OXYGEN DEMAND, ECOLOGICAL ENERGETICS AND NUTRIENT DYNAMICS IN MINIMAL EXCHANGE, SUPERINTENSIVE, BIOFLOC SYSTEMS CULTURING PACIFIC WHITE SHRIMP, *Litopenaeus vannamei*

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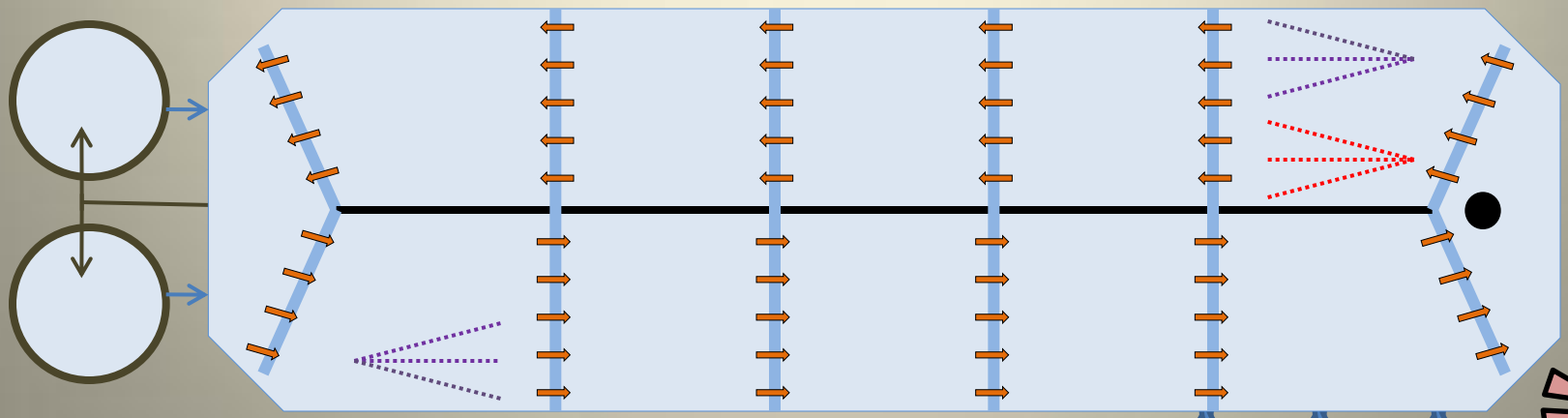
Purpose

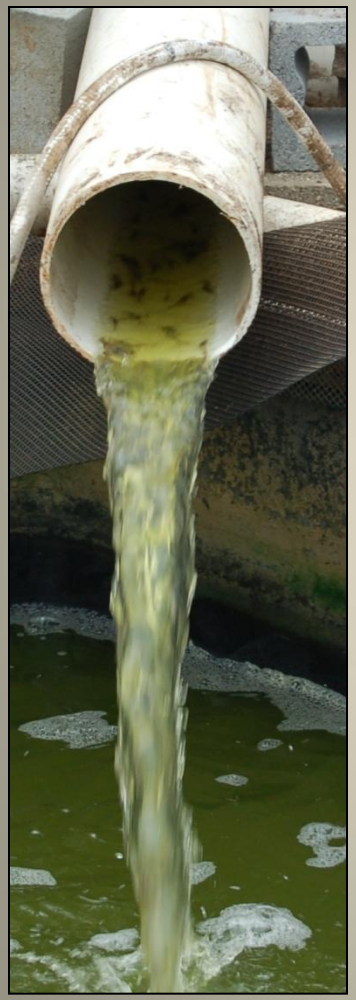
- To determine relative contributions to Total Oxygen Demand (TOD) by…
  - + shrimp (SOD)
  - + microbes in water column (WC-MOD)
  - + microbes attached to substrate (S-MOD)
- Calculate time to critical oxygen level in event of oxygen delivery system failure
- Use oxygen demand to predict shrimp biomass

Raceway Design & Engineering Specifications

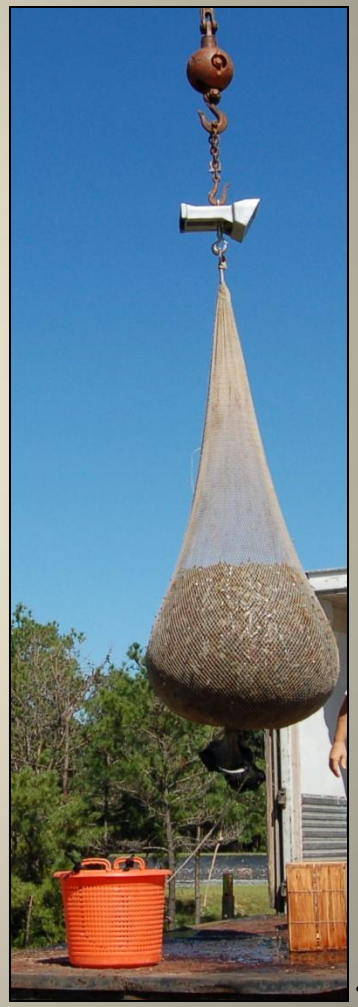
Item	Specs
Raceway	196 m^3, 271 m^2 110’ x 25’
Settling tanks	≈ 6000 l operating volume
O_2 generator, 1 hp pumps (2)	10 kW, 150 lpm pump output = 70-80 gpm
Heater, 1 hp pump	1,000,000 Btu propane boiler
5 hp blower, 56 airlifts	Blower output ≈ 180 cfm



