# MEALS

## Mars Experimental Aquaponics Long-Duration System

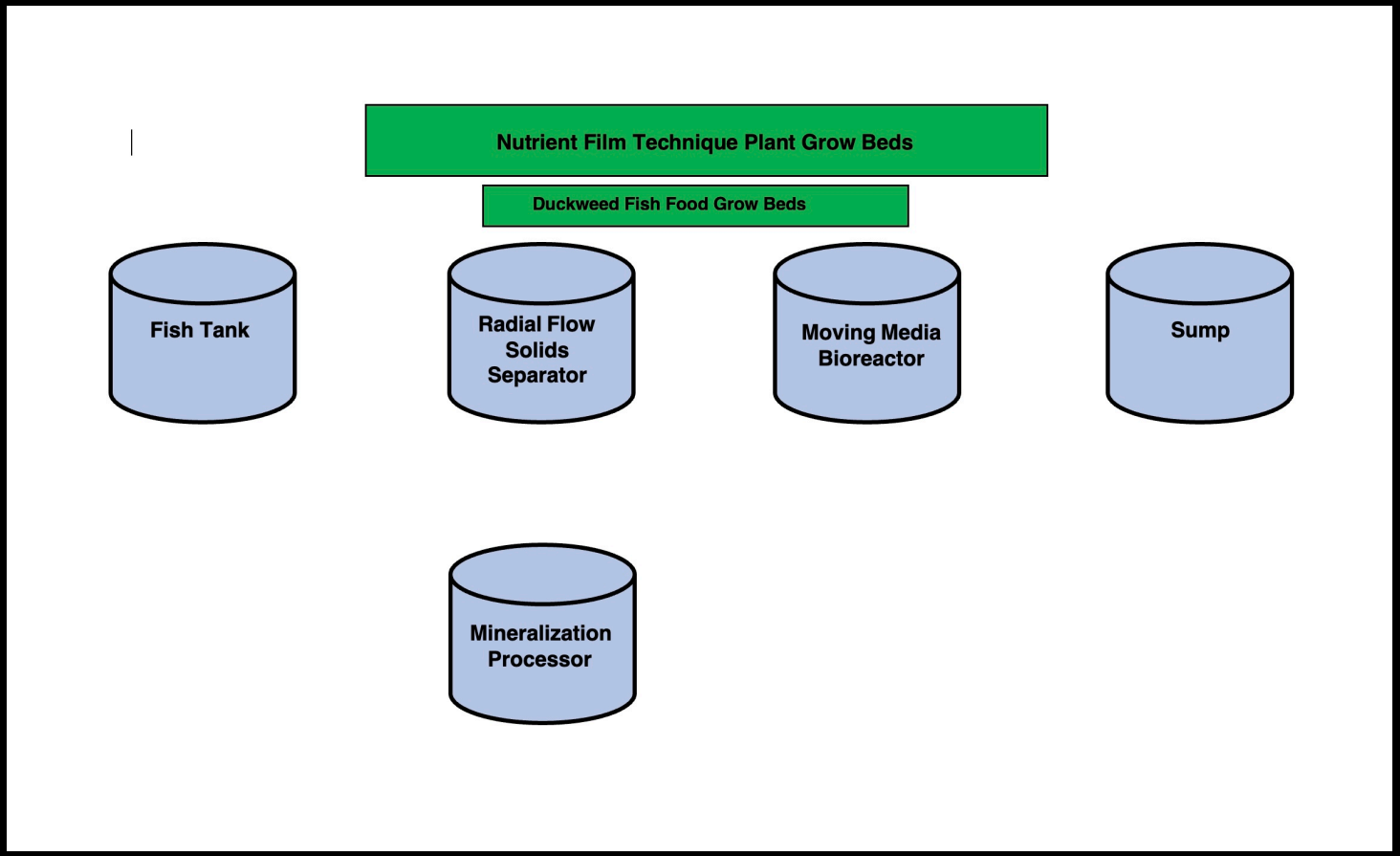

or

Carl Greenbaum © 2021

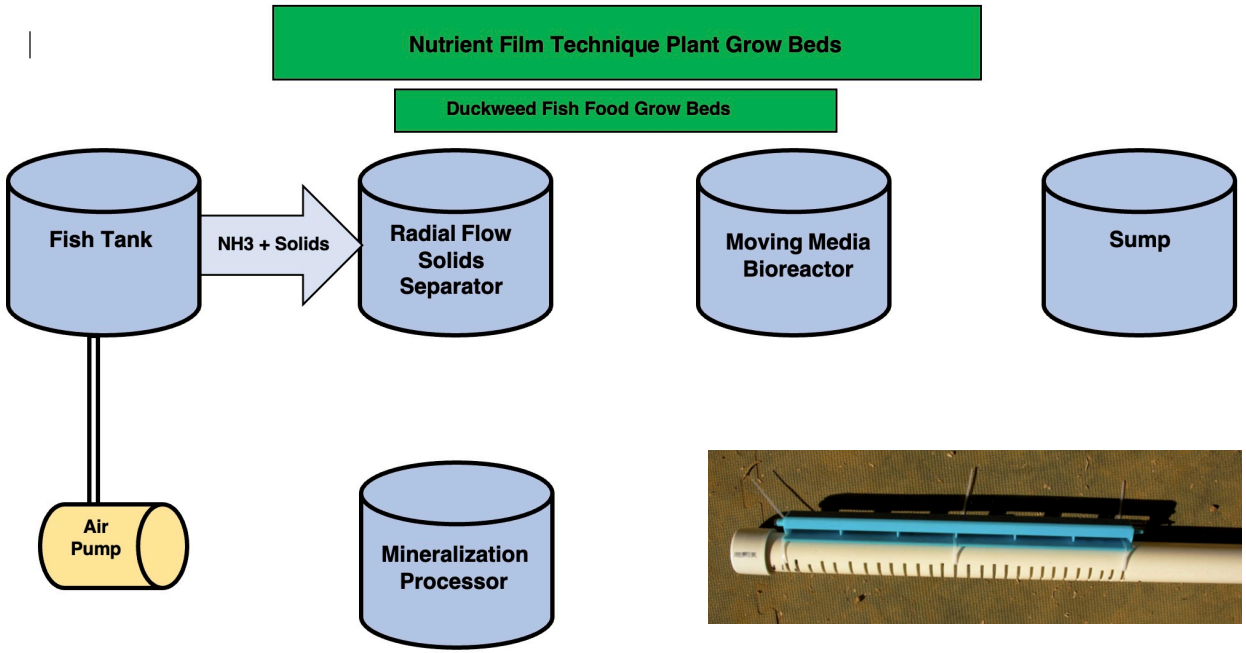
# MEALS Concept

- Aquaponics
  - fish waste is filtered and nitrified to eliminate toxicity and make nutrients available to the plants. The plants absorb the nutrients and the clean water is returned to the fish tank.
- Tilapia selected for fast growth and tolerance
- Vegetables and fruits are grown without soil
- Maximum automation to reduce crew tasking
- Duckweed grown as high protein fish food, supplemented with food scraps

