What is it? (Specifics)

Aquaculture (raising fish in containers), **plus**

Hydroponics, (growing vegetables in a nutrient solution),

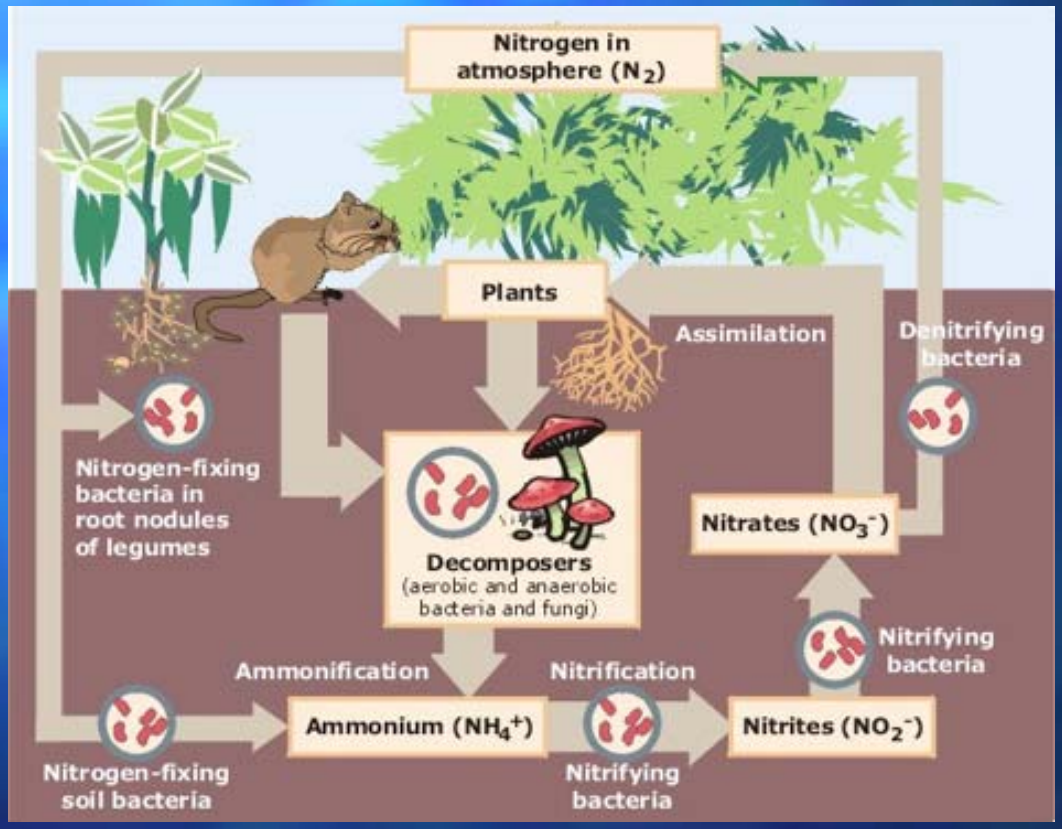
combined in a recirculating system

Equals Aquaponics

What Does It Get Or Do For You?

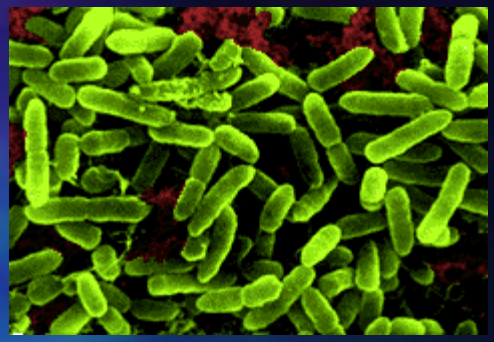
- Uses miniscule amounts of water.
- Does not require soil.
- Uses far less energy than food production in the soil, and all energy used is **electrical**.
- Is guaranteed organic: **no** toxins can **possibly** be used with it (kills the fish!).
- Produces protein (fish) as well as vegetables.
- Is easy to do in small spaces: you can have food freedom in your city backyard (or partial food freedom in your apartment!).
- Is much less work than growing in the ground (~ half!).
- Is easy to teach to others!

