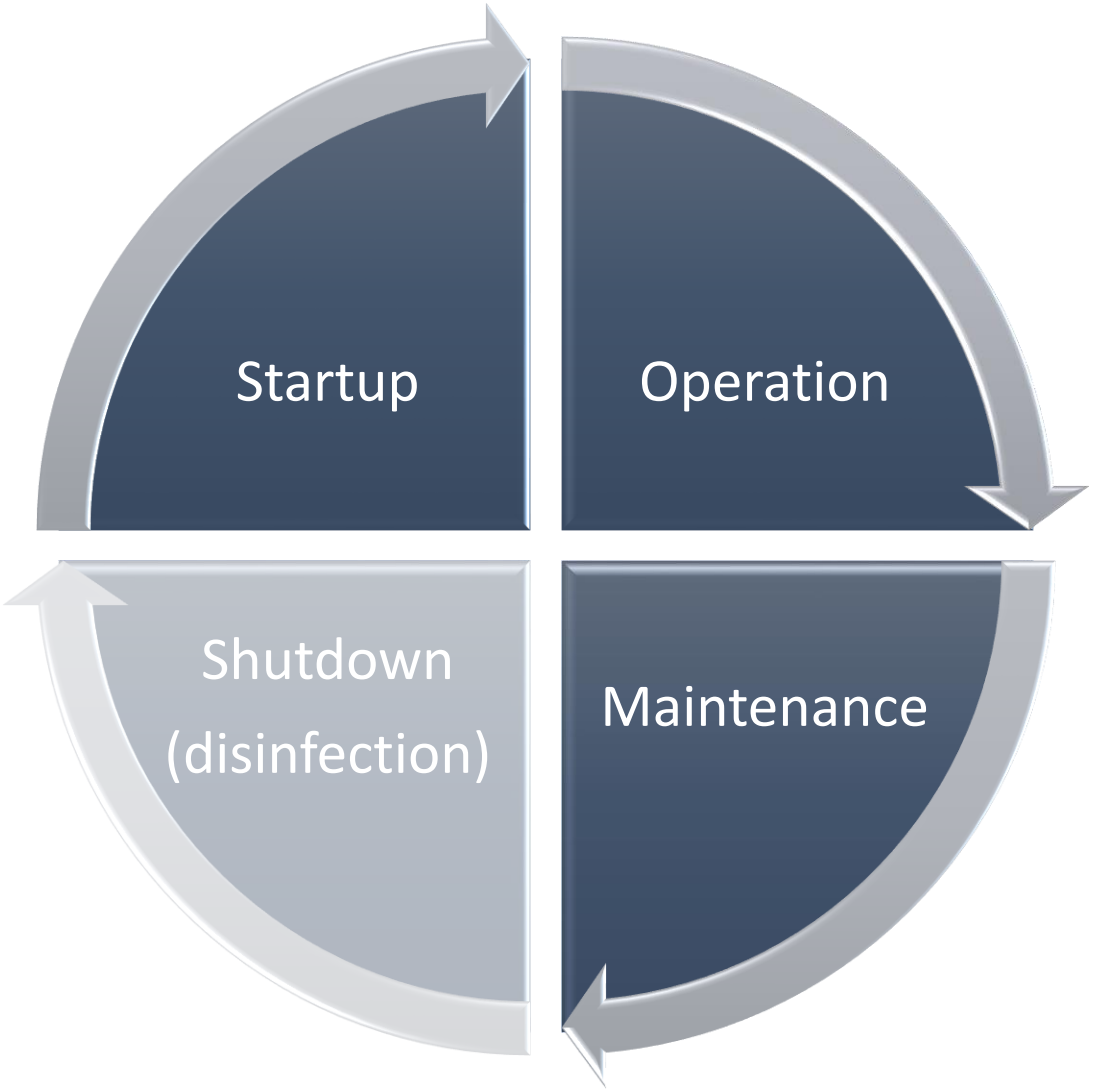
$NH_4^+ \rightarrow NO_2^- \rightarrow NO_3^-$