Background Data



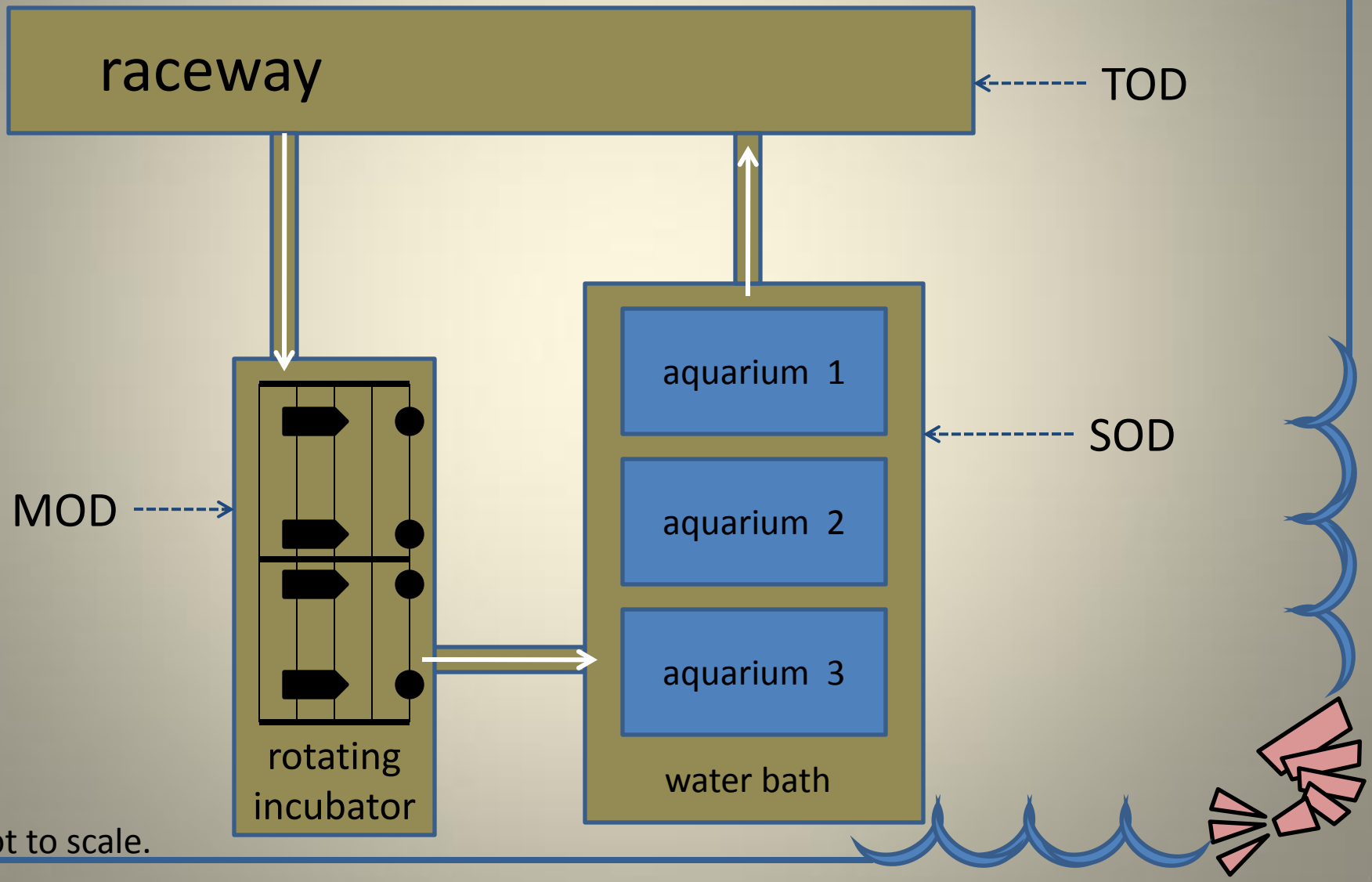
Stocking Date	10/8/09
Stocking Density	594 shrimp/m^3
Harvest Date	2/12/10
Culture Period	128 days
Yield	7.2 kg/m^3
Survival	79%
FCR	2.2
Growth/week	0.8 g



