

# Patriot Stockpile

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## Aquaponics and Hydroponics Overview

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**A**quaponics is the science, or practice, of combining **aquaculture** (raising fish, or farming fish in a closed system, like a tub, tank, wading pool or fish tank of any size) with **hydroponics** (raising plants in a soil less system) in one integrated system. That means that fish, plants and water are all contained and grown in one system by utilizing bacteria and worms to balance the system.

Yes. Bacteria and worms. Just like you bait a fishhook with, or find in your garden kinds of worms. You see, fish waste is full of ammonia, and even healthy plants slough off dead matter and leaves daily. Both ammonia and decaying plant matter are problems when fish are grown without plants, and plants are grown without fish. However, aquaponics, where the two systems are combined with bacteria and worms, solve almost all the issues caused by aquaculture and hydroponics!

### Why aquaculture and hydroponics work better when combined

**T**he ammonia in an aquaculture system (fish only) is toxic to the fish. Without a filter and a lot of effort and cost it's difficult and expensive to maintain. Yet adding plants to the fish isn't enough since plants can't use the ammonia either. If you simply cycle fish waste through your system hoping your plants will filter it, you'll kill both your fish and your plants.

Hydroponics, where plants are grown in water without fish, requires the addition of nitrates and fertilizers, which result in the excretion of salts, which build up and can kill your plants. You can over or under fertilize and just like with aquaculture the water must be replaced frequently.

But when you combine aquaculture with hydroponics, add some bacteria and worms, something amazing happens. Few people realize worms are really the critical players in the aquaponics process. They're the ones, along with the bacteria, that actually make the aquaponic magic happen.

In other words, you can put the fish in the tank, the plants in the water and switch on the pump to cycle it all, but without the right blend of bacteria and worms in the system, your setup will fail. The bacteria live on the grow bed medium, and

the worms live in the grow bed of your system. They both have critical roles in an aquaponic system.



A small aquaponic system

## How it all works

In an aquaponic system, the fish's waste and byproducts cycle through a plant bed that contains bacteria and worms. Two types of bacteria living on and in the growing medium convert the ammonia (fish waste) to nitrates. One type converts the ammonia to nitrites (*nitrosomona* bacteria), then the second bacteria converts the nitrites into nitrates (*nitrospira* bacteria). If you've ever grown a traditional dirt garden, you know it's the nitrates that the plants really love.

Once the ammonia in the fish tank has been converted into nitrates then it's pumped up so it flows around your vegetables' roots. Your happy, hungry, nitrate loving plants will then suck up all that freshly converted nitrogen in the water, leaving clean, clear, aerated water to be recycled back to your fish. And the cycle starts all over again.

But wait! While the bacteria are busy converting ammonia into nitrates, the worms are feeding on the plant matter and decaying leaves of your vegetables or other plants. They're also suppressing parasites, pests and plant diseases in the system. Like the bacteria, they too play a role in converting fish waste.

They break up the solid matter from the fish waste that is pumped into the growing bed. They take the solid matter from the fish and the decaying matter from the plants and make the nutrients in them more bio-available to the plants through their excrement: called “vermicompost.” They’re truly the invisible heroes of any aquaponic system.

And so the cycle continues—fish poop, bacteria and worms convert ammonia into nitrates and dead plant matter in bio-available nutrients and the plants suck up the nitrogen and the fish thrive in the clean water. Ah, the cycle of aquaponic life.

Still not convinced? Then consider the Pros of Aquaponics and/or Hydroponics:

- You can’t over fertilize an aquaponics system.
- Water can be used indefinitely
- Water only has to be replaced when it’s lost through evaporation and transpiration
- Aquaponics uses 1/10th the amount of water of traditional soil gardens
- Fewer pests
- Less expensive than aquaculture and traditional gardening
- No weeding
- More difficult for predators to gain access
- Less disease
- No bending to garden
- More productive (four to six times more!)