Bioreactor

A living organism

Life cycle of a RAS bioreactor



Several years…

Startup

Selecting the desired microbial community before the fish arrive

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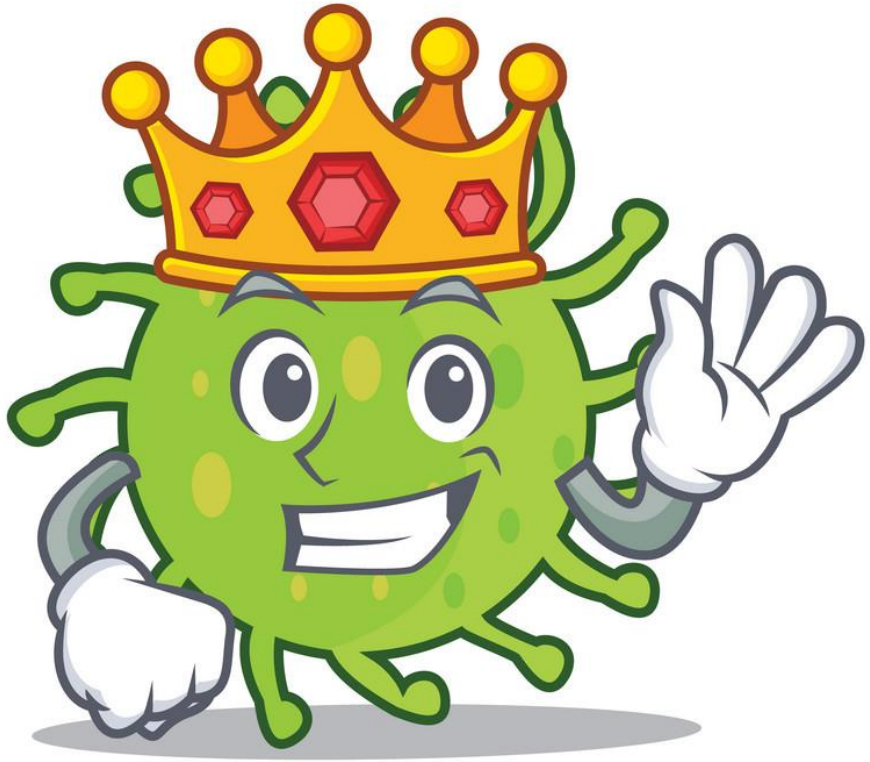
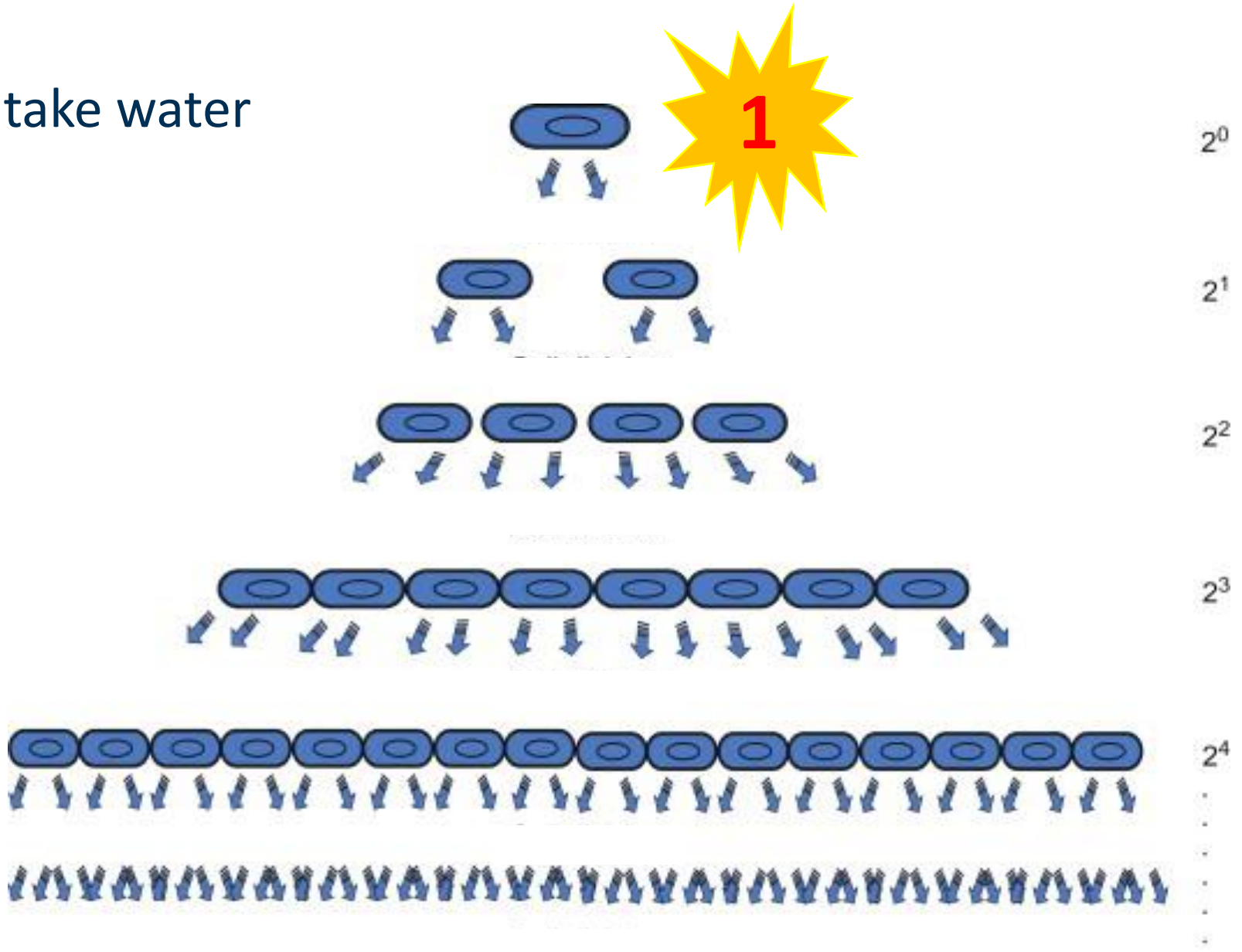
Startup - when microbes rule…

