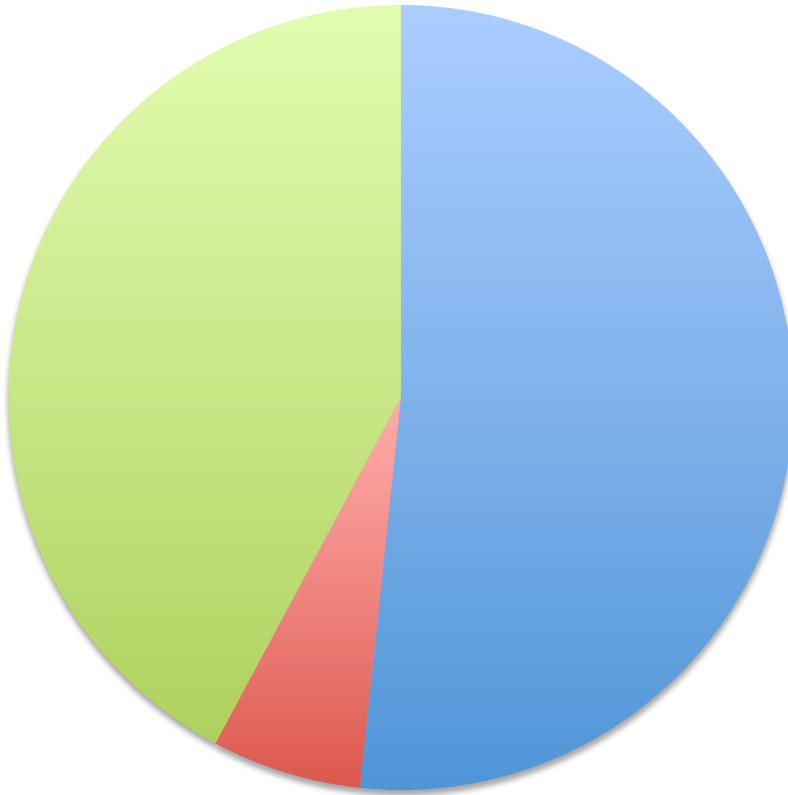


Food safety for produce in aquaponics



Illnesses: produce vs other foods*

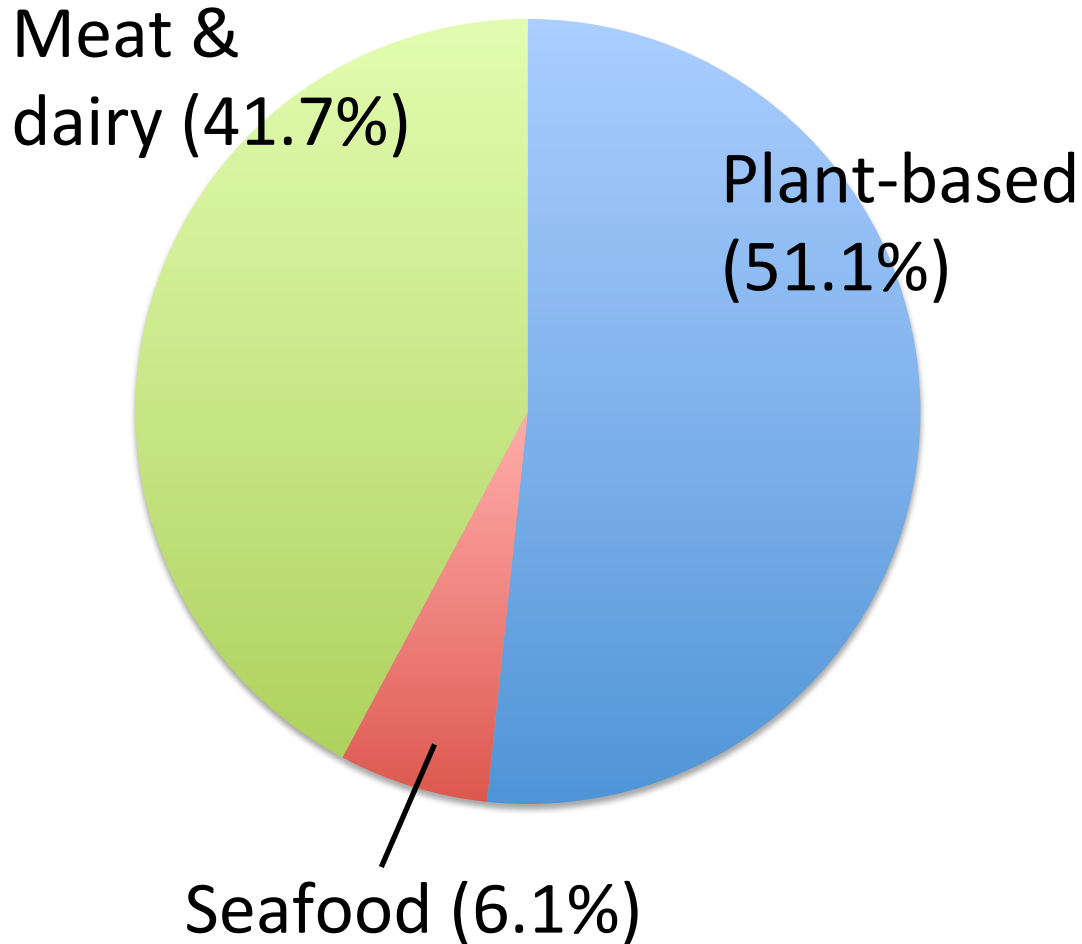


- Seafood
- Meat & dairy
- Plant-based foods

Which is which?