The Nitrifying Cycle: In The Ground OR In Water



Temperature's effects on nitrifying bacteria

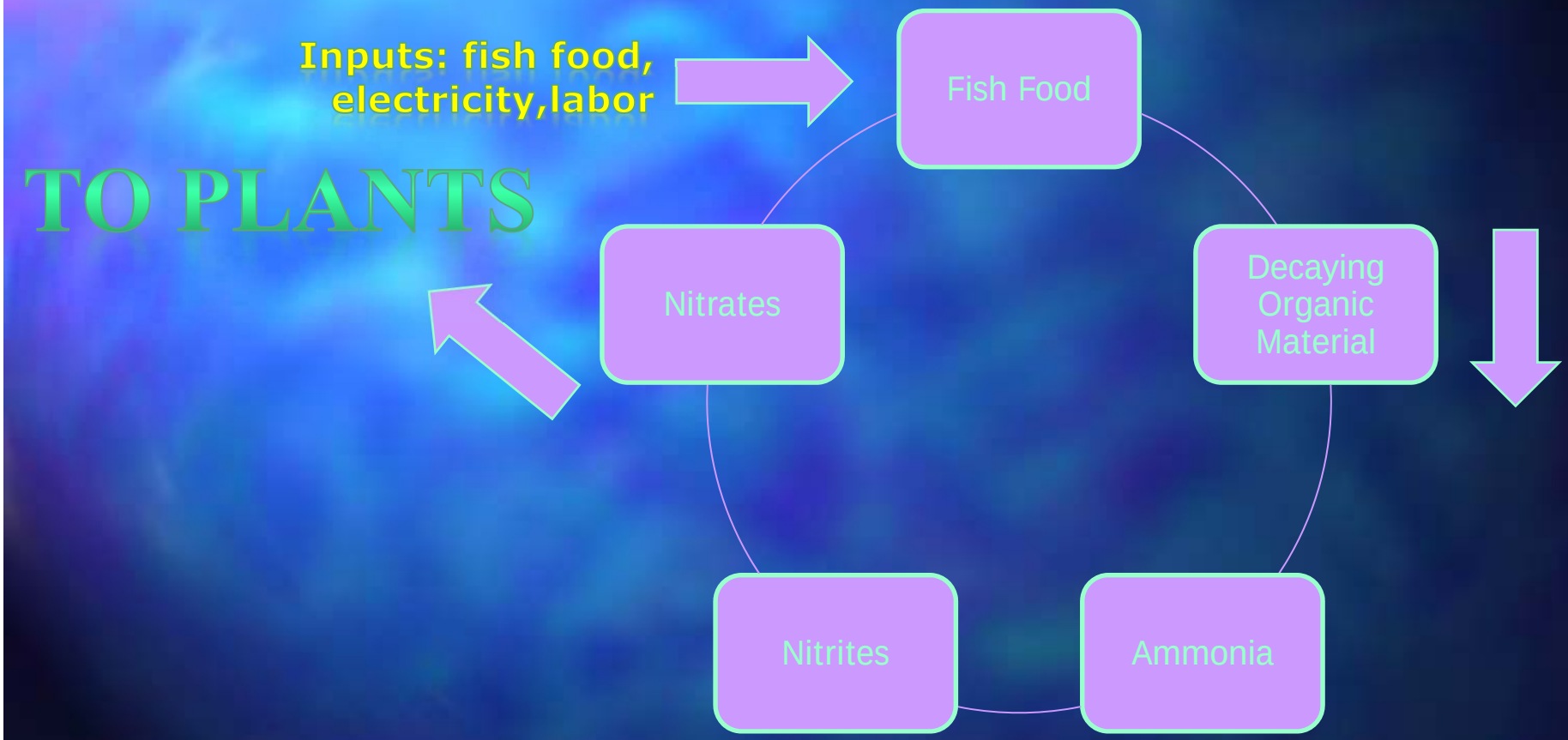
- The process starts with decaying organic material (fish poop, dead mosquito fish, plant roots that fell off a harvested plant), which turns into ammonia through bacterial and chemical processes.
- Next, Nitrosmonas bacteria use this ammonia to make nitrite.
- Then, Nitrobacter bacteria use the nitrite to make nitrate.