Not a bad deal! Okay, let’s move on to setting up your system, selecting a container and deciding upon a system, siting your tank, preparing your system, selecting and adding your fish, defending against predators and diseases and finally, harvesting the results of your hard efforts.

## Understanding the Three Systems

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### How to Build Your Aquaponics System

Assuming you have basic handyman skills, and can use a drill, a saw, and assorted screwdrivers and have a weekend or so to build your own, designing and building your own system can help you understand the principles as you go. This will enable you to expand your system in the future. The hard part is deciding which kind of aquaponics system you want to build. There are many systems and designs on the Internet, but you can create your own system by using the components listed below after deciding which system will work best for you.

### Should You Go Horizontal or Vertical?

You can grow up (vertically), or grow out (horizontally) with most of the systems described here. Vertical systems (usually consisting of vertical PVC pipe) are great if you lack a lot of room to spread out. Horizontal systems are also excellent if you want to be able to easily reach your crops, or if you have crops with vines, like strawberries and melons as they can hang off of the columns or pipes.

A vertical aquaponic system can grow more vegetables than a horizontal system if you're limited to the space above your fish tank for growing. By growing vertically, you can produce about twice the amount of plants as you can with a hydroponic system of the same area.

One five-foot tower can produce more than 200 heads of lettuce per year. Don't worry. The production rates are similar for a horizontal system, if you have the room to spread out.

The principles for a horizontal or vertical aquaponics system are the same, it's just the configuration of your system and the containers that are up to you. Once you understand the principle of how the water flows and the system works, you can design any kind of system to fit your property or needs.

Until then, the basic systems and an illustration to follow when constructing them are listed below. You can also skip the do-it-yourself part and simply buy a kit that comes with everything you'll need, except the fish, worms and water.



## 8 Must Have Components for Your System

We've listed these in another chapter, but it won't hurt to repeat the list in case you've skipped right to building your system. Whether you build or buy, these are the components you absolutely have to have for any aquaponics system:

1. A pump capable of moving the amount of water you have through your system. (Tip: You can't go wrong by buying a larger pump than you think you'll need.)
2. Aerator and air stone(s)
3. Container for fish
4. Container for plants
5. Grow media
6. Worms
7. Testing Kit
8. Siphon (only with certain systems)

## Commercial versus Home Aquaponics Systems

Commercial systems are far different and more complex than home systems. They operate on the same principles, but have redundant systems or backups, and more complex controls and systems. If you're ambitious and spatially oriented and handy with both basic electrical and plumbing tasks, the sky's the limit on what you can build. You can also simply save yourself the trouble and buy a kit in any size, from table top to large enough to fill a standard garage.

Whichever system you decide on, commercial or home, remember that they both come in three types of system:

- Media Filled Beds
  - Continuous Flow
  - Flood and Drain
    - Basic Flood and Drain
    - CHIFT PIST
    - Sump Tank Two Pump
- Nutrient Film Technique
- Deep Water Culture

Which system is best depends on you and your needs. Regardless of which type of system you decide to use, they all consist of a closed loop that incorporates fish, plants worms and bacteria.

If you still can't decide, then think about the flood and drain media based system. It is the simplest and most reliable of the different types of aquaponics systems. It's also the lowest maintenance, least expensive and easiest to set up. These factors make it the best choice for a home aquaponics system, especially for beginning aquaponic farmers.

## Media Filled Beds

A media filled grow bed is the most popular and common system for small aquaponics systems. It consists of a tank, a grow bed, media and a pump to circulate the water through the growing media. Water from the fish tank is pumped into the grow beds where the bacteria and worms turn the ammonia in the water into nitrites, then nitrates which is filtered back through the grow bed where the plants consume it and grow.

Media Filled Beds Can Be Horizontal or Vertical. You can use containers that let you grow up (vertically), or grow out (horizontally). Vertical systems are great if you lack a lot of space, horizontal systems are excellent if you want to be able to easily reach your crops.