*1998-2008 in US, via Painter et al 2013

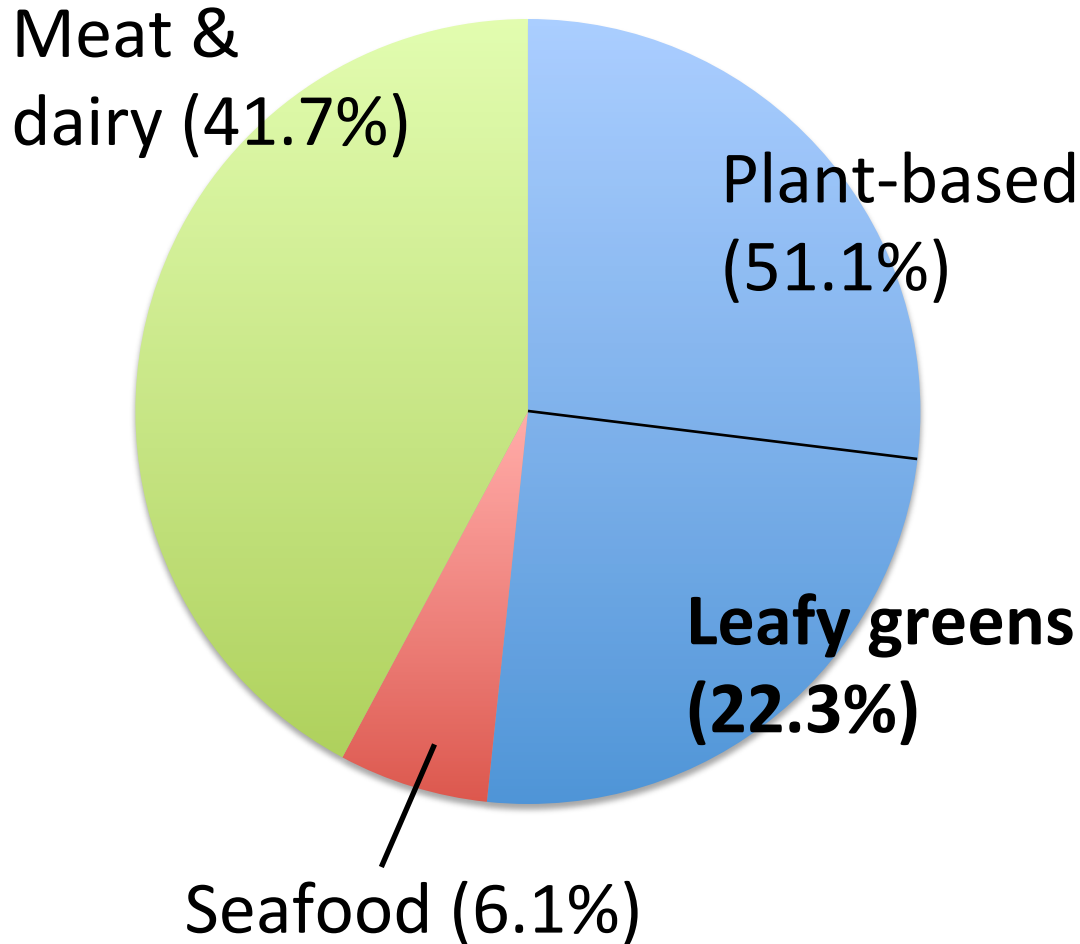
Illnesses: produce vs other foods



- Seafood
- Meat & dairy
- Plant-based foods

Which is which?

Illnesses: produce vs other foods



- Seafood
 - Meat & dairy
 - Plant-based foods
- Which is which?

Leafy greens

- Probably the #1 crop in aquaponics
- And #1 cause of FBI in US
- High-risk commodity!
 - Most pathogens on produce get there by contact by contaminated water or handlers -> surface area matters
 - Leafy greens have lots of surface area per serving

1 WATERCRESS NUTRIENT DENSITY SCORE: 100.00	
	2 CHINESE CABBAGE NUTRIENT DENSITY SCORE: 91.99
3 CHARD NUTRIENT DENSITY SCORE: 89.27	
	4 BEET GREEN NUTRIENT DENSITY SCORE: 87.08
5 SPINACH NUTRIENT DENSITY SCORE: 86.43	
	6 CHICORY NUTRIENT DENSITY SCORE: 73.36
7 LEAF LETTUCE NUTRIENT DENSITY SCORE: 70.73	
	8 PARSLEY NUTRIENT DENSITY SCORE: 65.59
9 ROMAINE LETTUCE NUTRIENT DENSITY SCORE: 63.48	
	10 COLLARD GREEN NUTRIENT DENSITY SCORE: 62.49
11 TURNIP GREEN NUTRIENT DENSITY SCORE: 62.12	
	12 MUSTARD GREEN NUTRIENT DENSITY SCORE: 61.39
13 ENDIVE NUTRIENT DENSITY SCORE: 60.44	
	14 CHIVE NUTRIENT DENSITY SCORE: 54.80
15 KALE NUTRIENT DENSITY SCORE: 49.07	

Small-scale AP marketing

- Farmer's markets and niche restaurants
- Can move... a few dozen cases per week?
- No food safety standards



AP marketing at scale

- An AP operation producing 100 metric tons fish/year will put out about 300-500 cases greens/wk
- Buyers at that volume use formal risk management!



Industry standards– wholesale market



GLOBALG.A.P.



- Industry has to deal with liability of marketing leafy greens
- How? Setting high, market-based standards
- These are industry-based– not government
 - The gov't (FSMA) will let you off easy for being a little guy, but **buyers don't care if you're small.**
 - Example: Audits
 - Ex. 2: California Leafy Greens Marketing Agreement
 - 90% of leafy greens grown in US follow CA-LGMA

Aquaponics vs. audits

- Market standards are geared for field ops
- So, HP and AP have a lot of built-in advantages re: these market standards
 - Indoor, controlled environment
 - Usu. municipal water supply
 - **Easier to maintain worker hygiene**