(above) *Nitrosomonas* nitrifying bacteria makes nitrites first

(above) *Nitrobacter* nitrifying bacteria makes nitrates next

The Nitrifying Cycle In The Aquaponics System Water



4 Basic Types of Systems:

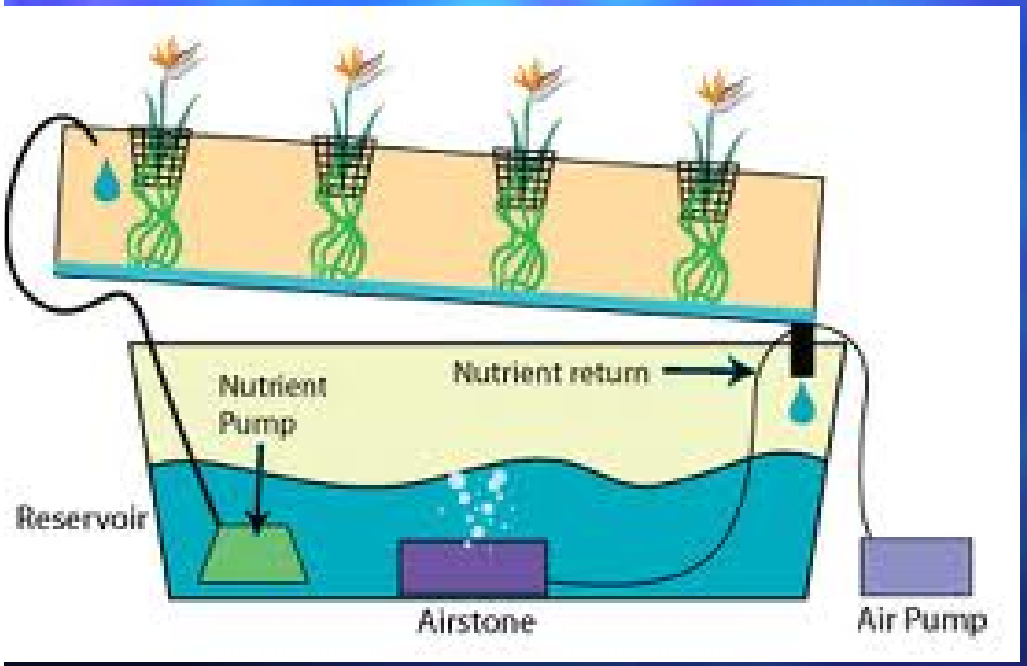
1. NFT (Nutrient Film Technology)

Advantages:

- Grows a lot of plants in a small space.

Disadvantages:

- You have to go to the plants, they don't come to you.
- Small amounts of water in tubes can heat up or cool down fast, easily kiling or damaging plants. Requires a narrow range of climate control, which is expensive.
- Lots of "stuff" costs lots of money.
- Clogs easily in aquaponics use, killing plants.



2. Media Based Systems (AKA gravel bed)

Advantages:

•Grows deep root vegetables such as carrots, potatoes, onions, quite well..

Disadvantages:

•You have to go to the plants.

•Air gets drawn down between the media in each flood and drain “cycle”, and the resulting temperature changes heat up or cool down the system fast, easily kiling or damaging plants and/or fish.

•Lots of “stuff” costs 4 times as much as DWC to build. Larger pumps for multiple trough systems are required, use more electricity.

•Requires roughly 3 times as much labor to operate; time-consuming to cull poor quality plants at any stage of growth (Important!).

•Cost is much more than “raised beds” (growing in the ground), but is not more productive.

3. UVI Deep Water Culture (Rafts): A High Density (Fish) System

Stocking Density: ~ 1.2 pounds of fish per square foot of raft area, and not a chance of making money on the fish.

Advantages:

- Got the aquaponics movement off the ground.
- Plants “come to you”.
- Virtually no temperature change because of huge thermal mass of water.

Disadvantages:

- It needs to be funded, because it can’t make a profit in the real world.
- Note brown areas near troughs. “Roundup” does not allow Organic Certification with its higher prices.