Water Quality

Parameter	Average (Std. Dev.) Range
DO (mg/L)	6.70 (± 1.23) 2.03-9.79
pH	7.09 (± 0.30) 6.44-7.83
Temperature (C^o)	28.5 (± 1.07) 23.5-31.1
Salinity (ppt)	16.9 (± 0.37) 16.2-18.0
TAN (mg/L)	0.49 (± 0.74) 0-2.96
NO_2 -N (mg/L)	0.06 (± 0.11) 0-0.49

Measuring Oxygen Demand: Experimental Design



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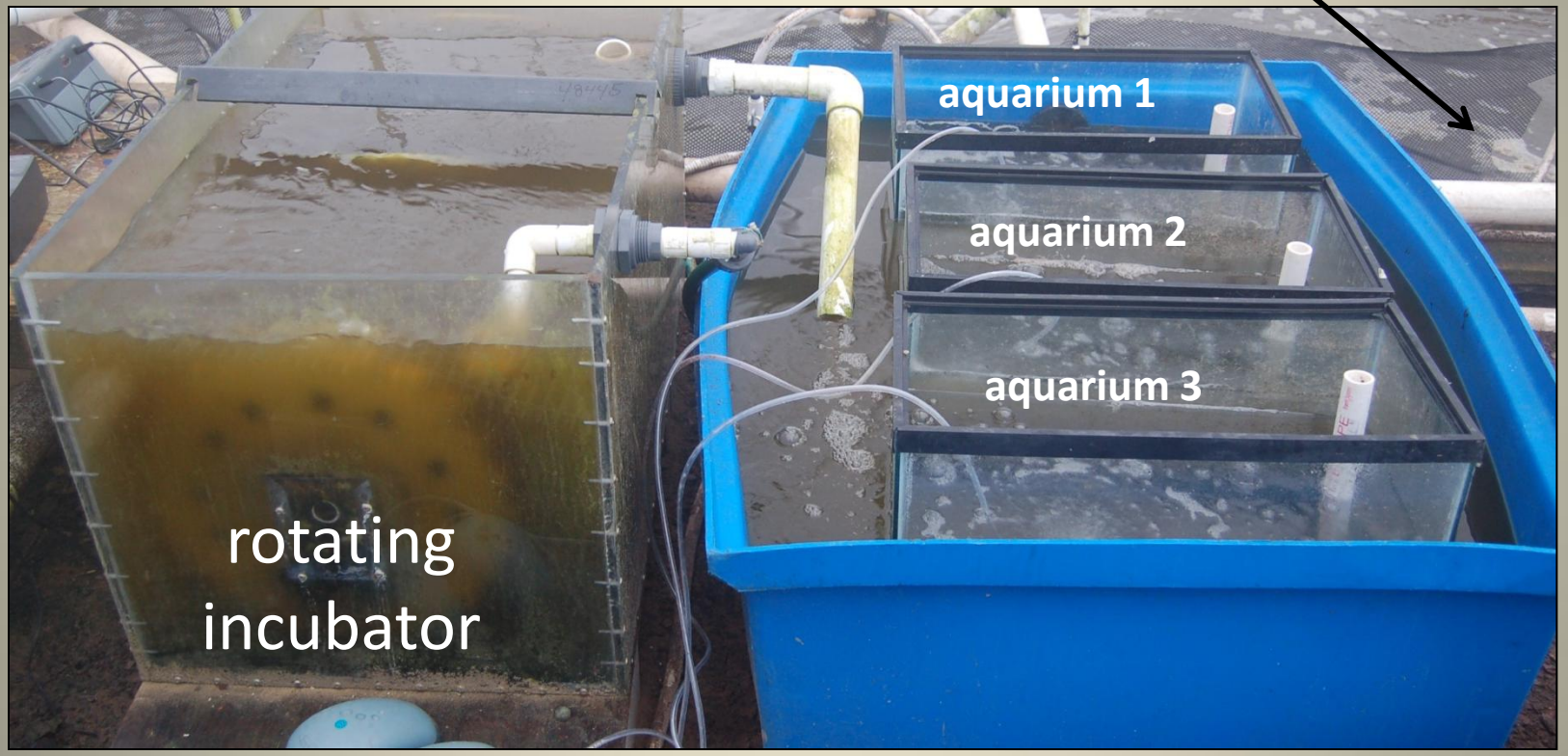


Measuring Oxygen Demand: TOD

- Measured every 3rd week
- Measured pre-dawn (5 am)

Total Oxygen Demand (TOD)

- Aeration/oxygen injection to raceway (blower, venturi pumps, O_2 generator) turned off/disengaged
- DO in raceway measured every 10 minutes with 3 YSI meters

Measuring Oxygen Demand: SOD

Shrimp Oxygen Demand (SOD)

Afternoon before study…

- aquaria filled w/ 45 L clear water
- same salinity (±2 ppt) & temp. (±1 °C) as raceway
- stocked w/ 25-27 shrimp