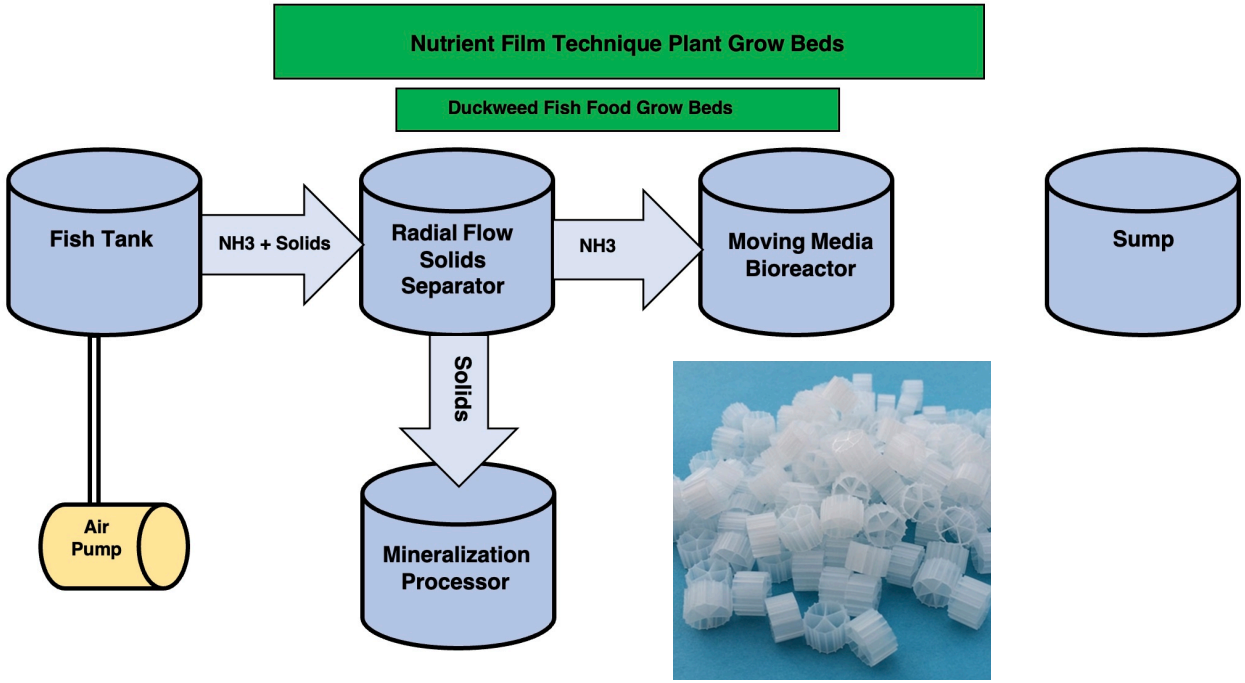
# MEALS Process Flow



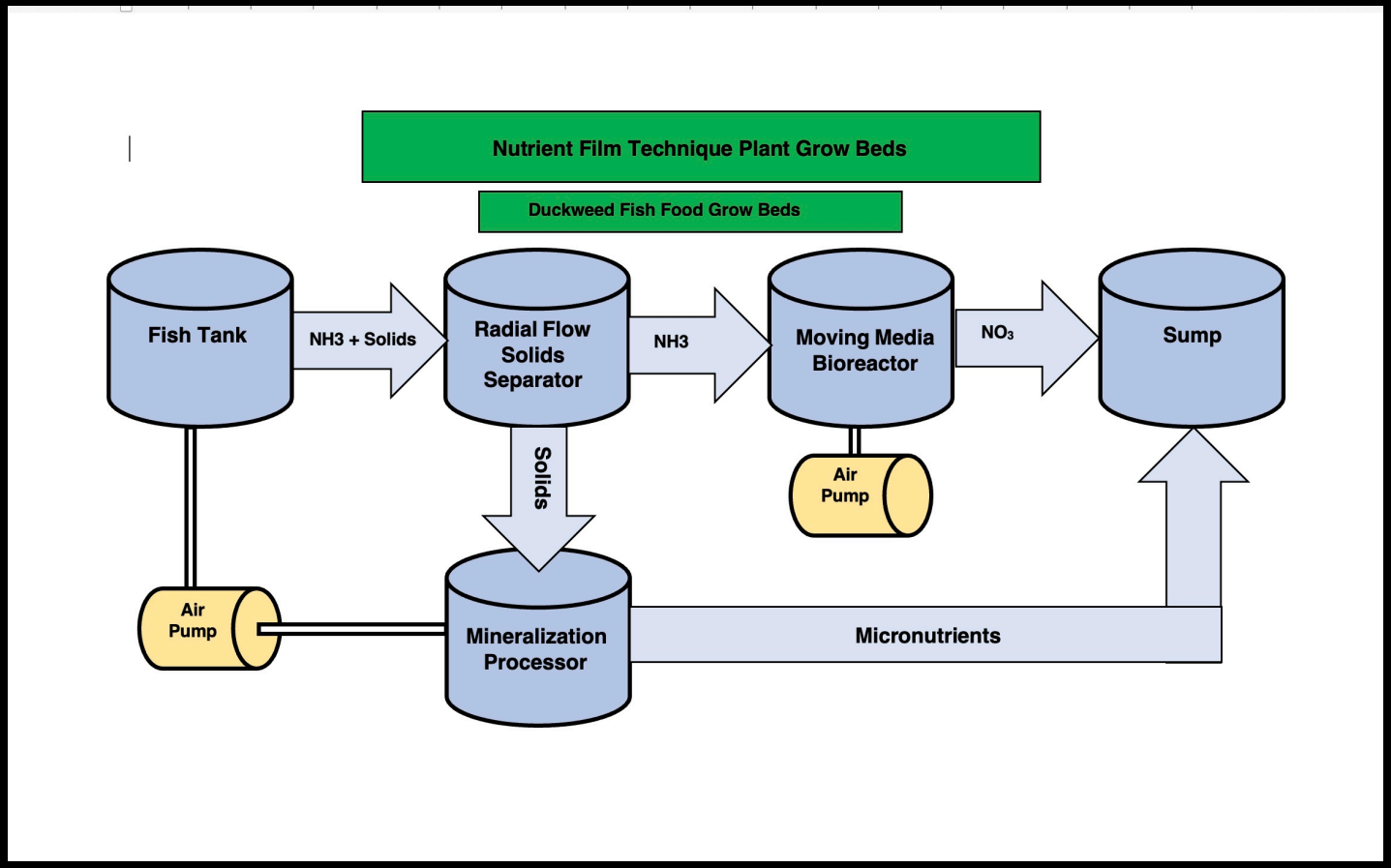
# MEALS Process Flow



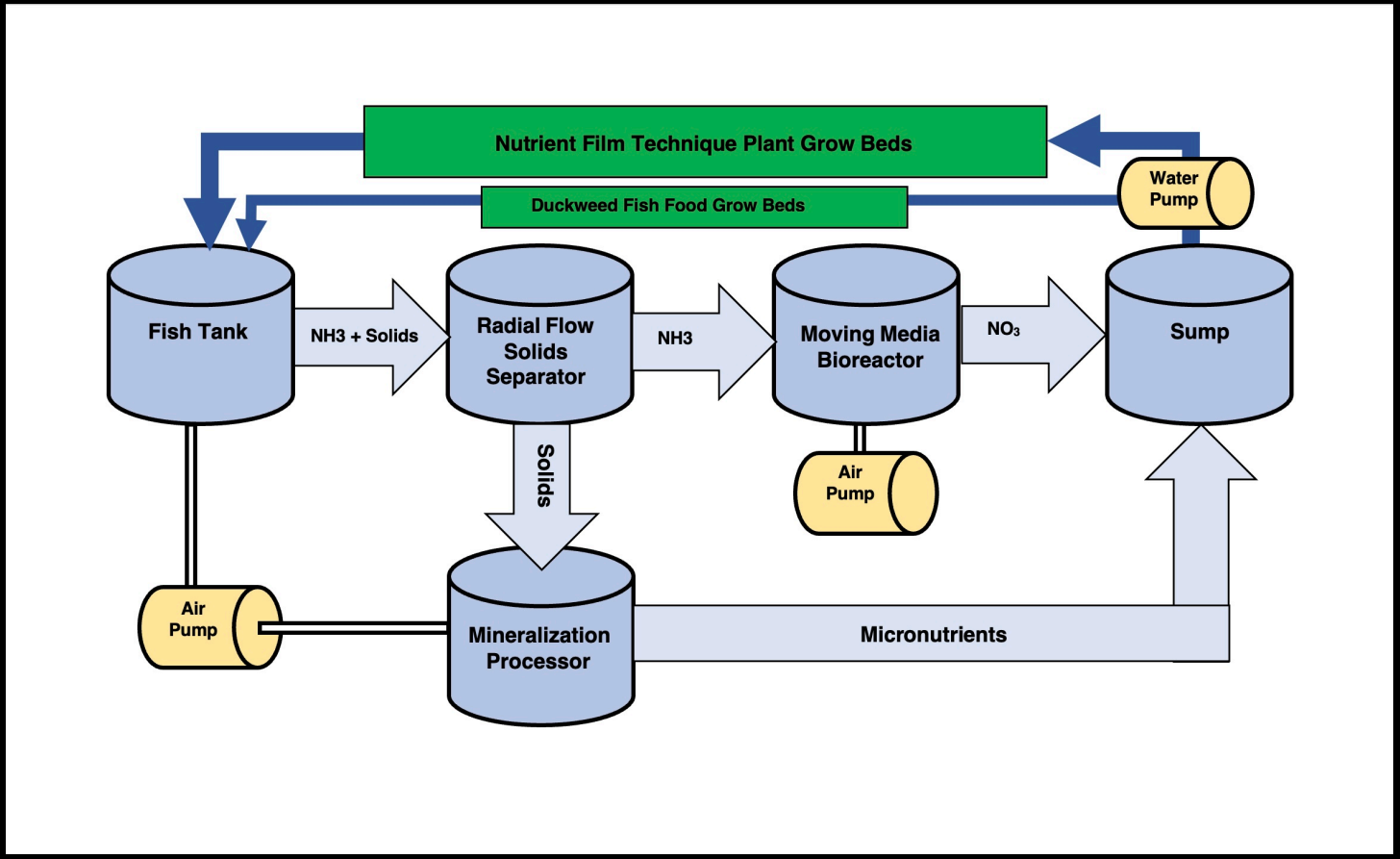
# MEALS Process Flow



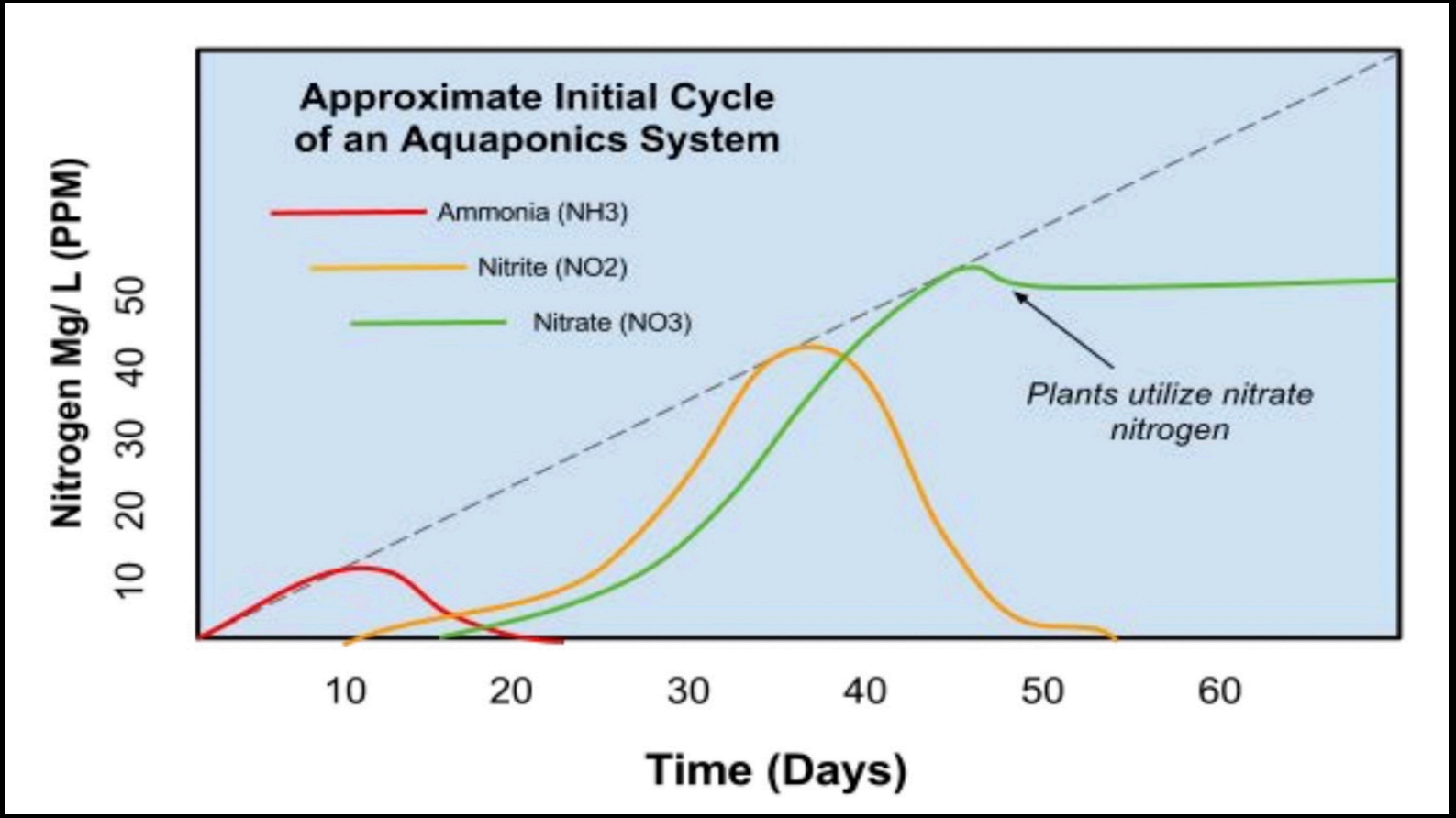
# MEALS Process Flow



# MEALS Process Flow



# Establishing Bacterial Colonies



# Hydroponics

| ITEM | TEMP RANGE | pH RANGE |
|---|---|---|
| Lettuces | Cool | 6.0-7.0 |
| Tomatoes | Hot | 5.5-6.5 |
| Radishes | Cool | 6.0-7.0 |
| Kale | Cool-Warm | 5.5-6.5 |
| Cucumbers | Hot | 5.5-6.0 |
| Spinaches | Cool-Warm | 6.0-7.0 |
| Beans | Warm | 6.0 |
| Chives | Warm-Hot | 6.0 |
| Basil | Warm | 5.5-6.5 |
| Mints | Warm | 5.5-6.5 |
| Strawberries | Warm | 6.0 |
| Blueberries | Warm | 4.5-6.0 |
| Peppers | Warm-Hot | 5.5-6.0 |

# System Sizing - Hydroponics

- Target production is 100% of produce for a Crew of 6
- 10 $m^2$ of hydroponics needed to feed 1 person; 60 $m^2$ for 6 crew
- For 4 hydroponic stacked growing levels, need 15 $m^2$ of floor space
- Grow Beds are 0.75m wide x 5 m long
  - 4 of these beds, each 4 layers high are needed

# Pollination

- Self-Pollinating Vegetables
  - tomatoes, green peppers, and chili peppers, eggplants, green beans, lima beans, sweet peas
- Wind Pollinated Vegetables
  - can fruit without insect pollinators.
  - squash, melons and zucchini.
- Small electronics ventilation fans are included on each level to facilitate wind pollination.