3. University DWC: Additional Costs

(Left) Clean roots

(Below) Dirty and clogged roots

Additional Costs, NO Profit:

- These systems need solids settling tanks, net tanks, degas tanks, sump tanks, larger water pumps, and a LOT more plumbing to keep the roots clean, which = higher construction capital and labor investment.
- Higher operating costs are generated from requirements for more fish food, more electricity for aeration and pumping, and more labor to feed and harvest fish.
- In most locations, fish are a loss item. If they are in your location, it is only sensible to operate an aquaponics system that uses as few fish as possible to grow the same amount of vegetables.
- Fortunately, such a system exists!

4. “Friendly” DWC, A Profitable Low Density Fish System

Advantages:

- Least costly to build by a factor of 4.
- Grows a lot of plants in a small space.
- Plants “come to you”.
- Ability to easily and cheaply cull poor quality plants means much higher production at lower labor costs.
- Virtually no temperature change because of huge thermal mass of water.
- Smallest pumps and blowers required for lowest electricity usage of any system.
- With new “Aquaponics The Easy Way”, system construction cost is closer to 8 times less than NFT or media beds.

4. “Friendly” DWC, A Profitable Low Density Fish System

Lower Construction Costs, PLUS Profit:

- These systems consist of a fish tank and vegetable troughs, period. They use much smaller water pumps, and much smaller blowers. This means less plumbing and equipment, which = lower initial capital and labor investment.
- Lower operating costs because of decreased requirements for fish food, electricity for aeration and pumping, and less labor to feed and harvest fish.

(Left) Where the solids go: the airstone bubbles in the fish tank violently break up the fish poop into pieces small enough to fit through the “window screen size” outflow filters we use.

These tiny pieces go out to the system, where the bacteria can work on them.

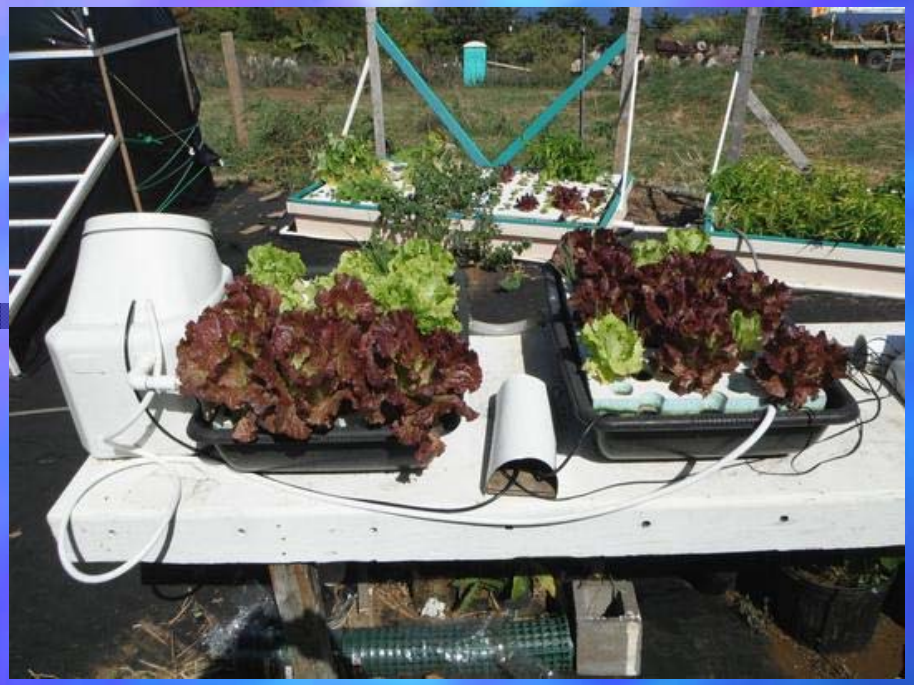
(Right and above) You don’t NEED solids settling tanks, net tanks, biofilters, swirl filters, sand filters, degas tanks, huge pumps, or any of that nonsense, in order to grow lots and lots of profitable vegetables!