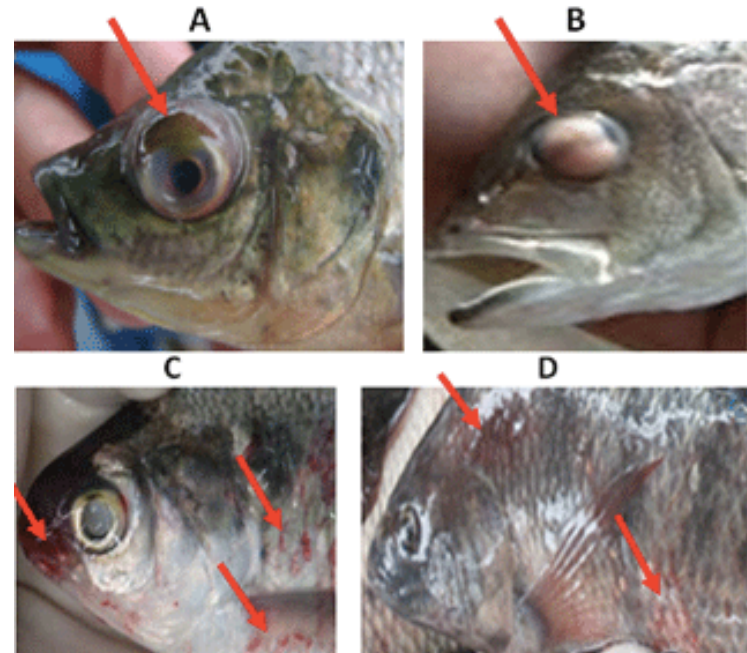
Downside of AP: fish

- Fishborne zoonoses

	Possible human pathogens	Proven human pathogens
Occasionally found in/on fish	<i>Edwardsiella tarda</i>	<i>Salmonella java</i> , <i>Listeria monocytogenes</i> ; <i>Yersinia</i> spp.
Frequently found in/on fish	<i>Aeromonas hydrophila</i> , <i>Plesiomonas shigelloides</i>	<i>Vibrio cholerae</i>

Case study: fishborne zoonosis in AP

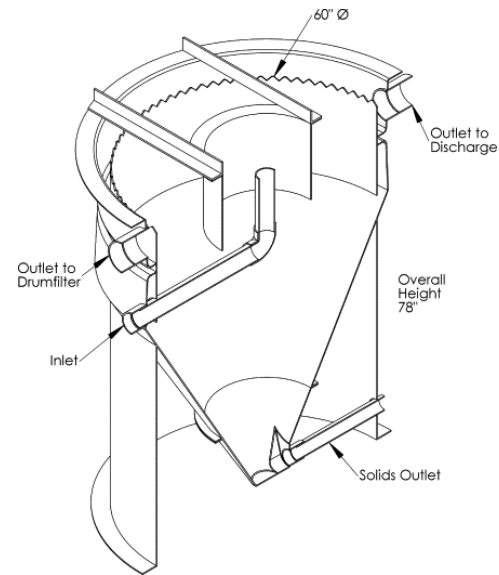
- Tilapia in a CA AP farm became sick
- Fish found positive for *A. hydrophila* and *Strep iniae*—both at least somewhat zoonotic
- Both are opportunistic on fish— infections only possible under poor hygiene
- But poor hygiene is very common in “vernacular” AP systems
- Poor solids removal sets stage for fish & human pathogens



Bottom line

- Yes, it is possible for foodborne pathogens to thrive in aquaponics.
- Yes, it is possible to mitigate these risks.
 - Using practices that RAS producers are already very familiar with
 - **Solids removal**