Morning of study…

- airstone removed from aquaria
- DO measured every 10 minutes with 3 YSI meters
- 4 BOD bottles filled with aquaria water, incubated at raceway temperature, initial/final DO measured

Measuring Oxygen Demand: WC-MOD, S-MOD

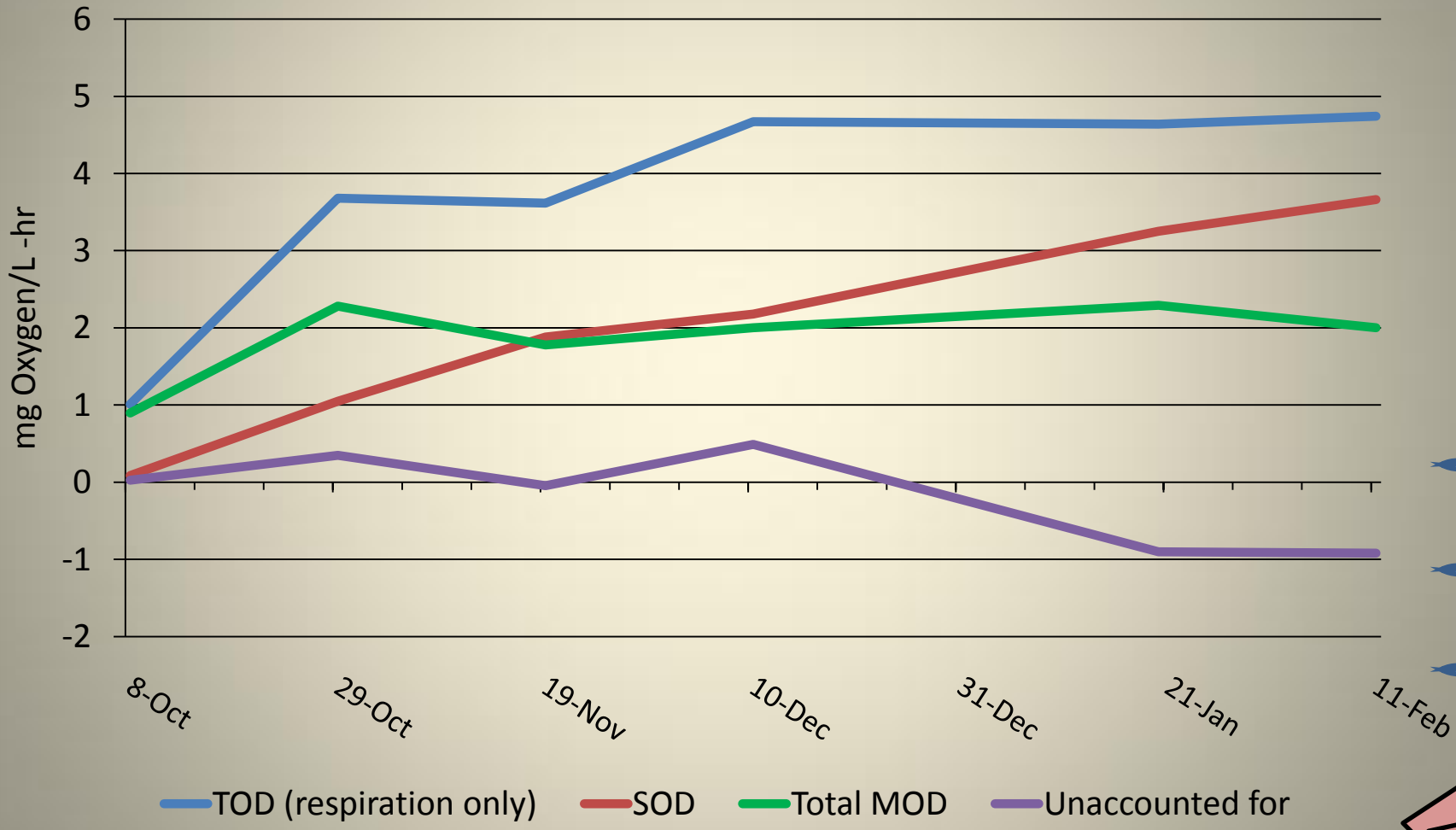
Water Column Microbial Oxygen Demand (WC-MOD)

- 4 BOD bottles filled with raceway water
- Bottles incubated on rotating incubator at raceway temperature
- Initial and final DO measured

