

Growing Great Tasting Fish for the Marketplace



Flavour profile



Critical to your business



Flavour change agents



Secondary metabolites of:

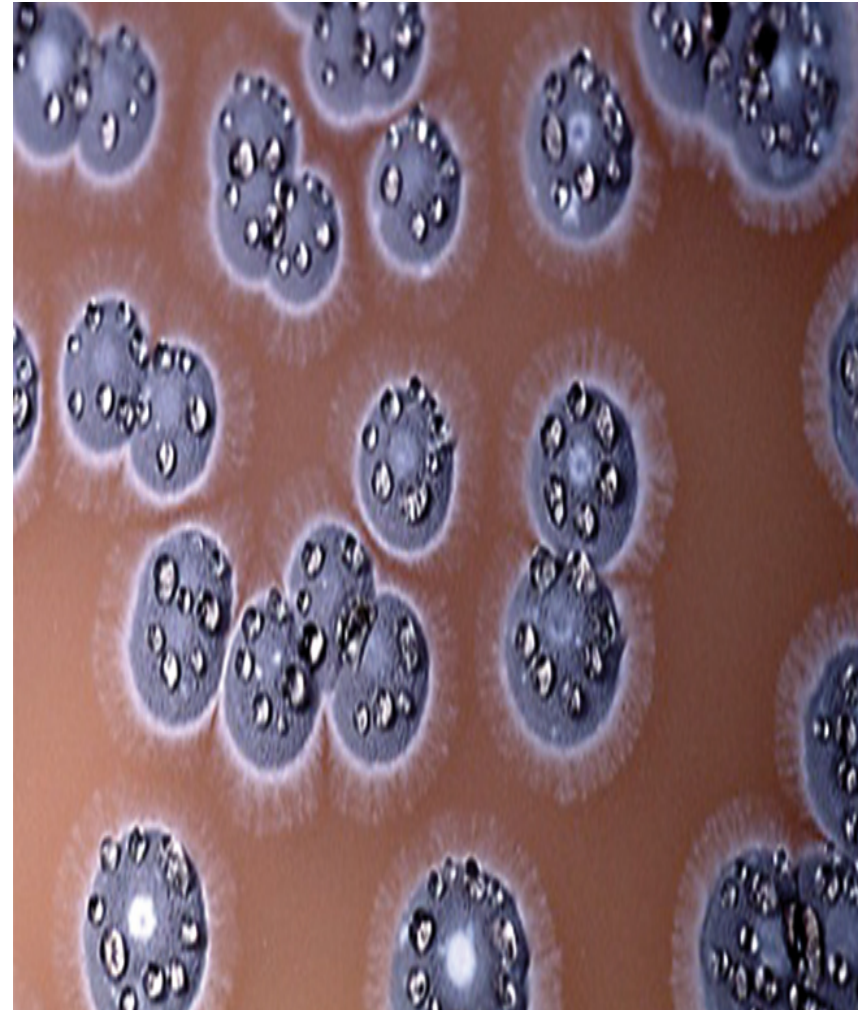
- cyanobacteria
- fungi
- actinomycetes
(streptomyces thought be predominant spp. in RAS)