# Aquaculture

| FISH | TEMP RANGE | GROWTH RATE |
|---|---|---|
| Tilapia | 18-30 | Fast |
| Trout | 14-20 | Slow |
| Catfish | 26-30 | Moderate |
| Bass | 24-30 | Moderate |
| Salmon | 13-18 | Slow |
| Prawns | 24-30 | Fast |

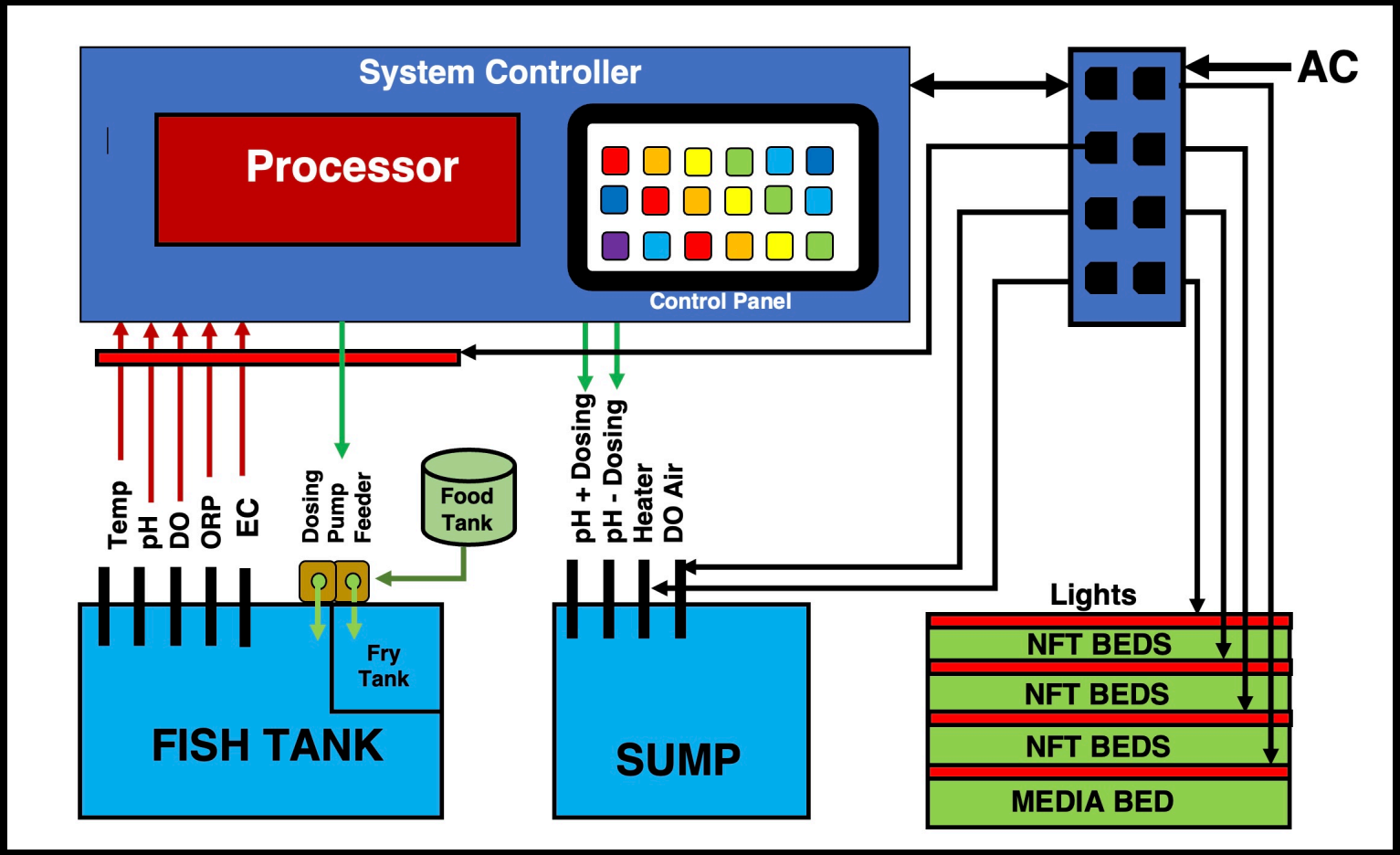
# System Sizing - Aquaculture

- Target Production is 50% of fish for a crew of 6
- For 250g of filet per crew /day, need 400 g total fish mass
  - need ~5.3 kg/day for 6 or 2.6 kg at 50%
- Fish are harvested in 8 months at 1 kg
- 240 day growth x 2.6 kg steady state fish mass= 624 kg
- At 42 kg/$m^3$ tank loading, need 15 $m^3$ tank
- Main Tank is 5m L x 3m W x 1m H(water Level)
  - Plus small partition for fingerlings