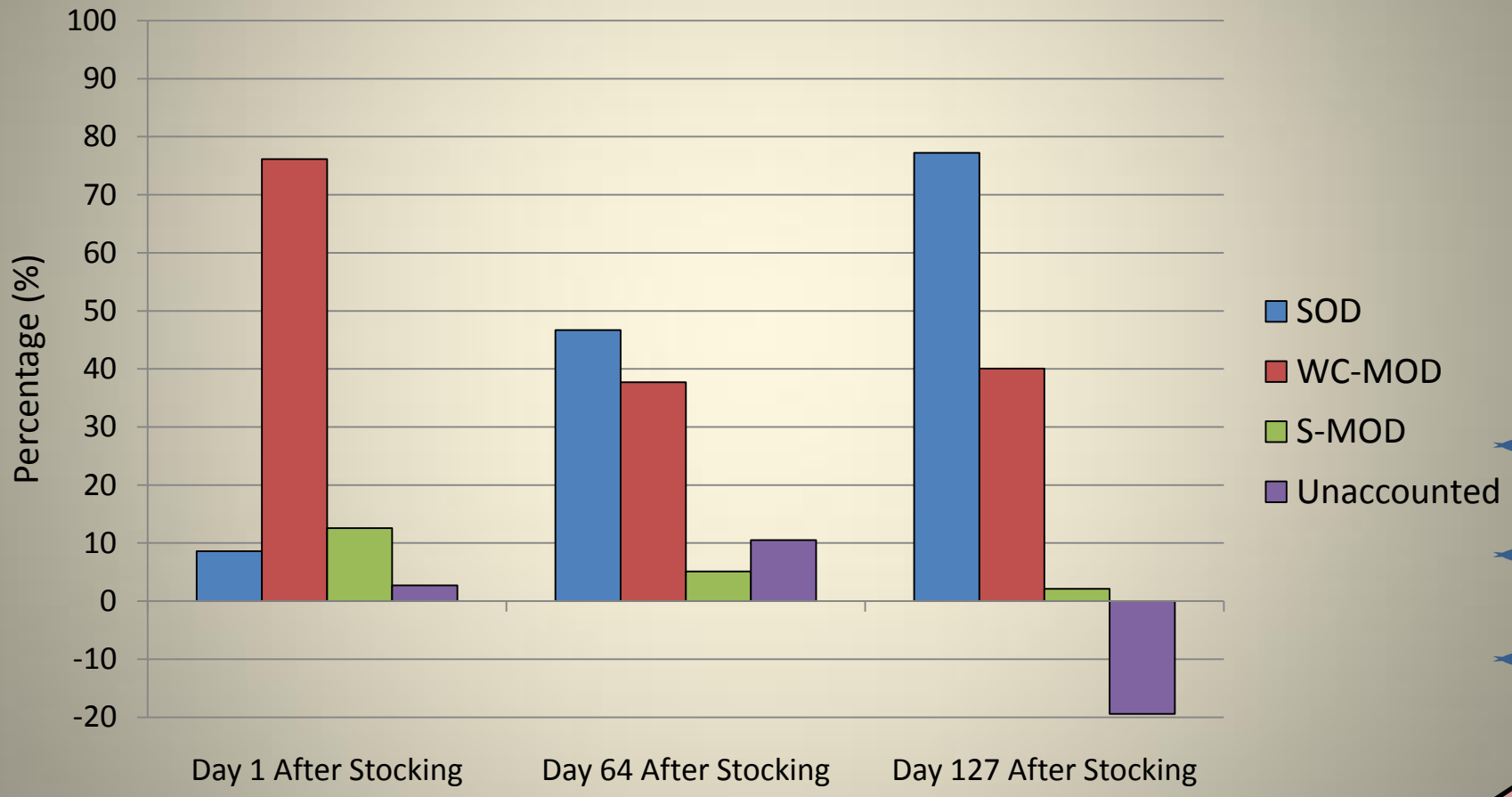
Substrate Microbial Oxygen Demand (S-MOD)