MIB

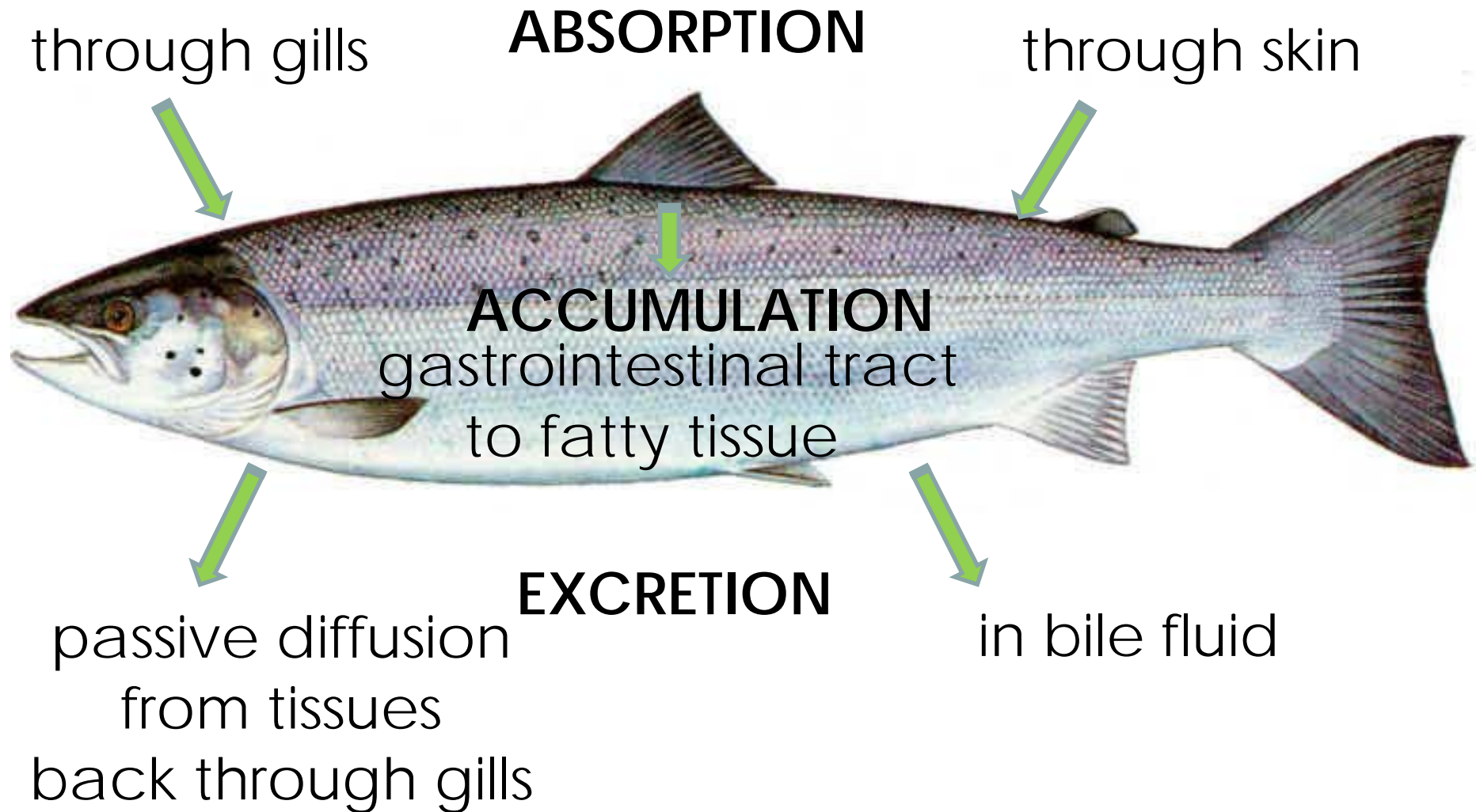
produced during life cycle

Geosmin

released when they die



Flavour change mechanism



Kuterra case study



- Commercial pilot scale facility - 470 T max capacity



Early-stage

First 12-18 months - purge in 6 days



Full-stocking



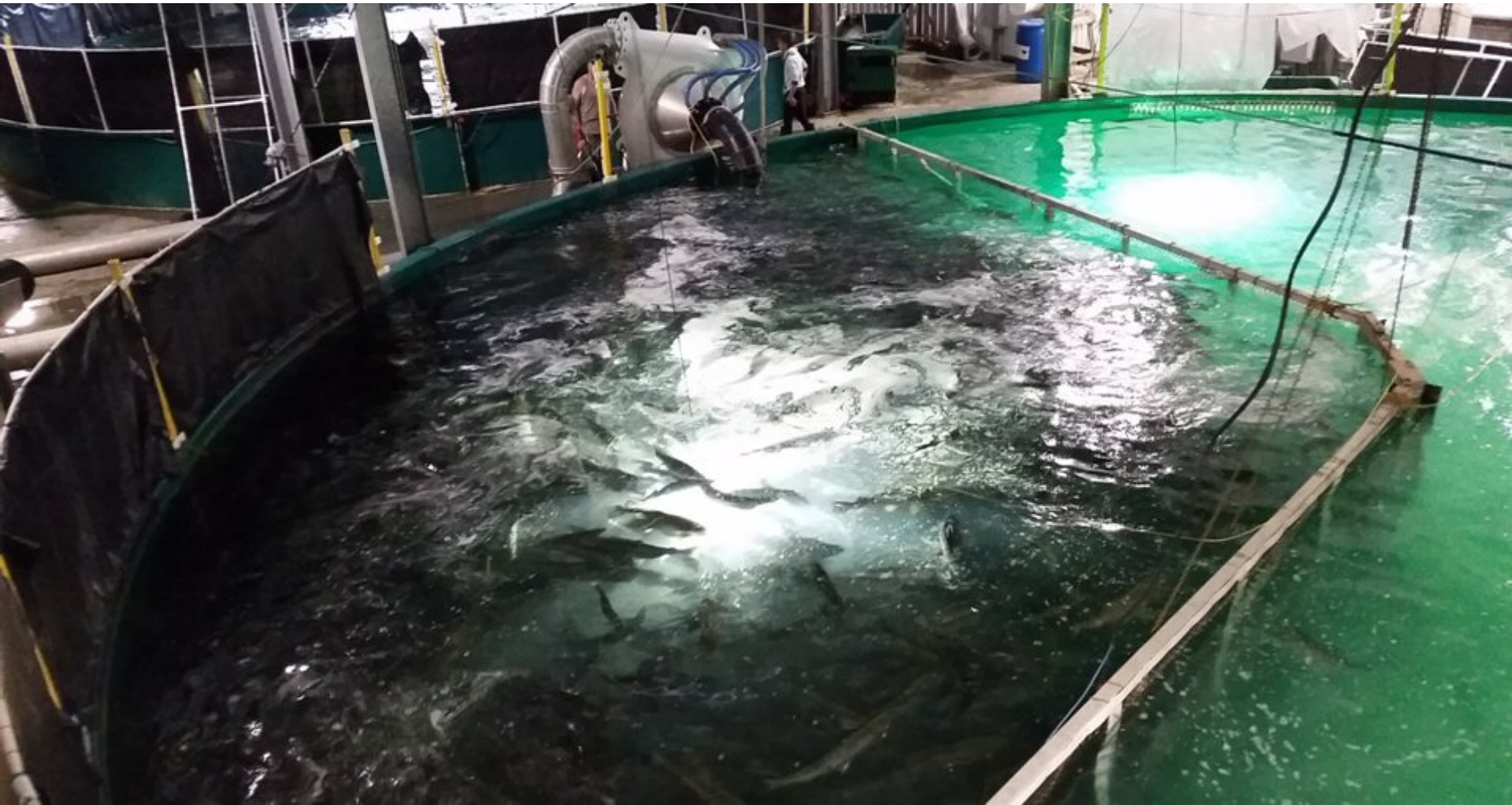
- Fully stocked (180T)
- Biologically mature system e.g. biofilm is a source