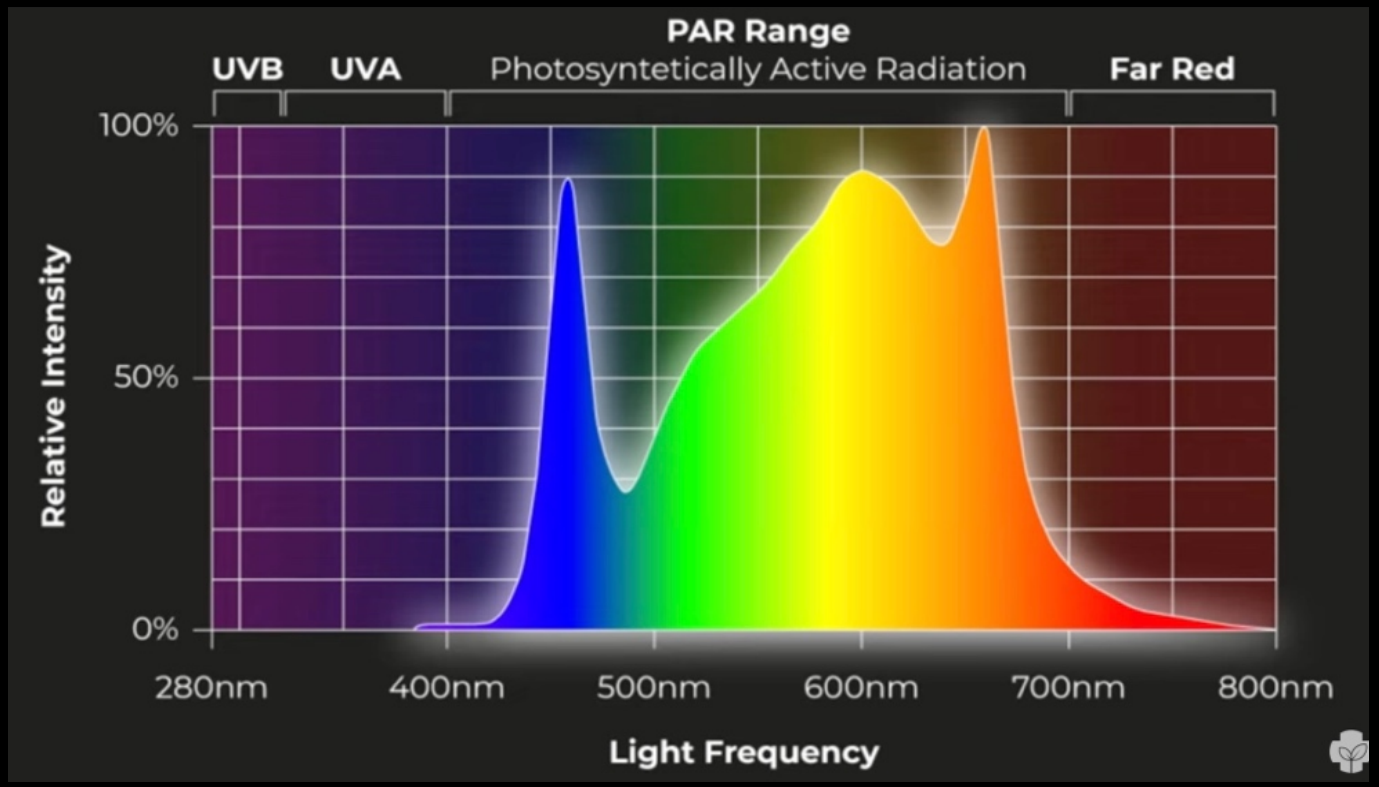
# System Maintenance Needed

- Feeding
- Temperature Monitoring/Adjustment
- Lighting Control
- pH Monitoring/Adjustment
- Dissolved Oxygen Levels
- Water Level Control