Yes



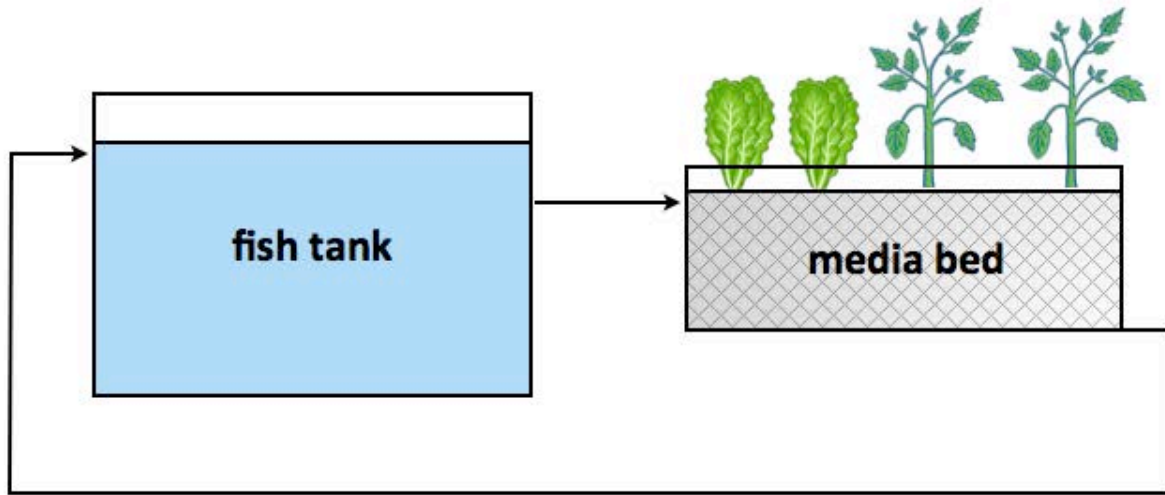
Yes



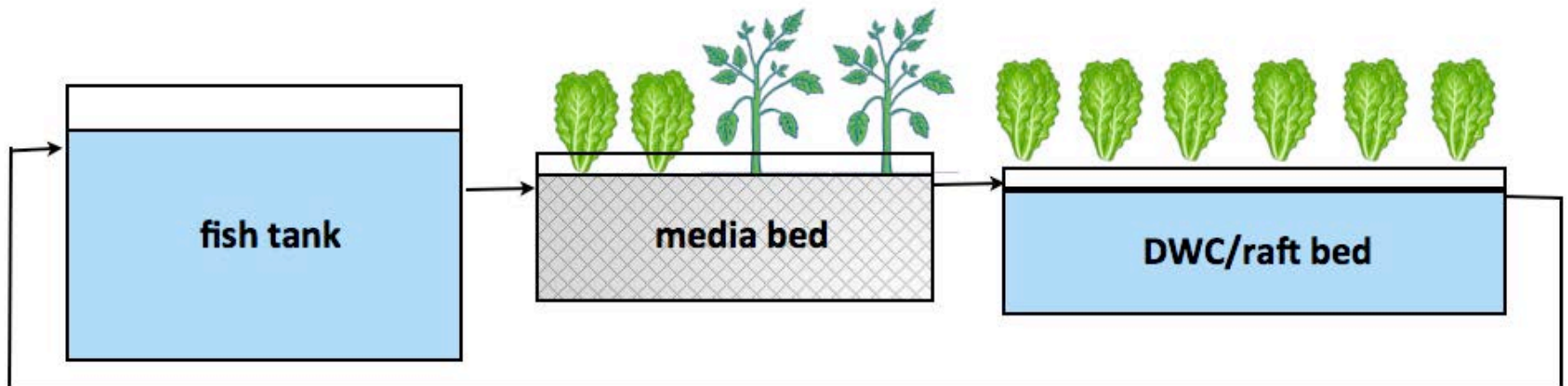