Rising Levels



- High geosmin in culture system which means:
- High purge-tank concentration



Current Practice



- Purge tank geosmin target < 5-6ng/l
- Purge period 12 – 13 days
- Other measures to ↓ creation and ↑ removal



Other measures



- Water supply - test wells for geosmin & MIB
- Higher exchange rate - better flushing



Fat content



Compounds accumulate in fatty tissue



Size



Bigger fish
= More biomass
= More fat
= Slower metabolism

All these factors give
higher loading and
increase flushing time.



Marketing



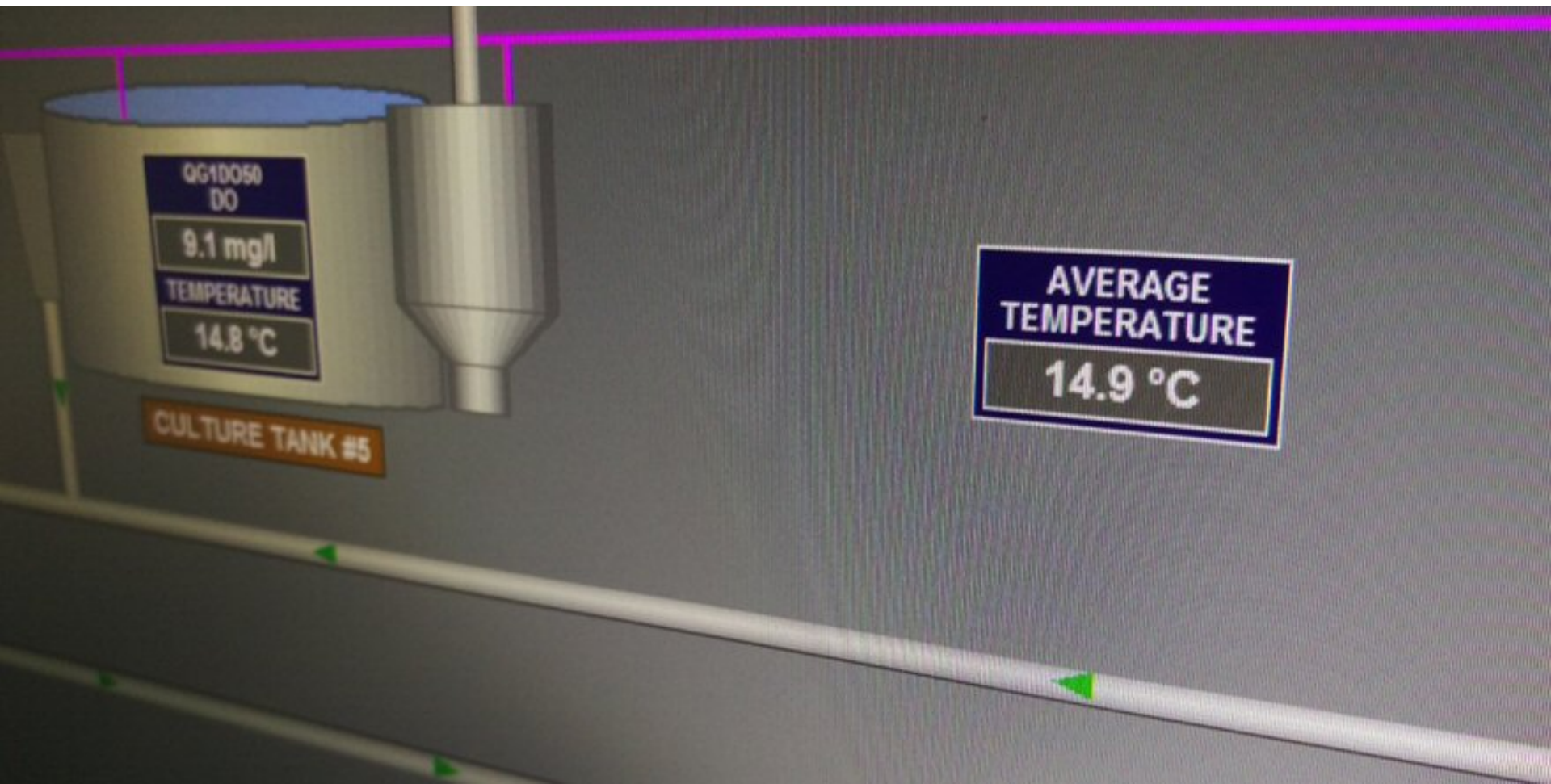
What is your end product?