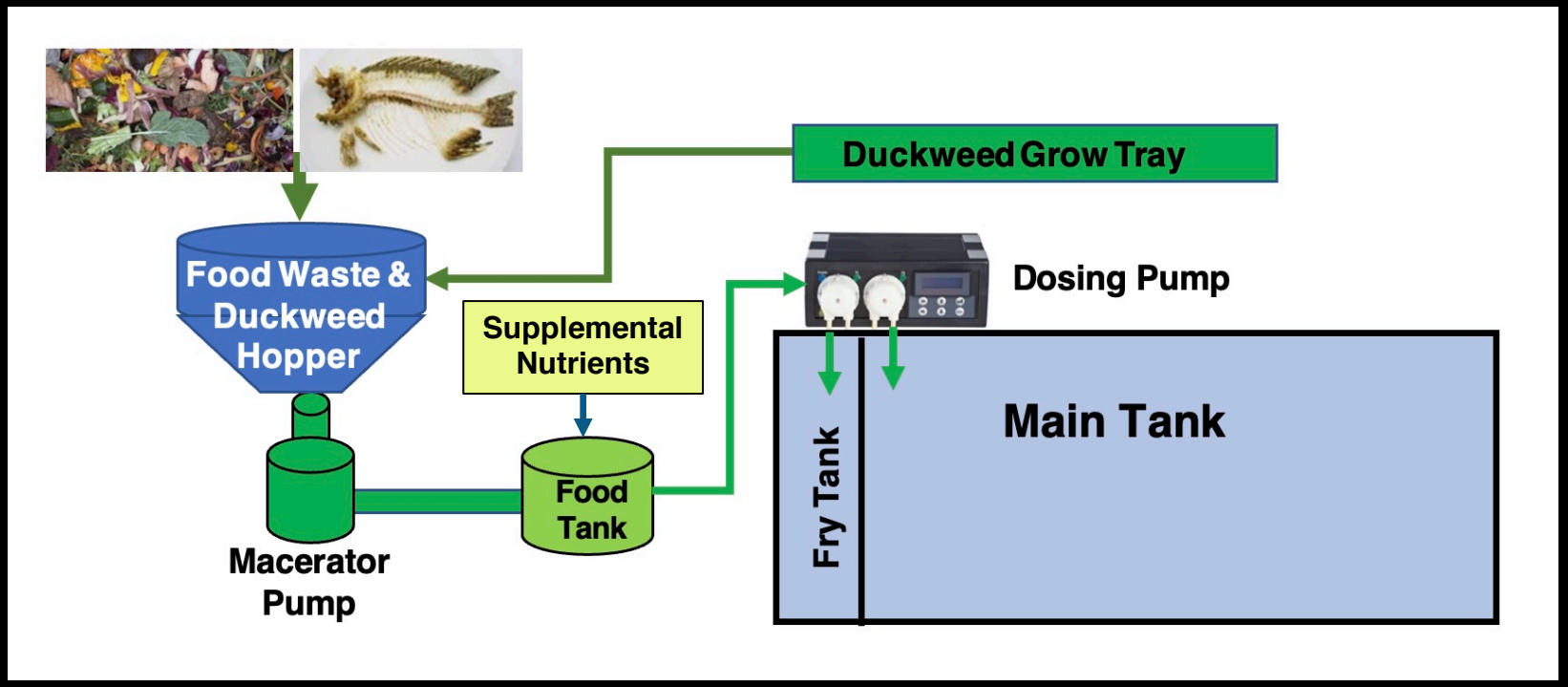
# MEALS Automation



# Full Spectrum Lighting



# MEALS Food Production System



# MEALS Fish Food Requirements

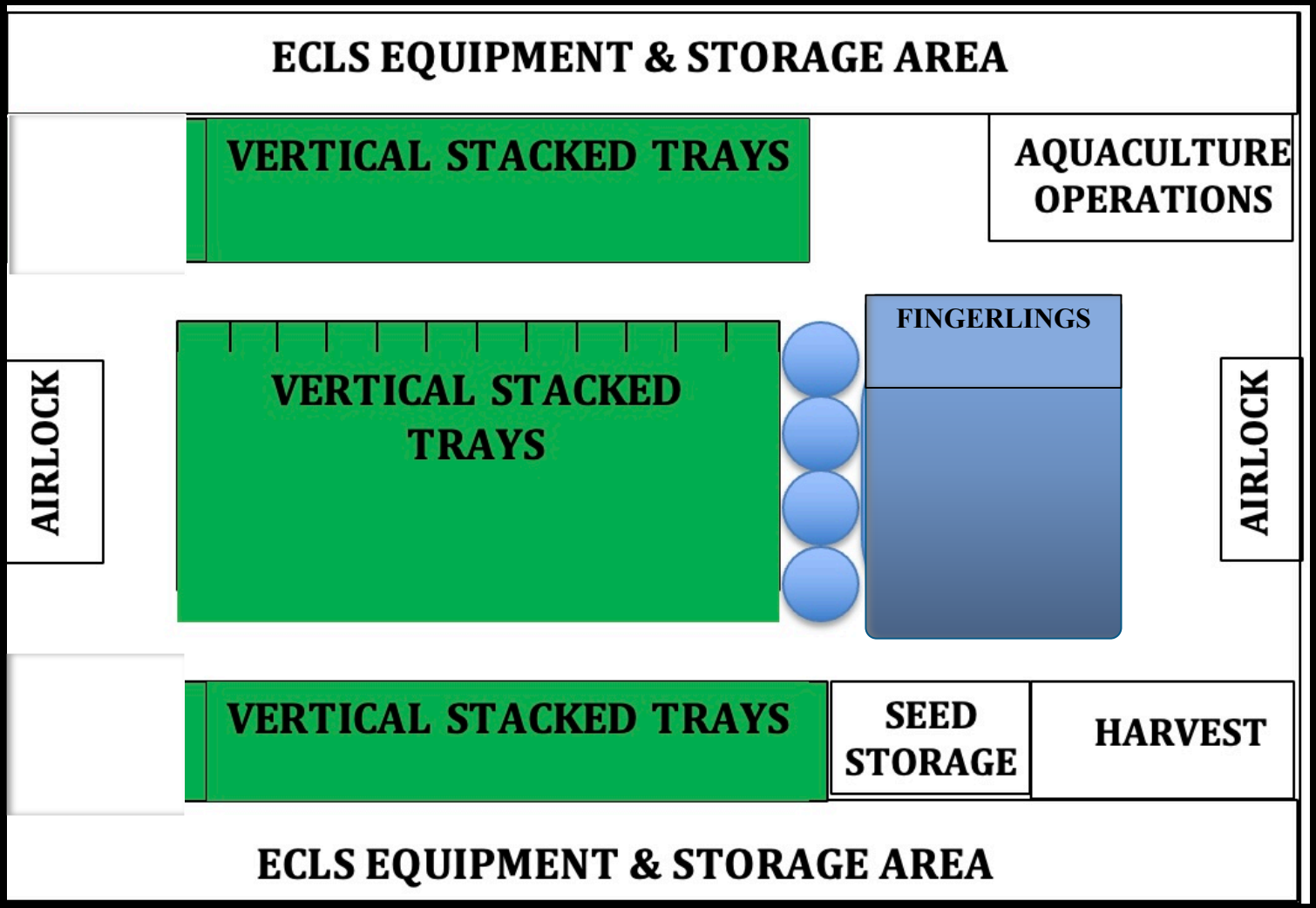
- Goal is to produce as much food locally as possible
- Daily food requirement is 2% of total fish mass of 312 kg
  - =6.24 kg of food /day
- Fish waste is 960 gr; Vegetable waste is 360 gr
- Need 5 kg of Duckweed (@ 3 $m^2$ per kg)
  - 15 $m^2$ is footprint hydroponic stacked beds
- A fifth level will produce enough Duckweed
- Need about 100g/day of concentrated nutrient powder to offset loses to nutrients in extracted food mass