NO

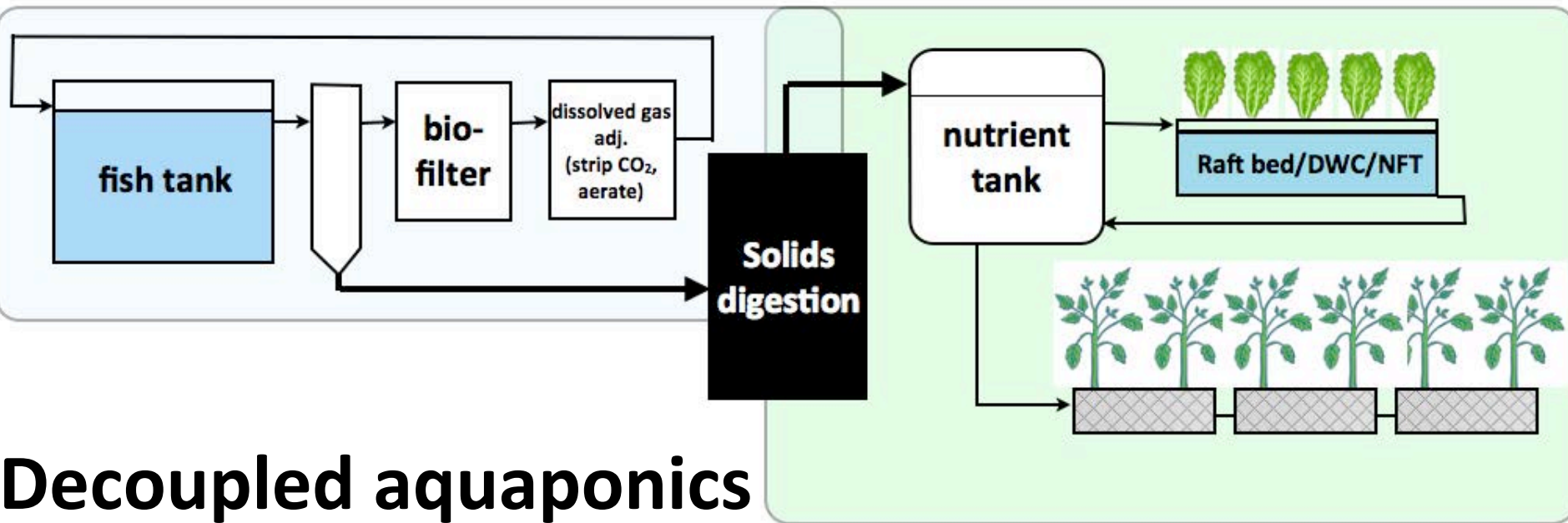
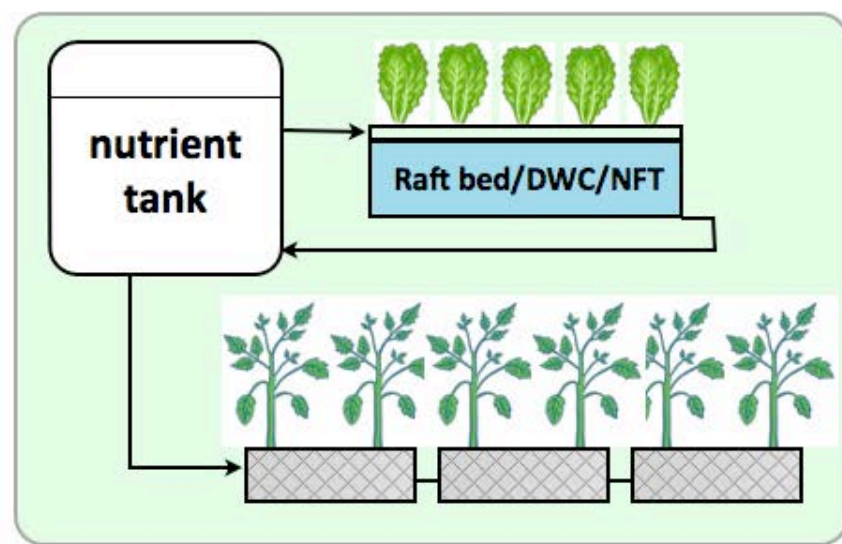