Temperature increase



- Higher fish metabolism
- Bacterial proliferation



Exercise



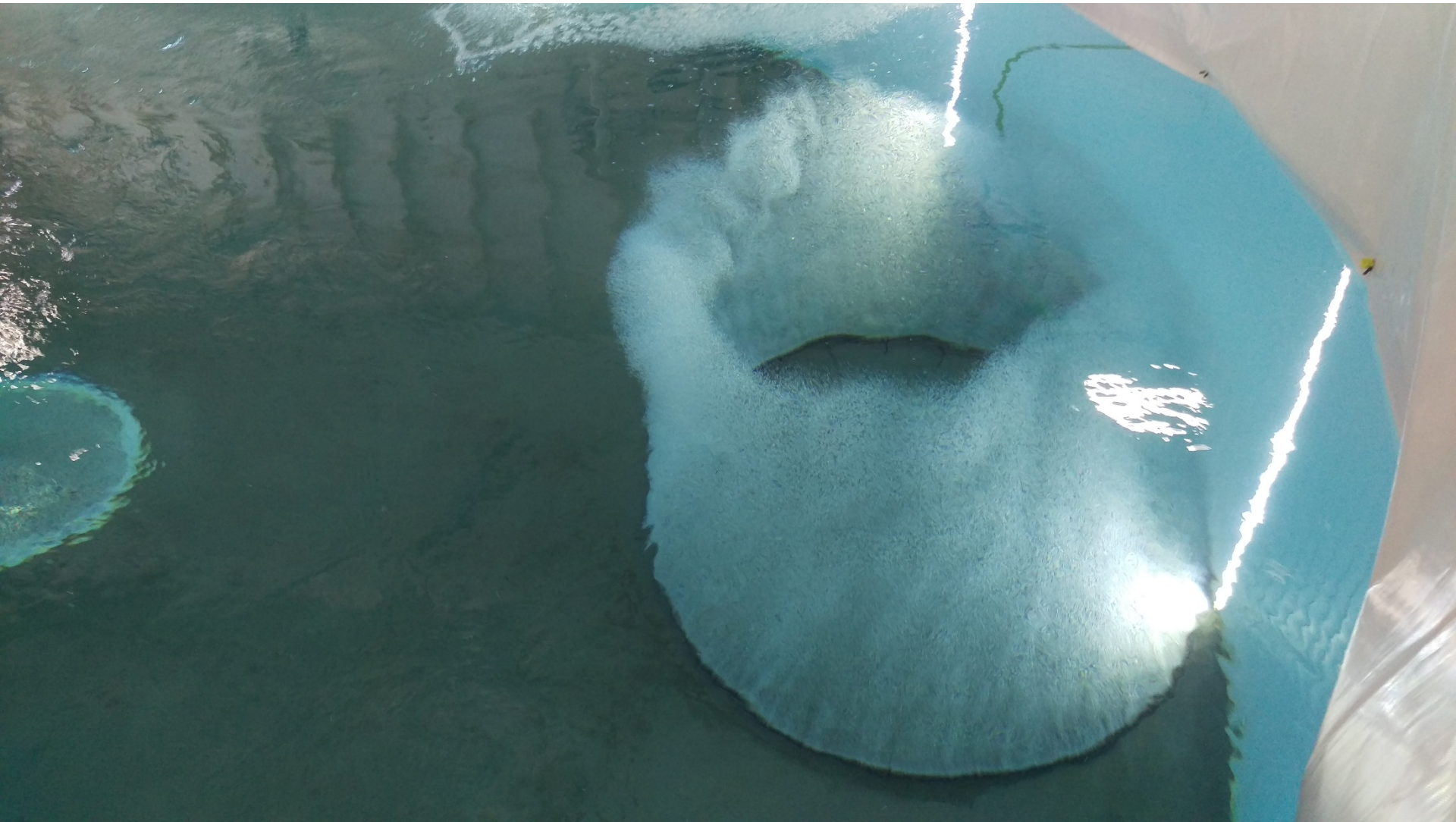
Increase purge tank rotational velocity



Oxygen



70% saturation to maximize gill ventilation and blood flow



Remove bio-film - Purge



- Scrub all accessible surface areas
- 250ppm peroxide for hard-to-reach areas



Cleaning – culture system



16" chimney sweep cleans up to 12" pipes



Big pipes & long spans



21-inch recirc return lines up to 200 feet long



Big pipes & long spans



Jet ball focuses flow - creates high-velocity scouring



The limit



There's only so much we can do!



Phosphorus



- Sarker *et al*, 2014 showed that geosmin levels was approx. 50% lower in fish fed a low P diet vs a high P diet.



Zinc



- Low Zn + high P may stimulate geosmin production in bacteria (Weinberg 1989)
- Increase Zn in diet



Denitrification



Often used to conserve water use e.g.

- Systems without - typically use >500l/kg of feed
- Systems with – typically use <300l/kg of feed

Denitrification can ...

- Remove roughly 70% of P of feed origin
(Shnel *et al* 2002)
- Reduce geosmin and MIB directly
(Guttman *et al* 2008)

But reduced exchange may cause
flavour-change compounds to accumulate

Biofilters



Known to concentrate geosmin producing organisms
(Guttman & van Rijn 2008)