# Meal Preparation

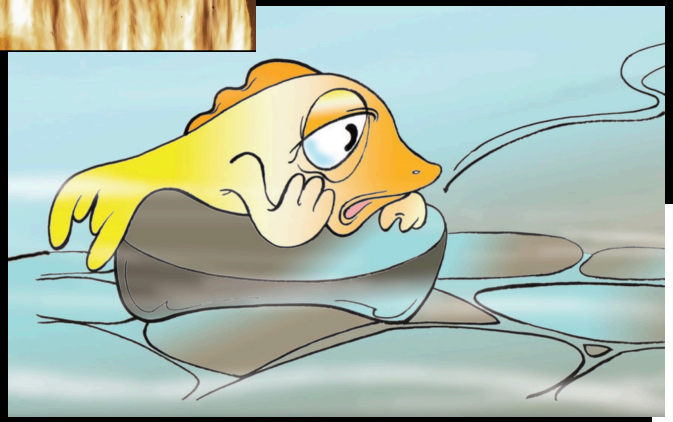
# Mealtime

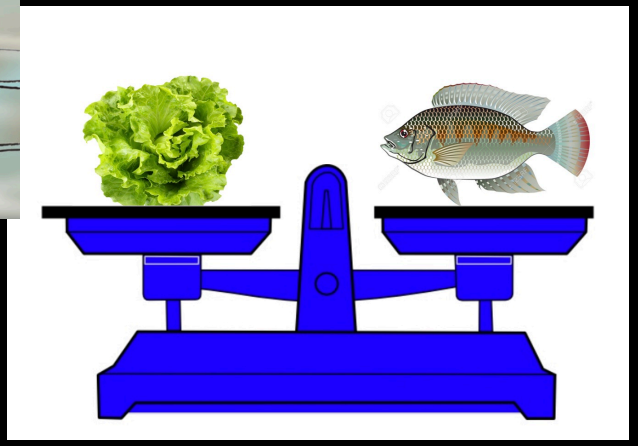

# Other Benefits


# MEALS Habitat Floorplan



# Knowledge Gaps

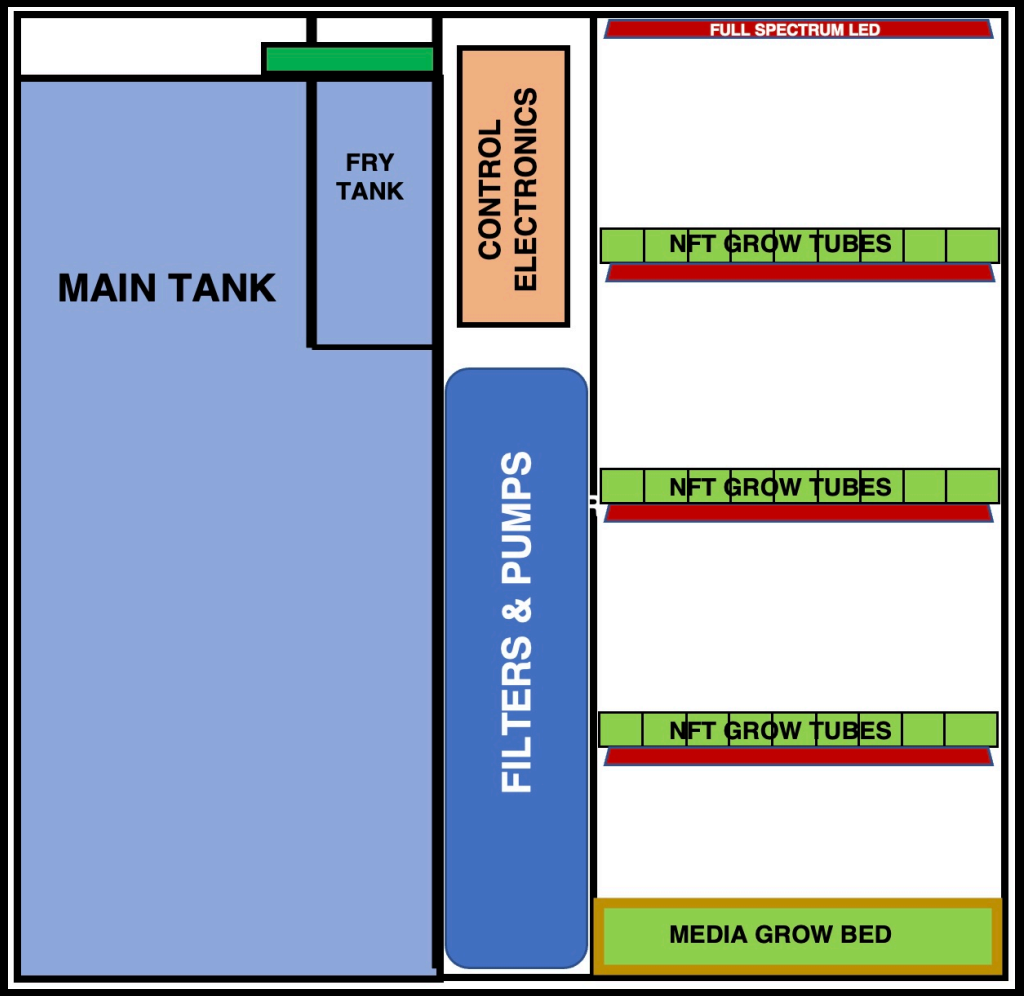




# Next Steps ?

Consider adding a smaller MEALS Demonstration system to the MDRS GreenHab

# Compact Demonstration System



# Thank You
# Questions ?

marsbaseconcepts@gmail.com