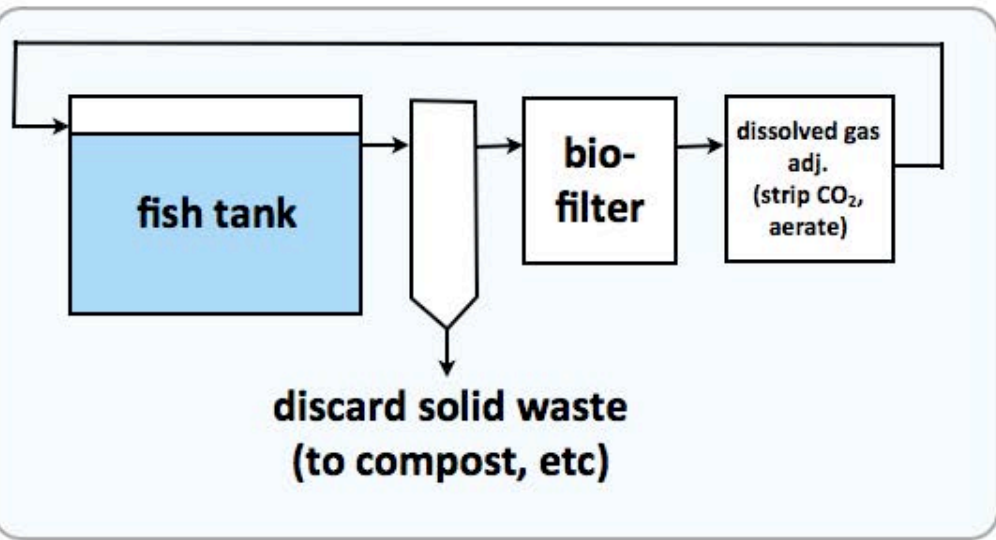
Design for food safety