Biofilters



Fluidized sand biofilter cells: 4 x 75m³, >100 T sand



Biofilters



Sand replacement → ammonia ↑ geosmin ↓

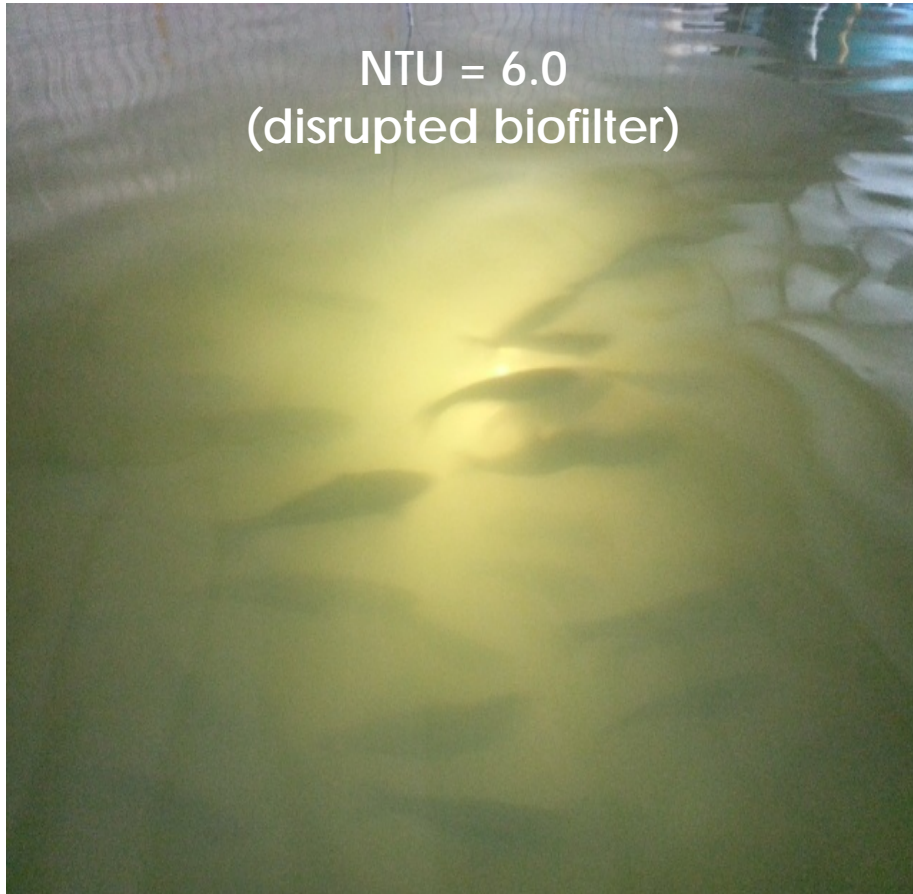


Turbidity and Ozone

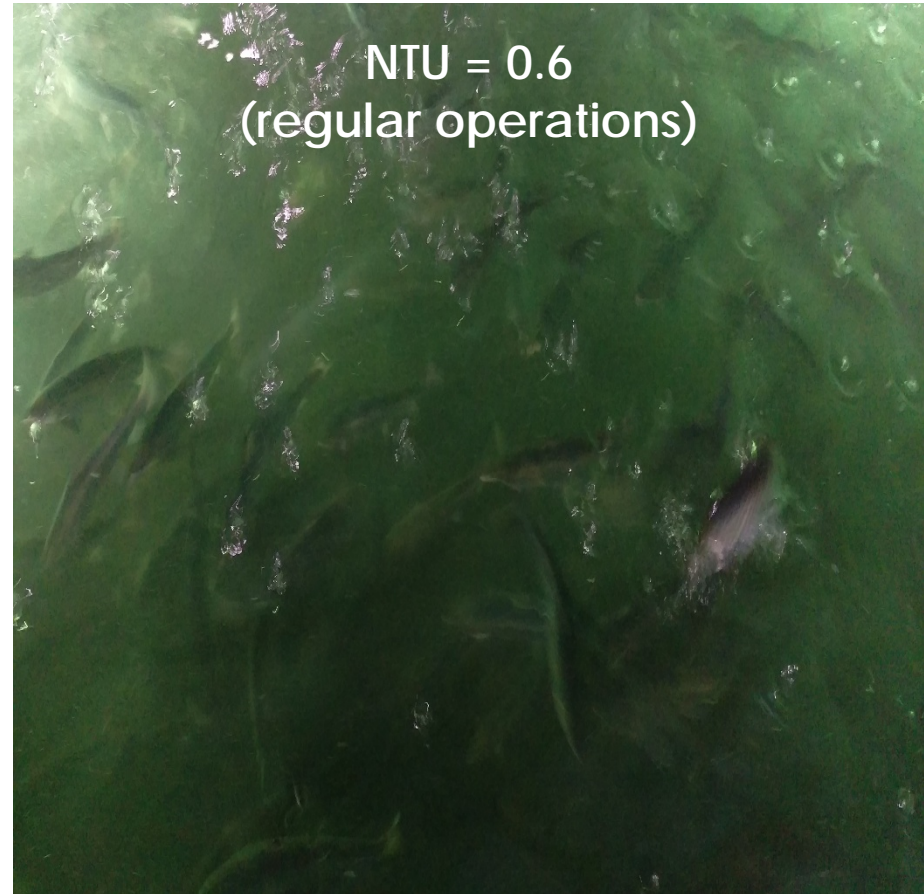


- Turbidity = more organics + nutrients
- Promote streptomyces growth (Auffret *et al* 2013)
- Ozone improves water quality

NTU = 6.0
(disrupted biofilter)