- Same as above *except* 3 cm^2 piece of liner material added to each bottle

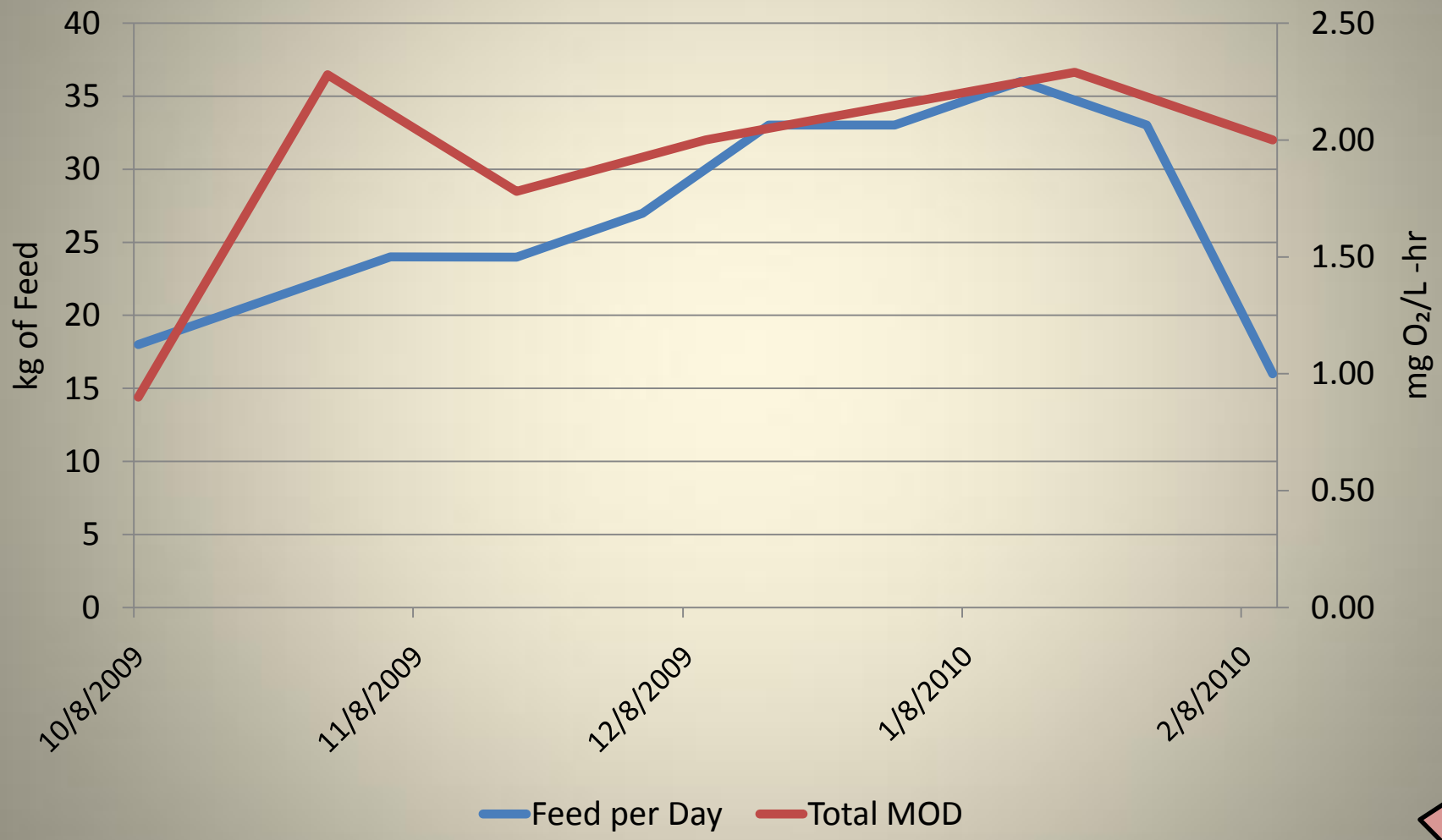
Oxygen Demand of Constituent Components



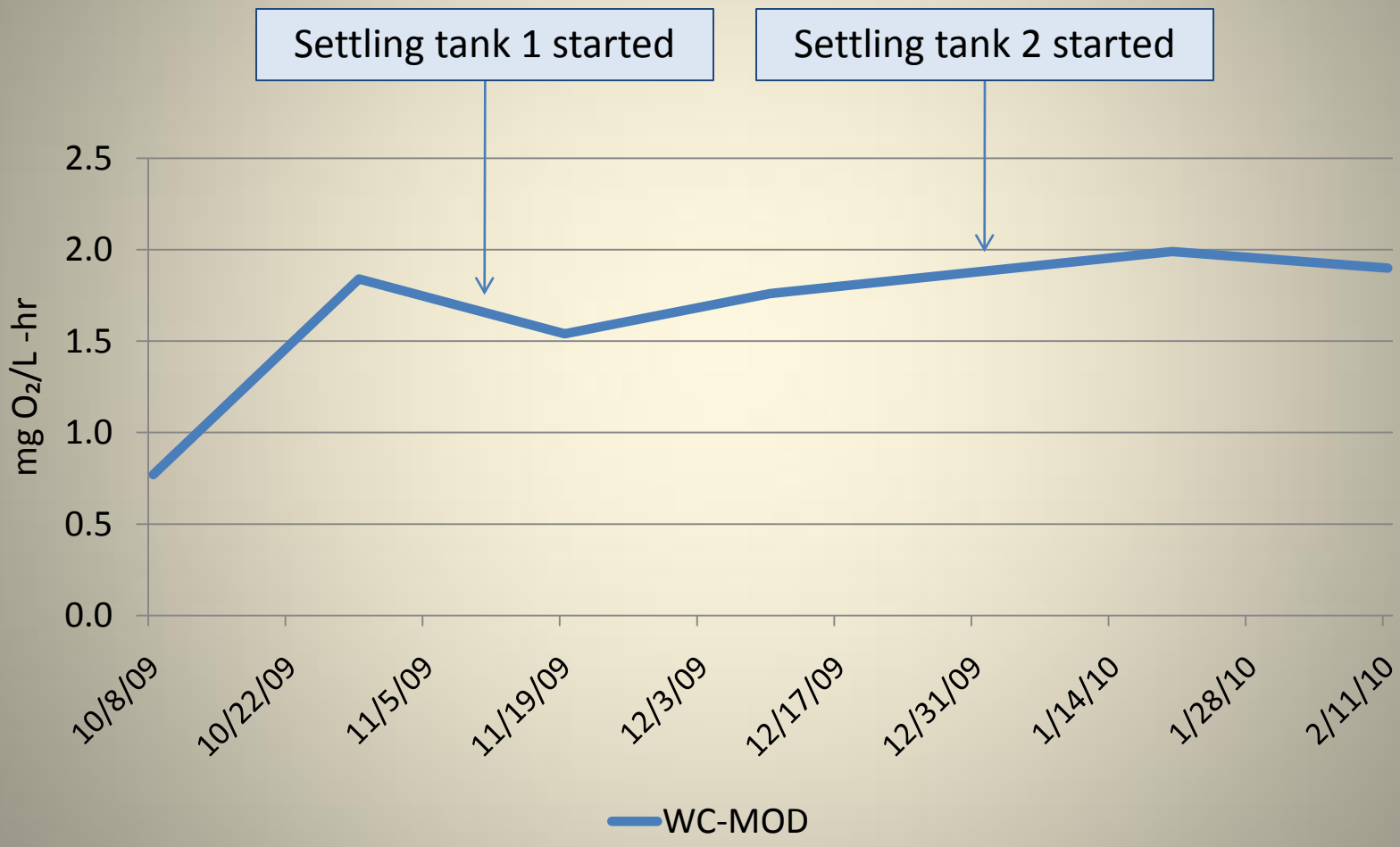
Relative Oxygen Demand at the Beginning, Middle, and End of Culture Period