A vertical aquaponic system grows vegetables in columns above your fish tank. By growing vertically, you can produce about twice the amount of plants as you can with a hydroponic system of the same area. One five-foot tall tower of PVC pipe configured to hold plants can produce more than 200 heads of lettuce per year. Don't worry. The production rates are similar for a horizontal system.

There are two types of media filled systems:

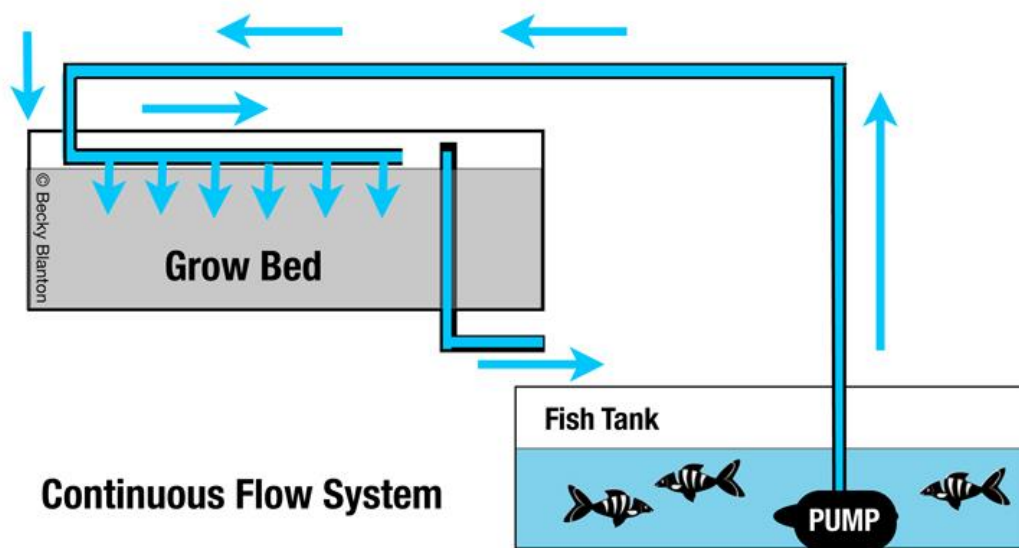
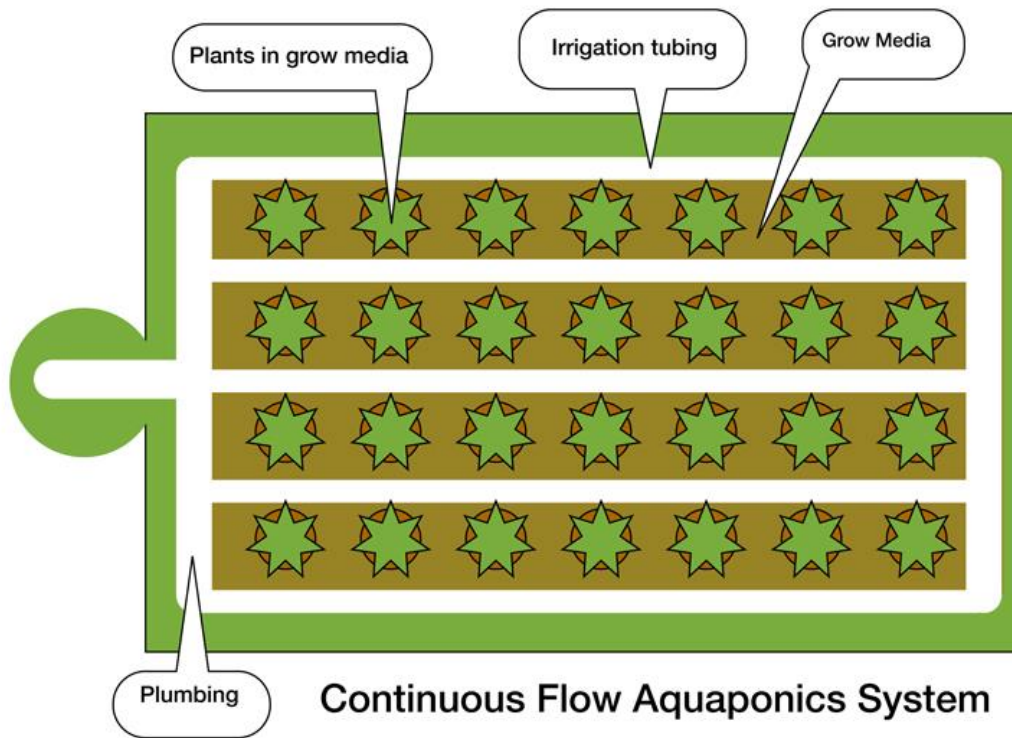
- Continuous Flow
- Flood and Drain