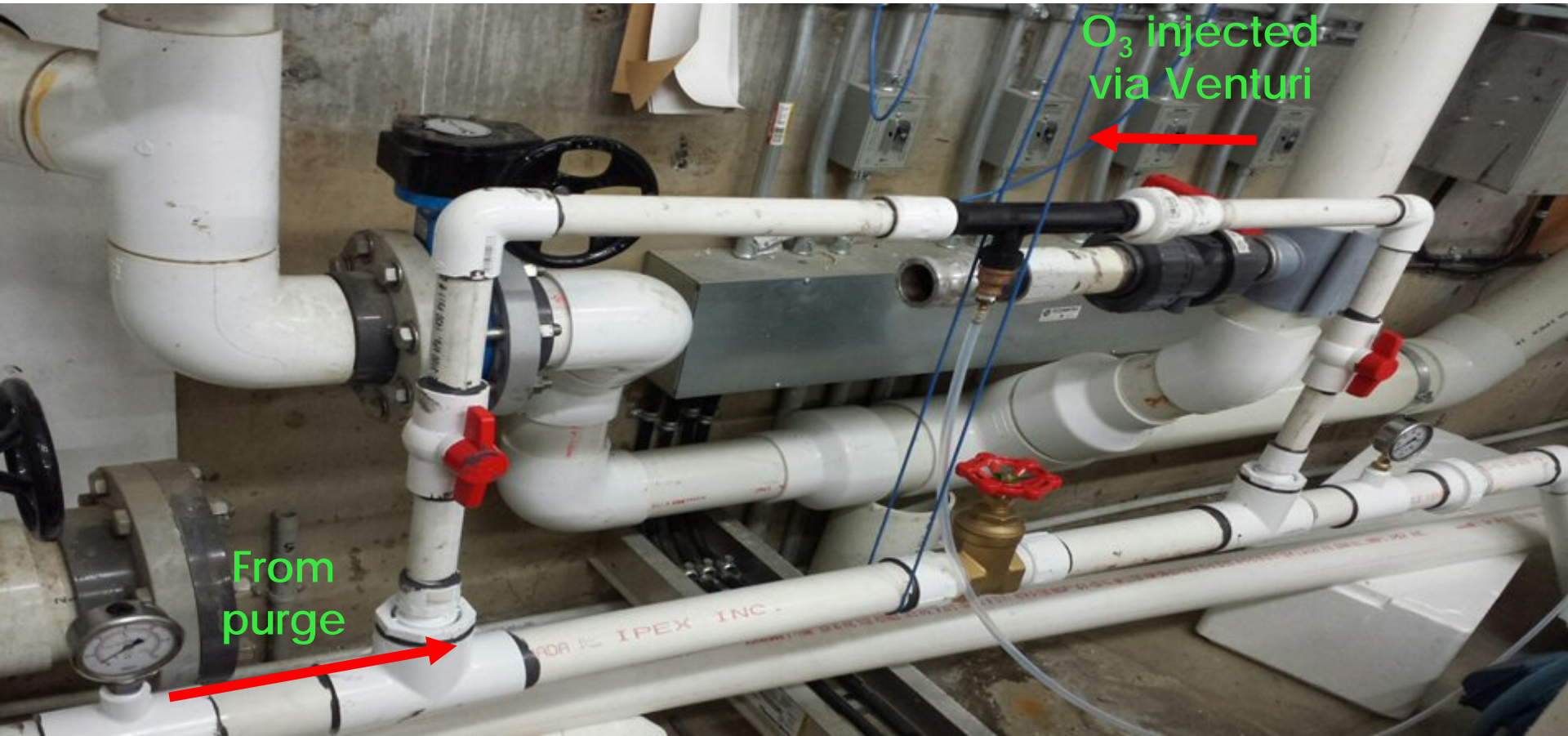
NTU = 0.6
(regular operations)



Ozone/UV



- Ozone with 2-3 min contact: 1.5 - 3 mg/L
- Then UV 600 mJ/cm²
- Geosmin ↓ 90% + (Collivignarelli & Sorlini 2004)
- Compared to 60% ozone alone



Ozone/UV trials



- Only 15% geosmin reduction
- ORP, O_3 , total Br readings indicate residuals in outflow