- **Startup**, not “maturation”
- Can manipulate
  - Temperature
  - pH
  - Alkalinity
  - Salinity
  - Other…

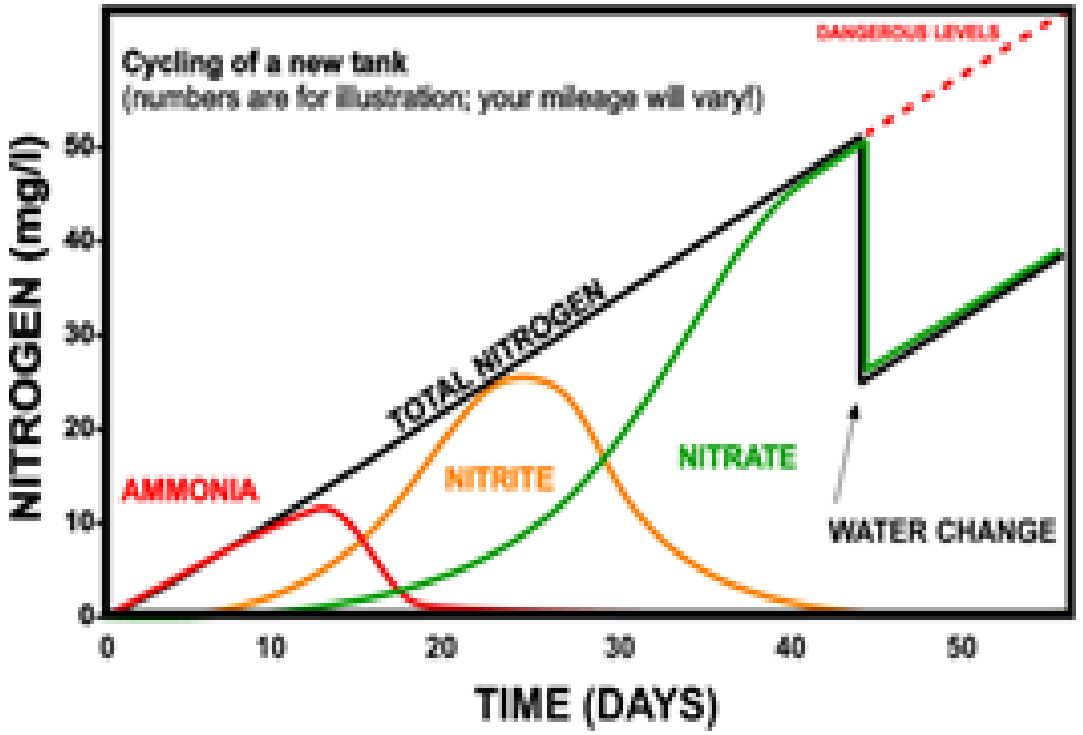


How much bacteria do you need to grow a bioreactor?