## Continuous Flow

In the continuous flow system water is pumped from the fish tank to the grow bed. It's what most people envision when they think about aquaponic systems. The water drains through the media and back into the fish tank. Easy and simple. All this type of system needs an irrigation grid consisting of pipes placed over the grow bed to

ensure there is an even distribution of water, otherwise most of the media will stay dry and other parts of the media will stay soaked.

Here's a top view and a side view of a continuous flow system.



## Flood And Drain

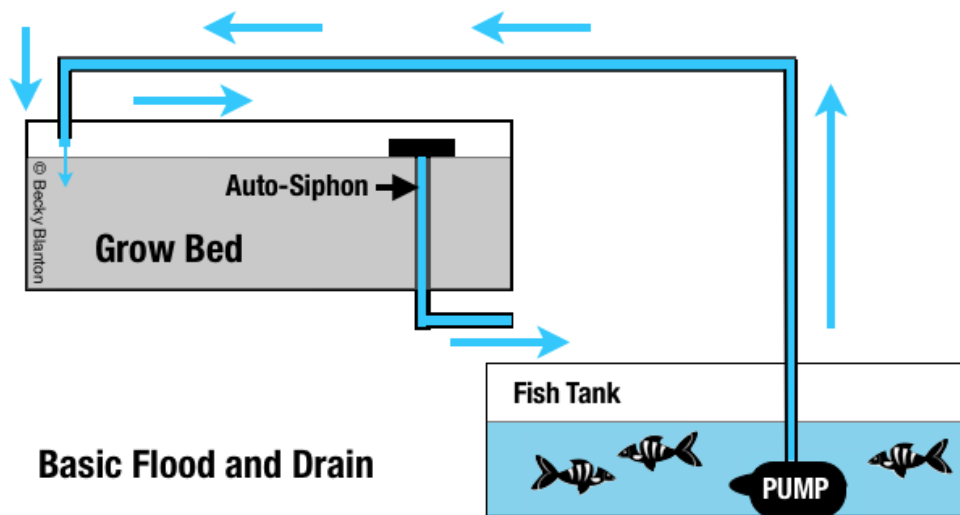
There are three types of flood and drain aquaponics systems:

- Basic Flood and Drain
- CHIFT PIST
- Sump Tank Two Pump

### Basic Flood and Drain

**B**asic flood and drain systems work just like the name says. Water is pumped from the fish tank into the media grow beds which are allowed to fill up, and then drained. These cycles repeats using an automatic siphon, or a timer that operates a pump. The siphon requires no electricity and is thus more popular with growers, but it's also a little more difficult to set up and adjust properly the first time around.