Systems Can Be Small And Inexpensive

Table Top System:

"Big Parts" for 6 square foot system,

"Little Parts"



Systems Can Be Small And Inexpensive

Table Top System

"Alive"

Table Top System "Alive", Rear View

Back to back Micro Systems

Systems Can Be Medium Sized and Inexpensive

Systems Can Be Big And Inexpensive

Aquaponics can be operated from alternate energy sources

The cost for the energy for this off-grid aquaponics system (over 20 years) is $150/yr; for energy from the grid, $250/yr (with further price increases).

Aquatic Species

Tilapia (Blue and White)

macrobrachium rosenbergii
(AKA Tiger Prawn)

macrobrachium lar
(Tahitian Prawn)

Chinese Catfish

Plant Selection

Mexican Oregano

Laupele (Samoan Hibiscus)

Leeks And Green Onions (Behind)

Watercress

Plant Selection

The systems grew all kinds of things.

Some things needed a greenhouse/or screenhouse

Some things grew fine in the open

Some things grew really well

Some were a mystery

These systems need fish food, electricity, water, labor, and OCCASIONALLY some chelated iron and calcium carbonate (crushed oyster shells)

Climate considerations for fish selection

- Get a warm water fish (tilapia, koi, catfish, bluegill catfish) for locations that primarily have trouble with heat.
- Pick your fish intelligently if you've got BOTH heat and cold problems, and include how you're going to keep them warm or cool in your thinking. You will need insulation, possibly a greenhouse or enclosure, AND an active heating system for the wintertime.
- You can run an AP system during your normal growing season only, then overwinter your fish in an insulated tank kept at the lower end of their "comfort range"; whether you've got "cold" or "warm" fish.

Climate considerations for fish selection

- Get a cold water fish (trout, yellow perch, channel catfish) for locations that primarily have trouble with cold
- Pick your fish intelligently if you've got BOTH heat and cold problems, and include how you're going to keep them warm or cool in your thinking. You will need insulation, possibly a greenhouse or enclosure, AND an active heating system for the wintertime.
- You can run an AP system during your normal growing season only, then overwinter your fish in an insulated tank kept at the lower end of their "comfort range"; whether you've got "cold" or "warm" fish.

One More Thing

(Above) One of our fine young cannibals; this is why you have to keep smaller and larger fish separate, whether they are omnivorous or carnivorous.

(Left) This is why you have to keep tilapia and other omnivorous fish separate from the vegetable troughs

Economical & Simple Hoop House

- Can extend growing season a month or two in each direction.
- Warmer conditions inside even benefit aquaponic crops in tropical locations such as Hawaii.
- Protects young plants from weather damage (hail, cold rain), and enhances growth during early stages.

(Water) Temperature Ranges and Growth

- Warmer water yields more fish, fewer vegetables, (70-85 degree F water). You need fewer fish per plant because fish metabolize faster. You may need heat-resistant vegetable varieties for the best yields.
- Colder water yields more vegetables and fewer fish, (70-80 degree F water). You need more fish per plant as they metabolize more slowly, AND your nitrifying bacteria slow down their production of “fertilizer” in cold water. Trout and yellow perch work well in water colder than 65 degrees, but ALL fish like DO’s in the 6-7 ppm range.

Sprouting and Planting Systems

- Germination is often variable, ALWAYS test-germinate each time you get a new batch of seeds to check germination
- Conventional sprouting on greenhouse tables is a lot of work; there are better ways.
- Sprouting in aquaponics system's rafts works well but takes up system real estate and results in less overall production.
- Note huge amounts of space between these teeny plants; we developed methods that put far more plants into the system.

Sprouting and Planting Systems (continued)

- Sprouting table system in aquaponics

  sideflow works <u>really</u> well for sprouting and enhances productivity greatly.

Sprouting and Planting Systems (continued)

- Covered sprouting table works even better than uncovered, even in tropical Hawaii!
- This table has “98’s” in it; these are 98-hole nursery trays that we start most plants out in.
- The structure is strong, but the clips holding the plastic on are weak: when there’s a 40-mile and hour wind, it pops all the clips off and deposits the plastic on the downwind side of the sprouting tables, where you can reinstall it after the wind is gone.