- “Disinfected” intake water
- Feed
- Inoculum

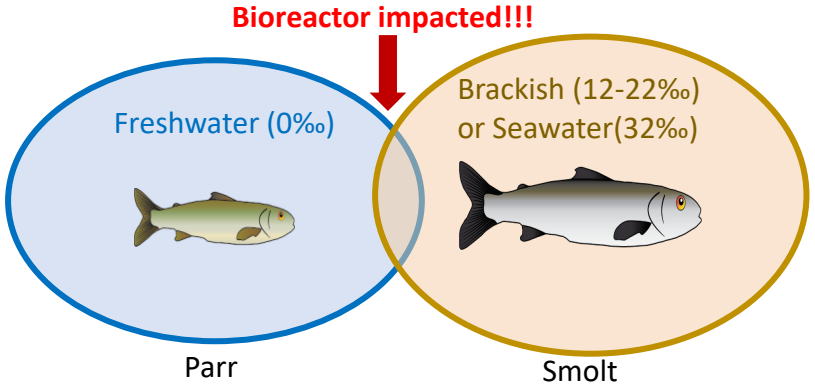


Is your bioreactor ready for fish?



- Complete nitrification ≠ Ready
- Does the bioreactor have sufficient nitrification capacity?
  - Initial feeding rate
- Increase the substrate (ammonium)