Total MOD in Relation to Daily Feeding Rate

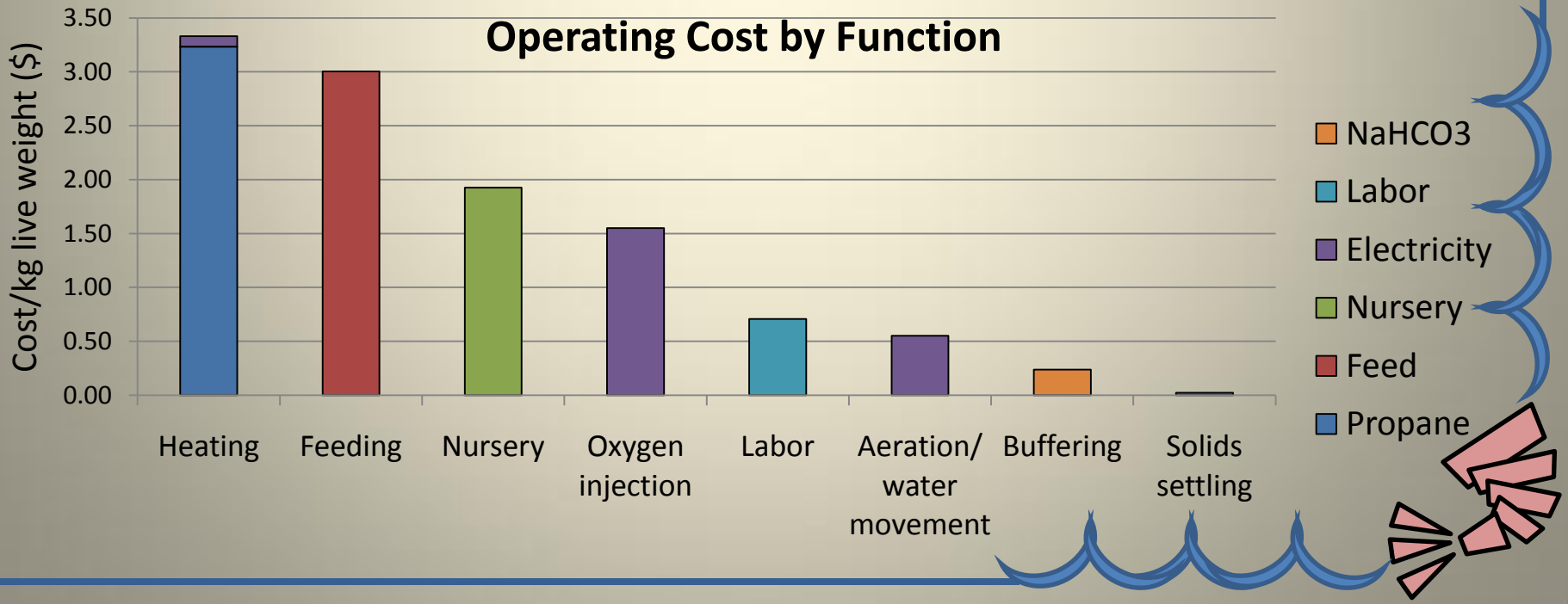


Influence of Settling Tanks on MOD



Cropping Biofloc

- Oxygen injection is 4th highest operating cost
- Microbial community consumes 42-89% of oxygen in raceway
- Need to crop biofloc to ↓ MOD
- Studies show cropping biofloc can ↑ growth