- Priority #1: solids removal
 - **RAS is not a compost pile**
- But still need to break down the solids to get nutrients
- How to accomplish both these goals?
 - Decoupled approach



**Popular
“vernacular”
aquaponic
systems**





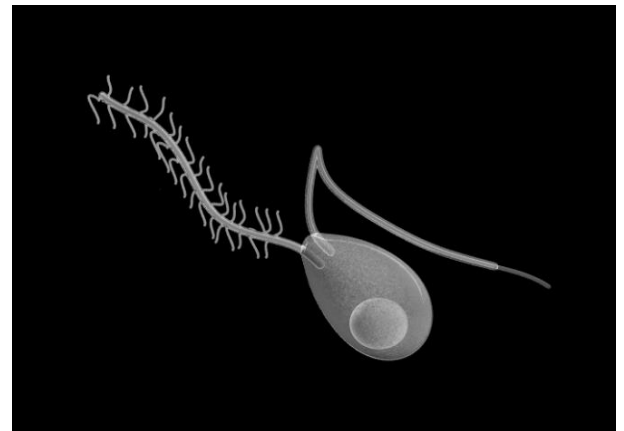
Decoupled aquaponics

Solids digestion methods

- Anaerobic → will need further treatment
- Aerobic → may achieve food safety objectives
- Ozone → kills everything
 - A sanitizing step is required by some food safety audits for recirculating HP anyway
- Watch pH & micronutrient chemistry
 - HP typically runs at pH 4-5 to keep micronutrients (Fe, Co, etc) dissolved
 - But neutral pH and esp. O_3 can precipitate micro's

Food safety keeps plants healthy too

- HP/AP plants need O₂ saturation in root zone
- High organic matter makes it hard to keep O₂ in play
- Some plant diseases (esp. Pythium) also thrive on rotting organic matter, *and* low O₂ levels
- Pythium is a HUGE problem in aquaponics– coincidence?



Food safety keeps plants healthy too



^Roots should look like
this— ~same size as aerial
part of plant & **bright white**



Conclusion

- Decoupled AP resolves the known, AP-specific issues for food safety
 - Ditto for any other approach that removes solids and allows sanitizing of the water
- Still have to deal with universal ag issues like worker hygiene, pest control, etc
- Already have RAS expertise— seek out horticulture design, marketing, compliance expertise before getting into AP!

Questions?