Saline bioreactors



Constant salinity

- Bioreactor can be started up directly at that salinity

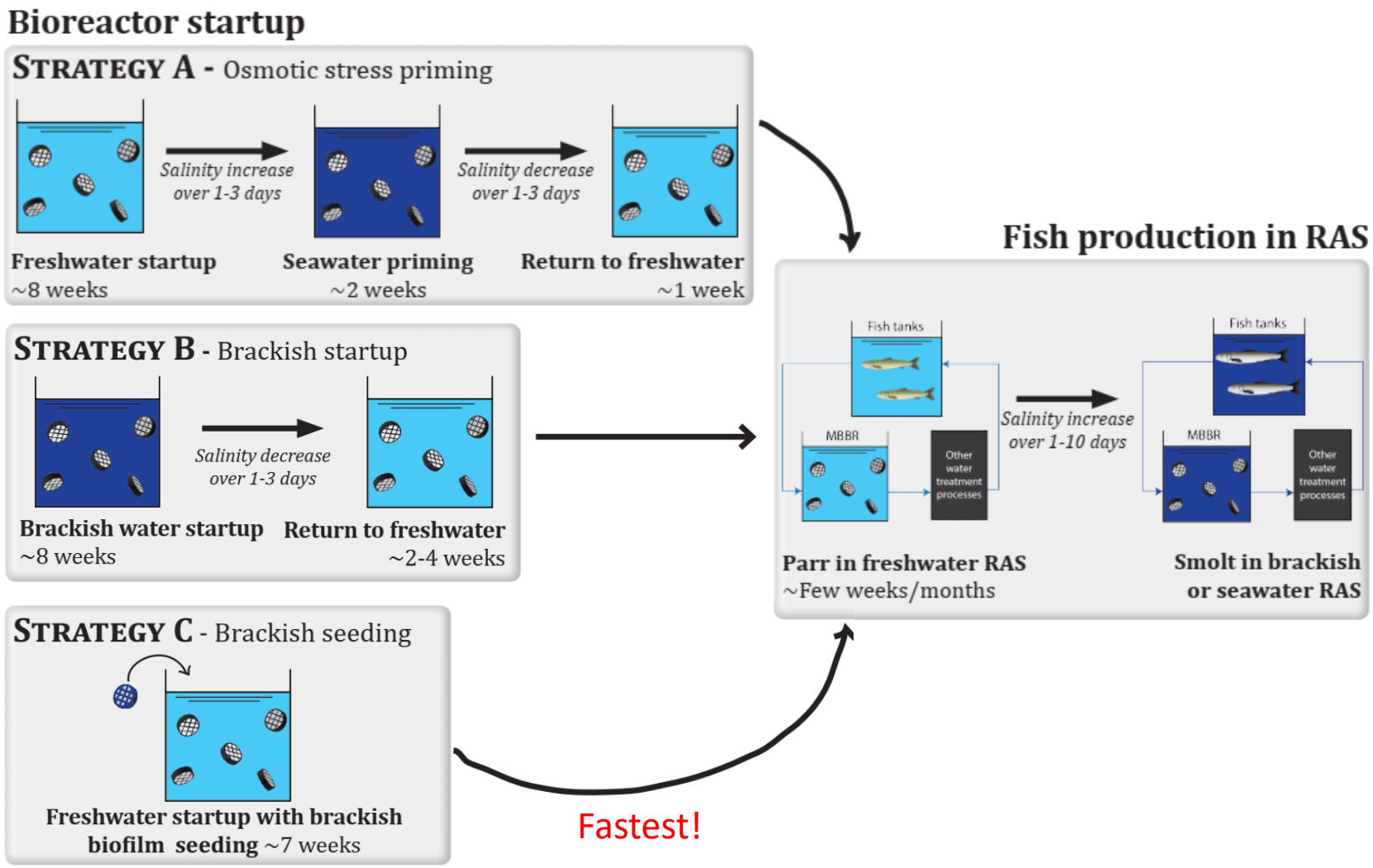
Conducting salinity change in RAS

- The first salinity increase in a freshwater bioreactor is the most challenging
  - NH_3 ↑, NO_2^- ↑ **Toxic to fish!!!**
- Bioreactors should be made salinity-tolerant during startup
- Large salinity increments with long acclimatization time most practical

After salinity change

- High nitrite levels typical in saline RAS (several days after salinity increase)
- What are realistic safe nitrite levels for brackish RAS? (chloride reduces nitrite toxicity)

Startup strategies for variable salinity RAS bioreactors



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Navada 2021 (PhD Thesis) Salinity acclimation strategies for nitrifying bioreactors in RAS (chapter 3.4 Industrial Application)

Operation

When fish is king

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Fish needs come first, but do not forget the microbes

- Bioreactor is **a living organism** – like fish!
  - It takes time to adapt to changes
  - During this adaption time, performance drops
  - After the adaptation, bioreactor can recover
- Overfeeding, increase in fish feeding rate
  - Nitrite oxidation cannot catchup
- Alkalinity
- Dilution is not always the solution

Maintenance (hibernation)

Caring for the microbes between fish batches

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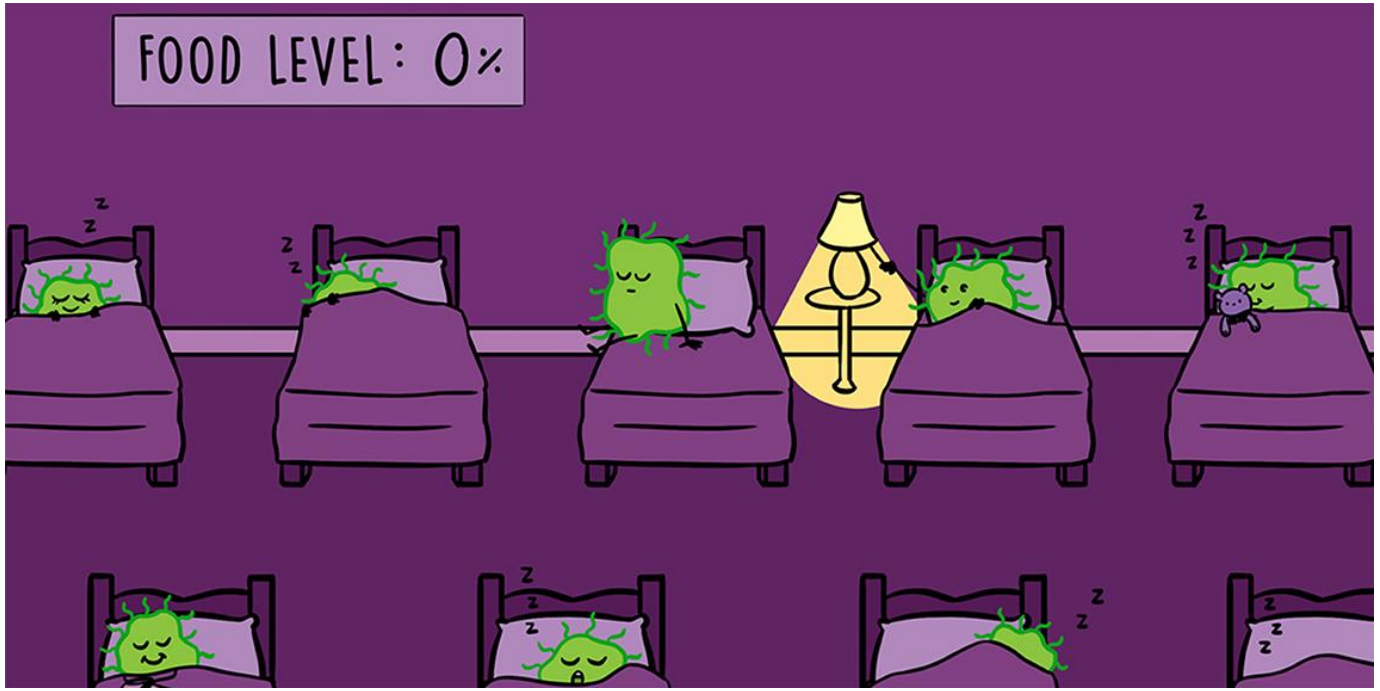
Maintenance between fish batches