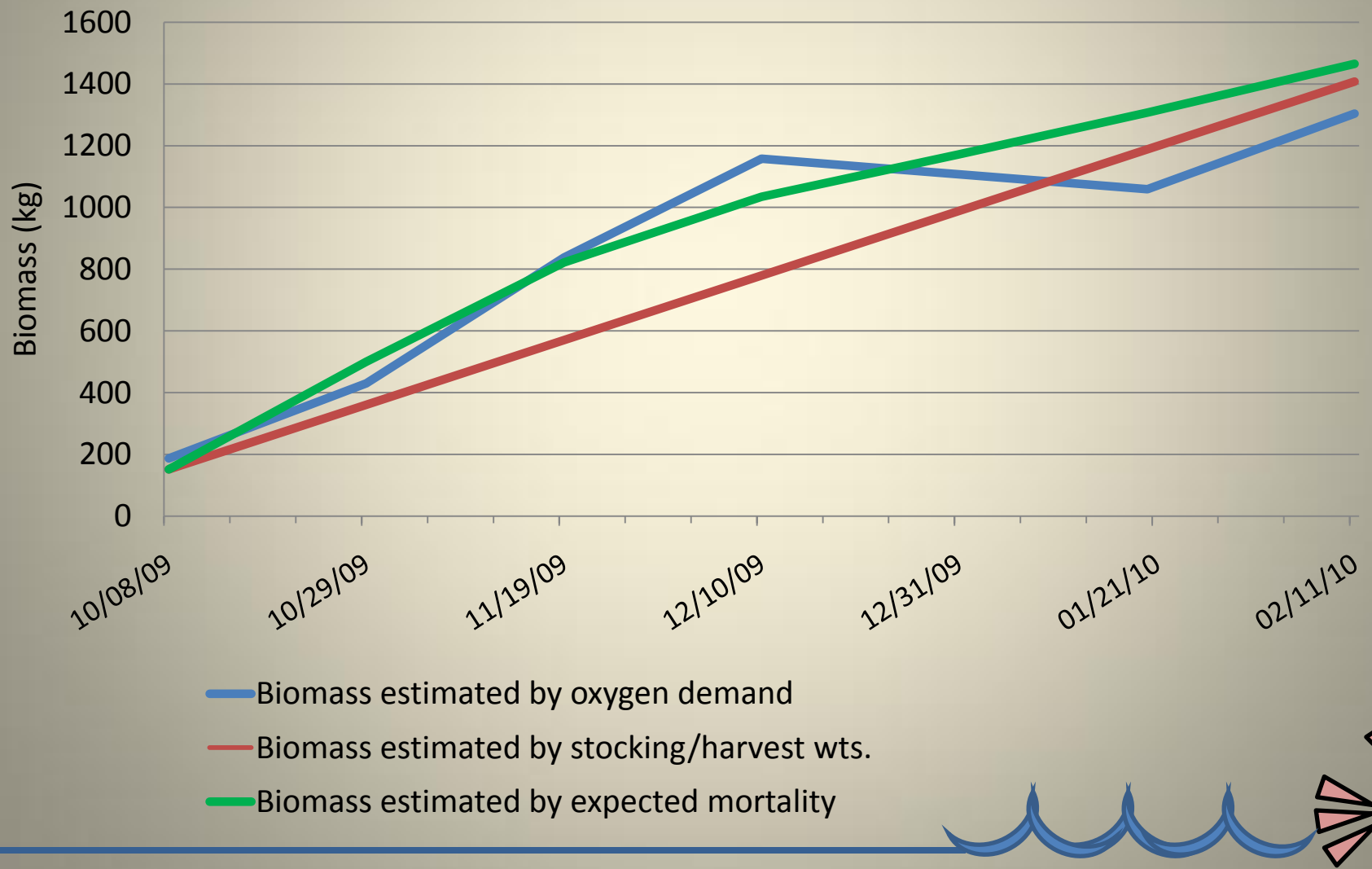
Estimating Biomass: methodology

$$\frac{\text{aquaria biomass}}{\text{absolute aquaria OD}} = \frac{x}{\text{absolute raceway OD}}$$

x	=	raceway biomass
absolute aquaria OD	=	SOD x aquaria volume
absolute raceway OD	=	(TOD - MOD) x raceway volume

aquaria biomass – shrimp weighed prior to stocking
SOD – measured
aquaria volume – 45 L
TOD – measured
MOD – measured
raceway volume – 196,000 L

Estimating Biomass: oxygen demand vs. expected mortality



Conclusions

- Oxygen delivery system failure leads to critical oxygen levels in **< 1 hr** after day 21
- Biofloc microbes consume 42 – 89% of oxygen
- Settling tanks may moderate increase in MOD
- Relationship between feed rate & MOD probable
- Oxygen demand can provide rough estimate of shrimp biomass

Thanks!