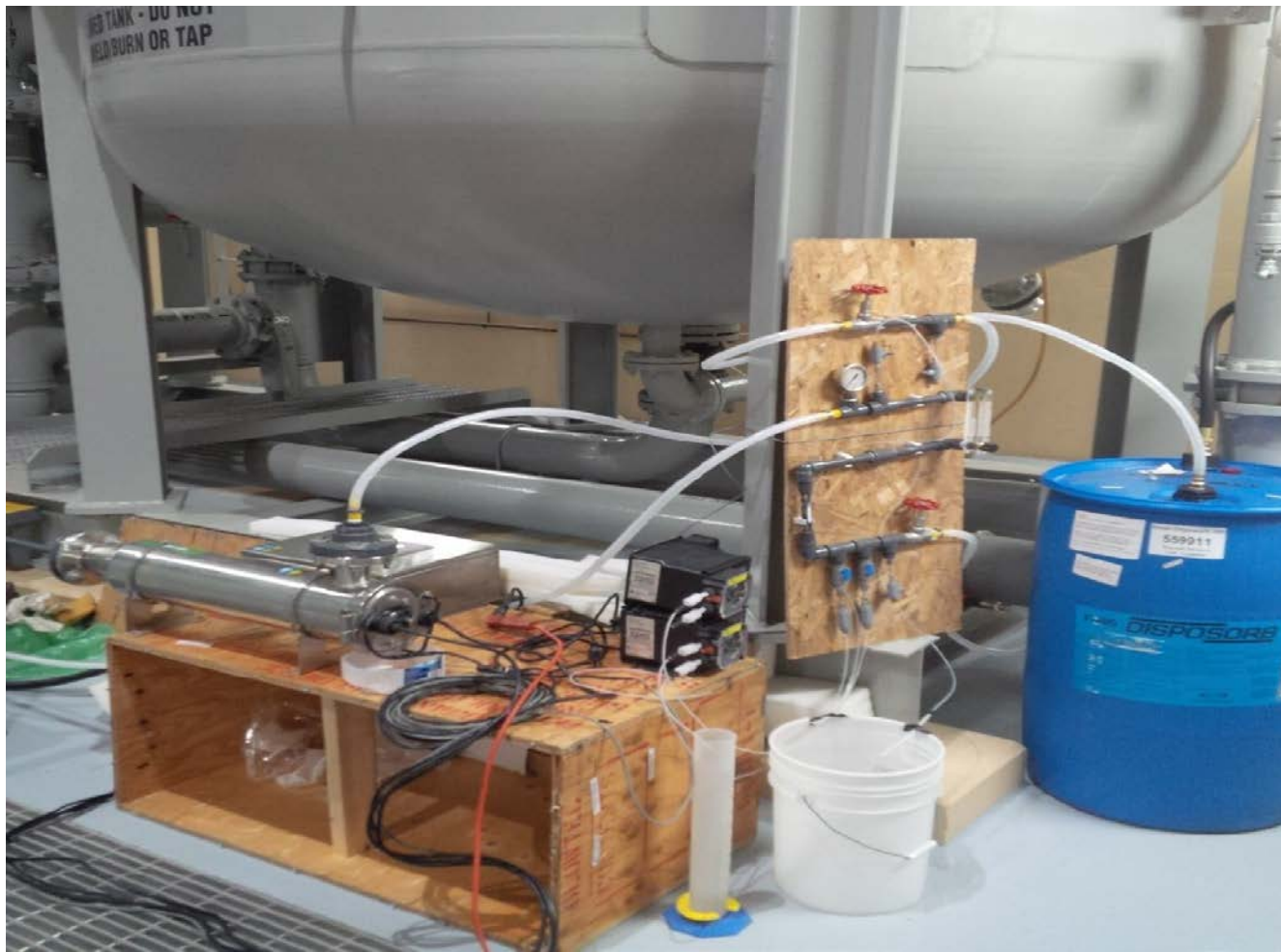


UV/Hydrogen peroxide



Purge: 1.1 log reduction from 60ng/l in 4h = US\$135k

Main: 0.3 log reduction from 180ng/l in 24h = US\$175k



Granulated Activated Carbon



Advantages

- Low capital cost
- Simple to operate
- Effective

Disadvantages

- Carbon loses efficiency
- Expensive to replenish
- Backwashing

Regeneration possible but needs precise conditions to be economical (proximity, volume, etc.)



Bacteria



Advantages

- Low-tech, low infrastructure, low maintenance
- Non-chemical, non-toxic

Our mix

- Non-pathogenic probiotic strains known to help biodegrade organic waste
- *Bacillus subtilis* which initiates biodegradation of geosmin

Geosmin biodegradation may require a number of bacteria working together (Hoefel *et al* 2006)

Geosmin absorbed onto probiotic strains then *Bacillus subtilis* secretes an enzyme to biodegrade the molecules

Ultrasound



Findings to date

- 10 min @ 640 kHz → geosmin/MIB ↓ to < 50% in demineralized water (Song and O'Shea 2007)
- 15 mins @ 850kHz → similar ↓ in RAS fresh water and RAS seawater (Nam-Koong *et al* 2016)