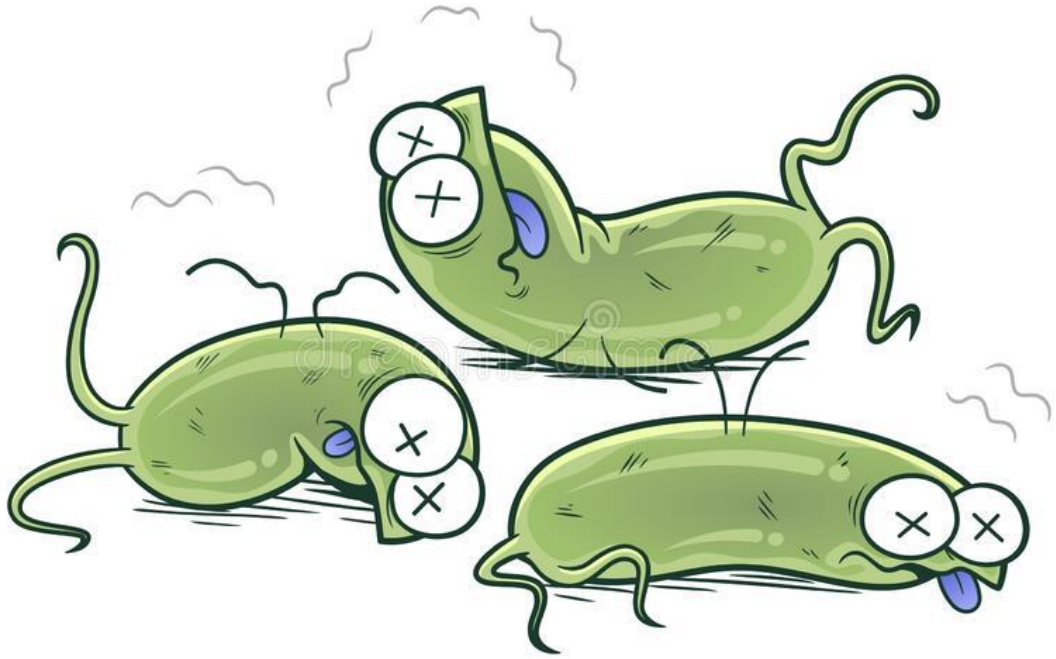
- RAS is empty but the microbes must be kept alive!
- Microbes need
  - O_2
  - **Substrate (carbon, ammonium**)
  - Inorganic carbon, alkalinity
  - Micronutrients
- Nutrient requirement depends on
  - Duration of hibernation
  - Feeding rate (capacity) before and after hibernation
- Nitrite oxidation challenging

Disinfection and restart

Implications on bioreactor performance

Disinfection and restart

- No validated protocol
- Differences in
  - Chemical - Peracetic acid, Cl_2, H_2O_2 etc.
  - Dose (conc and duration)
  - Flushing to remove toxic residuals
- Dismantling the system
- **Restart**
  - Biofilm carriers – disinfected or new?
  - Disinfection method
  - Too fast?