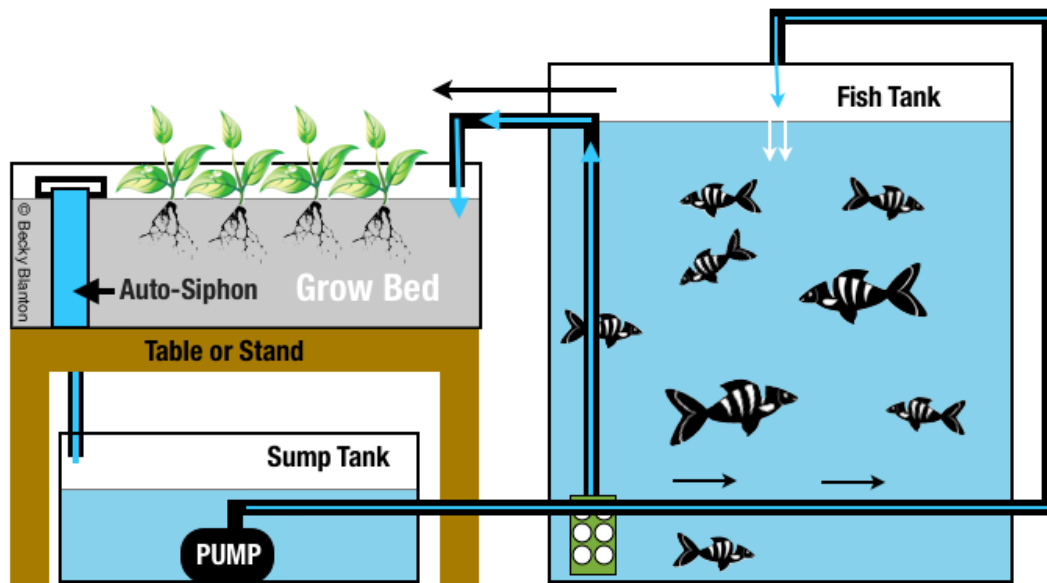
The good thing about flood and drain systems is they are the simplest and also provide the best growing environment for the plants. The alternate flooding and draining allows oxygenation of the grow beds which is great for the plants, worms and nitrifying bacteria. Also, because the grow beds get completely filled each cycle there is better nutrient distribution and no dry spots.



### CHIFT PIST (Constant Height In Fish Tank - Pump In Sump Tank)

In a CHIFT PIST system a sump tank is added to the usual grow bed and fish tank set up. The pump is placed in the sump tank instead of the fish tank. Water is pumped from the sump into the fish tank, then flows out through an overflow, and then into the grow bed. Once in the grow bed water drains back into the sump tank. The sump tank keeps a constant water level in the fish tank.

The down side to this system is that the sump tank needs to have low sides, but a large volume too. That makes it hard to find the right container. In CHIFT PIST systems the fish tank has to be raised too. That means you need a very strong stand because of all the weight of the water and the tank.



**CHIFT PIST System**

It sounds like a lot of trouble, but it's worth it. The solids go into the sump tank, so your pump will last longer and won't ever get blocked. The main pump in the sump tank is a true pump, meaning it actually pushes water up or up hill through a pipe. And like all pumps, solids will block it.

The true pump pumps water up into the fish tank. From there the fish tank overflows into the grow beds. From the grow beds it drains into the sump tank.

The second pump, located in the fish tank, is not really a pump at all, but more like a propeller, so it won't get blocked by solids. It's called a power head, and its sole purpose is just to agitate the water in order to oxygenate it.

The advantages of a CHIFT PIST aquaponics system are...