Advantage

Relatively unaffected by water quality or conc. of geosmin/MIB

But need to reduce power use, capital cost

New purge design



Two tanks permit weekly harvest



New purge design



Only essential components



New purge design



No LHO



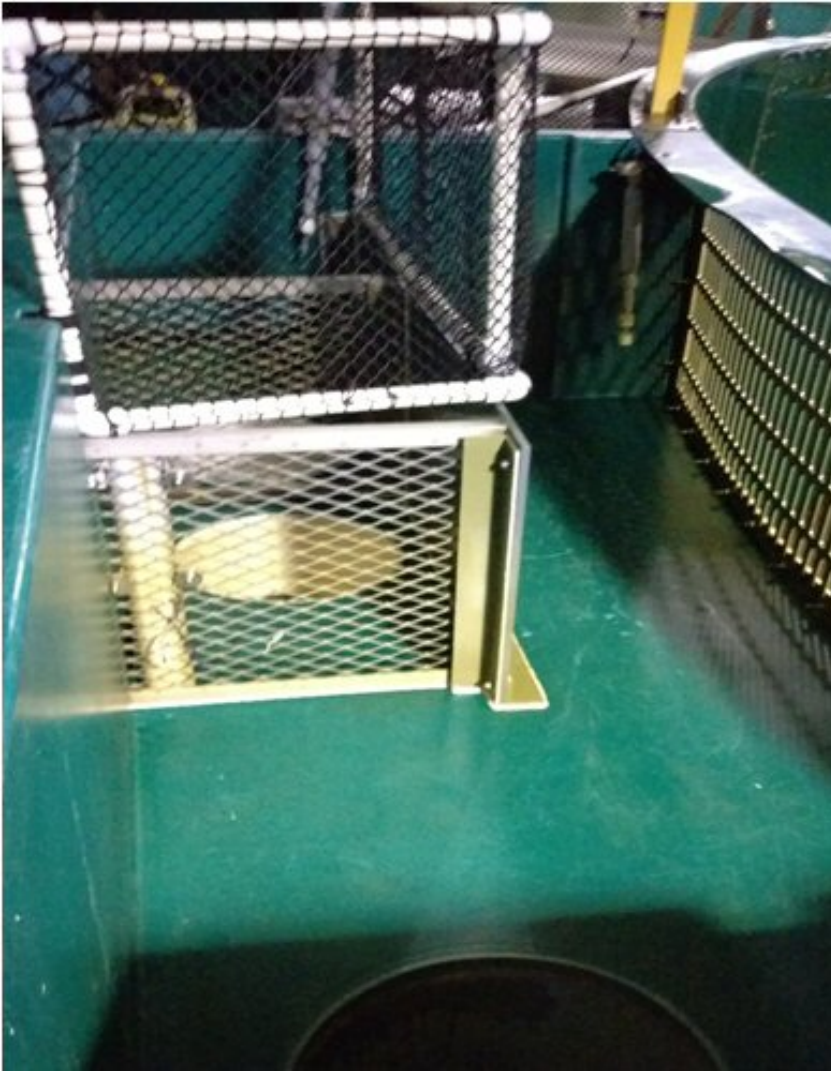
No CO₂ degasser



New purge design



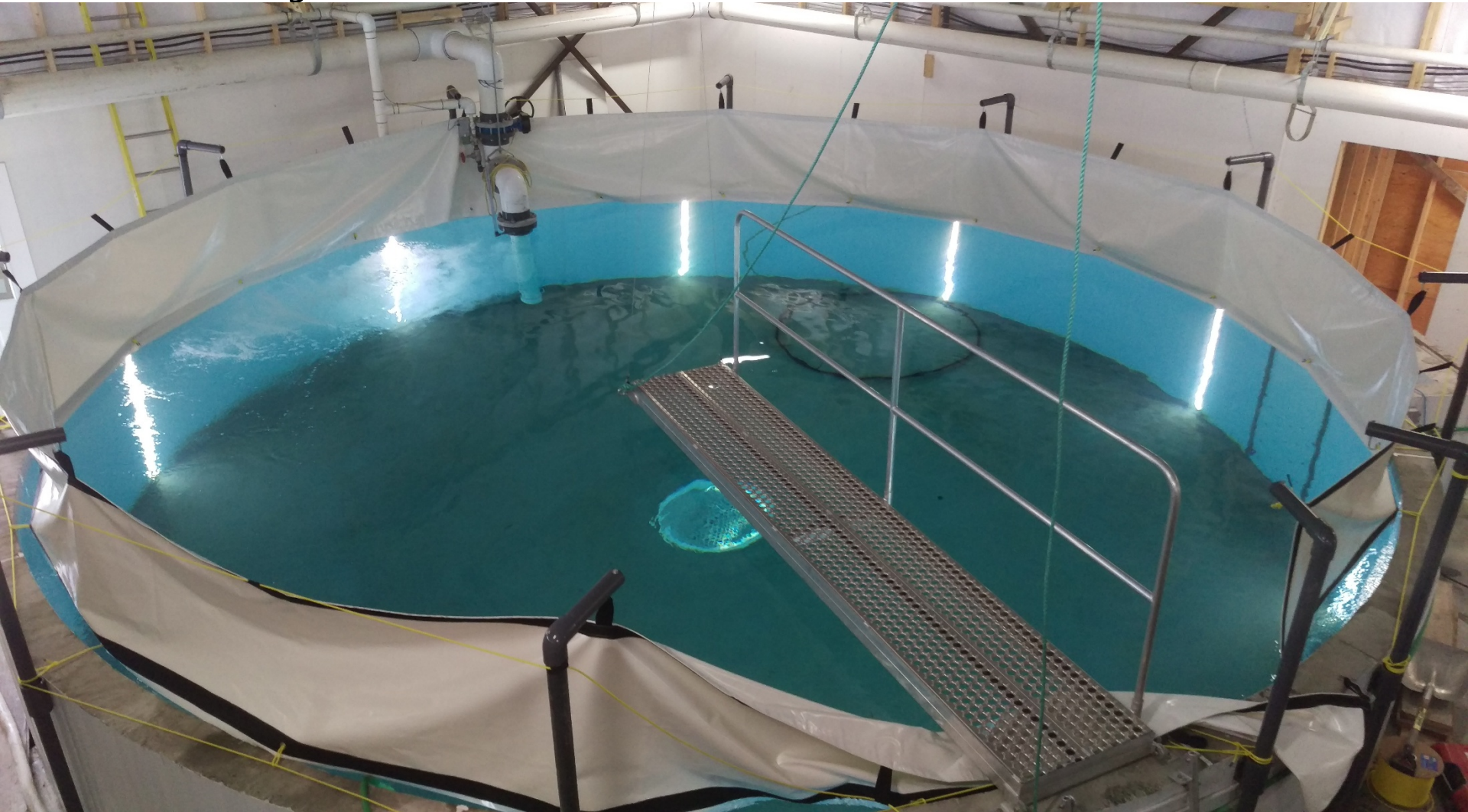
No pumps or associated infrastructure



New purge design



- 90% less pipe volume
- 60% less system volume



Overall impact



>58% ↓ in geosmin levels in the culture system
>90% ↓ in geosmin levels in the purge system



Overall impact



Weekly harvest

Satisfy market demand, especially foodservice

More streamlined process

Preserve product quality

Consistent flavour profile

Satisfy consumers, maintain brand and market



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