Slant grading for slanted troughs saves money on grading and gives you more useful space in the aquaponics area: also makes the aquaponics “footprint” much smaller

Another view with fish tank in foreground

48-Hole,
4-Foot By 8-Foot Rafts!

- Heavy
- Breakable

Raft Hole Spacing And Cycling Tricks

There's about as much root mass as plant mass. If the plants are too widely spaced you will not grow the optimum amount per raft. If too closely spaced you will lose some plant growth due to crowding.

Raft Hole Spacing And Cycling Tricks (cont.)

UVI uses 48 plant holes in a 4-foot by 8-foot rafts. We initially used 128 holes per raft in our lettuce systems in these MONSTER 4-foot by 8-foot rafts (then cut them all into 2 foot by 4 foot rafts).

An early trial using 54-hole 4x8 rafts. Lettuces and *brassica* grew well, but spread out horizontally and attenuated. The yield with these was more per hole, but 50% less per raft than 128 hole rafts (and just look at all the "white space").

Raft Hole Spacing And Cycling Tricks (cont.)

This 32-hole 2-foot by 4-foot raft is our standard. We tried 66-hole and 88-hole rafts the same size to see which was best, but the 32-hole rafts produced the most by weight for the same area.

In a nursery technology, make 110 holes in a 2-foot by 4-foot area. This increases the amount of plants in our existing area by 254-290%.

Fish Disease Problems

- These fish didn't have a disease, they had 24 volts AC in their system water due to a poor ground on a pump motor.
- Minimal disease occurrence in aquaponics fish in the UVI systems, and none in ours in SIX YEARS, (despite ridiculously high levels of ammonia and nitrites that occurred in our "stupidity" events), indicates that disease is difficult or impossible to establish or maintain in aquaponics systems.

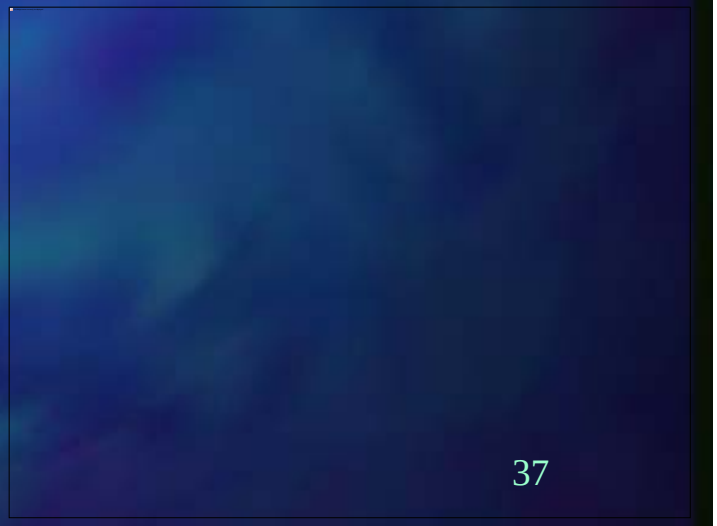
- Our conclusion: the high water quality found in aquaponics systems lowers stress on fish, keeps stock healthy, and sidesteps disease problems.

Where Do You Get The Fish To Stock With?

- Stock with fish you are sure of. If you bring diseased fish into your system it may be difficult to get the disease out
- You don't need to use tilapia or catfish; any fish will work just fine to get your system started.
- Buy fry and raise them to 2-3" fingerlings in a separate tank before putting them into the rearing tank with big fish, or buy fingerlings.

Stocking With Fry

Large Fingerling



Tilapia Quirks

- Don't crowd the fish! Tilapia feed and grow much better if they have the largest fish tank possible: a minimum 3' by 4' rectangular tank. IBC totes are great if you can be certain they're not toxic!
- They like deep water (3' minimum depth) and get nervous in water shallower than 2 feet.
- Tilapia are explorers; you need to manage their explorations with nets/tank covers/high tank sides.
- If you have herons nearby you need to cover your tanks with covers or shade covers that prevent their access to your fish (especially hatchery tanks with smaller fish!). You will lose all your small fish if you don't!
- They're bulletproof: our fish withstood ammonia events of 25 ppm for three weeks, and a nitrite spike of 12-15 ppm for two weeks.