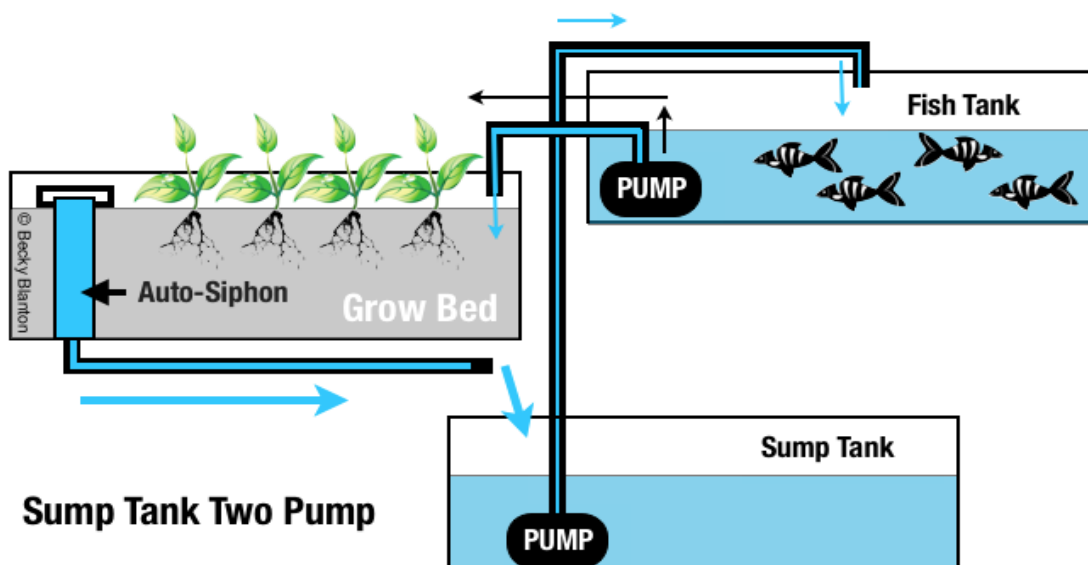
- Other than the overflow pipe the fish tank has no holes in it so no leaking unless you crack or rupture the tank somehow
- High water levels all the time keep the fish happy. More water in the system because of the sump gives you a more stable system and acts as a buffer, giving your system more time to sort out extremes in water conditions.
- The fish tank has no pump in it so not a lot can go wrong with it (just the power head propeller thing).

The pump is in the sump, where the water is clean and filtered and free of fish solids

## Sump Tank Two Pump

In the Sump Tank Two Pump system you have two pumps, a fish tank and a grow bed tank. You put one pump in the sump tank, then add a second pump in the fish tank. Water is pumped from the fish tank into the grow beds. It drains from the grow bed into the sump tank.

From the sump tank it's pumped back into the fish tank. The difference in this system is that the pump in the sump tank is switched on after the water reaches a set level. That level triggers a float valve that cuts the sump pump on. If the pumps fail or there's a power outage things could get bad as one or more tanks could overflow