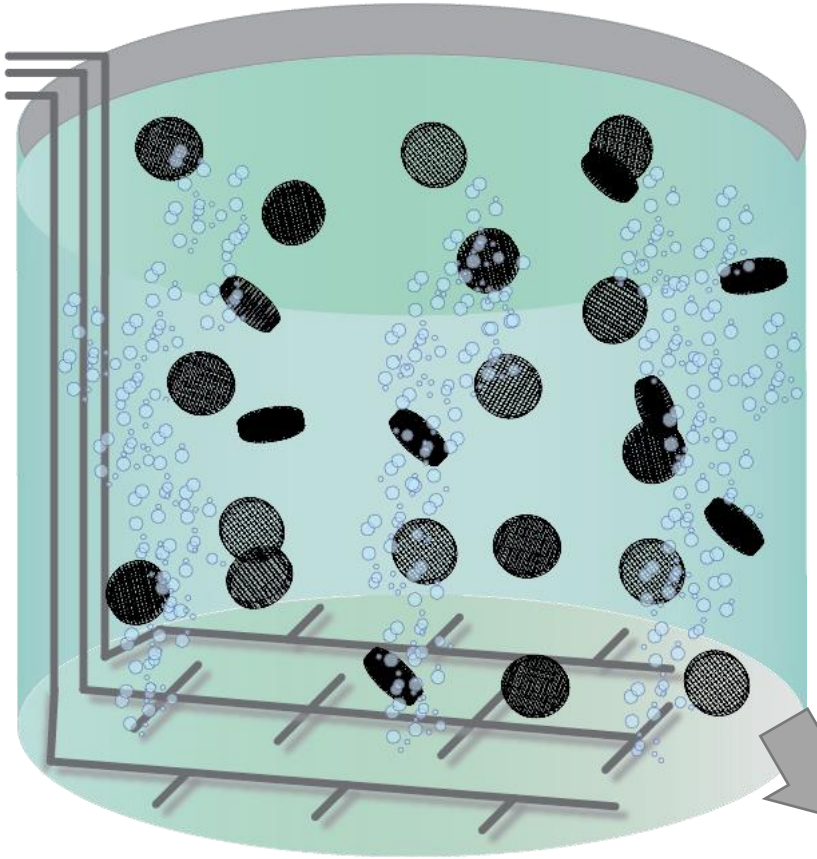


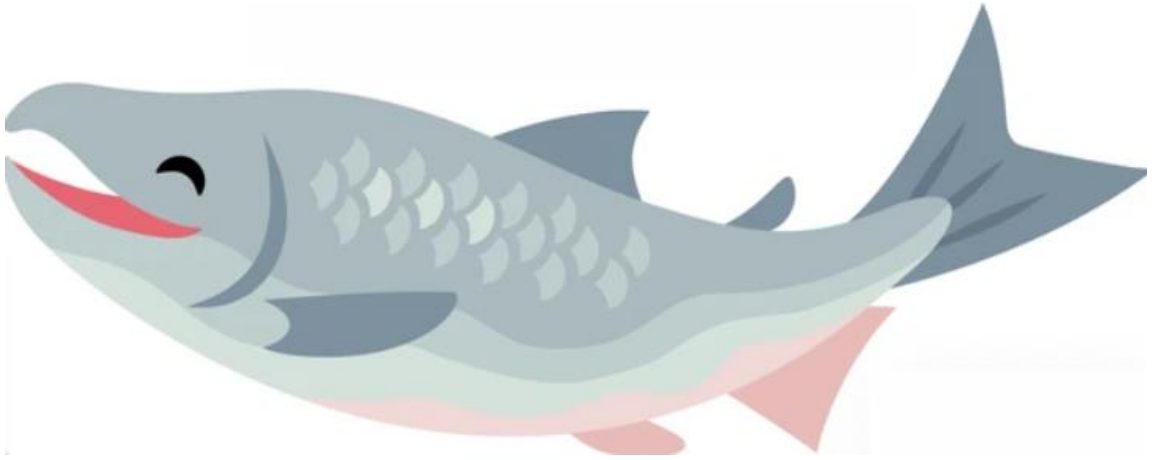
Lazado & Good (2021) Survey findings of disinfection strategies at selected Norwegian and North American land-based RAS facilities: A comparative insight. Aquaculture

Routine disinfection of bioreactors NOT recommended

- Bioreactor is like WINE – takes YEARS to **mature**
  - Nitrification capacity
  - Nitrite
  - Microbial community
- Stable microbial community can deter pathogens
- Routine disinfection destroys this stable community
  - opportunistic bacteria (potential pathogens)

Remember to care for the bioreactor too, not just the fish!





A living organism

Happy microbes → Happy fish