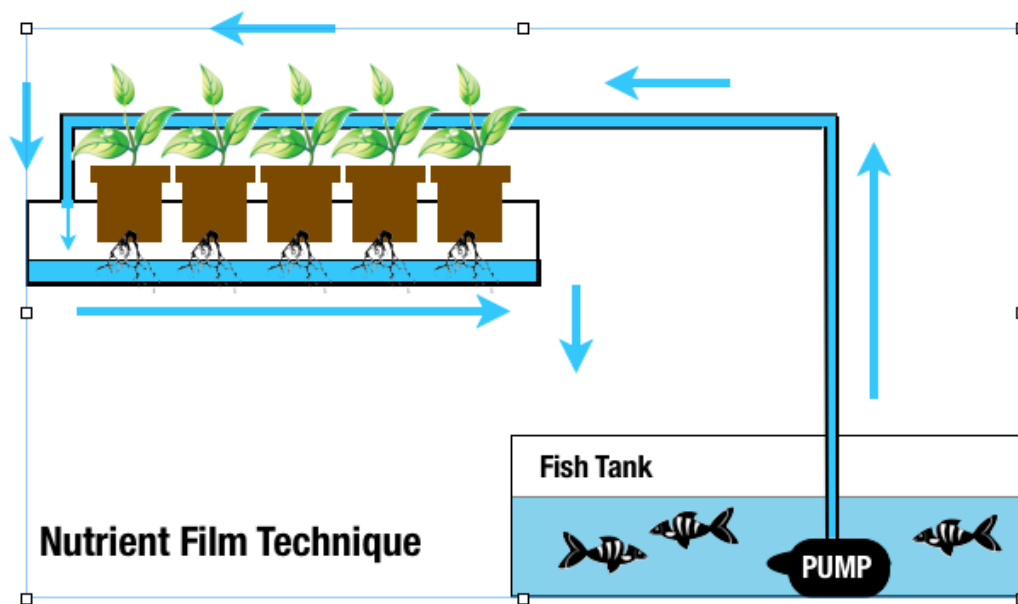


## The Nutrient Film Technique (NFT)

The Nutrient Film Technique is a commonly used hydroponic method, but is not as common in aquaponic systems as the ebb and flow or media filled system. Still, in the right system it works very well. In NFT systems, nutrient rich water is pumped down small enclosed PVC pipes (see below).

The water is a trickle, not a flood of water. All the water flowing down the gutter results in a very thin film of water. Plants sit in small plastic cups or baskets filled with a grow media. This props the plants up while allowing their roots to access the water flowing through the pipe. Their roots absorb the nutrients 24 hours, 7 days a week, or as long as the power is on.

While easy to set up and particularly easy to harvest plants, or swap them out if you choose, it's really a system better suited for lettuce and shallow rooted plants like herbs. Plants with larger root systems will clog up the pipes, and become too heavy for the pipes or rain gutters that some people use.



Lettuce and herbs in a NFT system



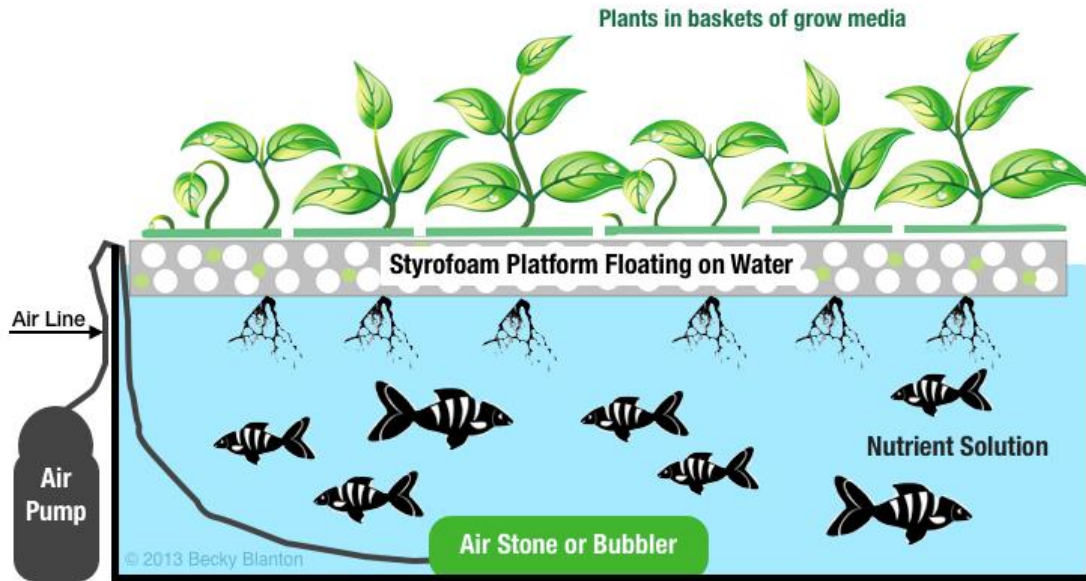
The hobby or small home grower can use the NFT system, although it's mostly a commercial system design. If you chose this design, be sure to filter your water from the fish tank before pumping it into the NFT channels. Unfiltered water from the fish tanks will contain many particulates which will attach to the plant roots. The water will still flow okay, but the particulates will ultimately stop the roots' ability to absorb nutrients from the water.

## Deep-water culture (DWC)

**D**eep Water Culture is the most common system in commercial aquaponics because it's easy, fast and inexpensive to set up and grow a variety of lettuce, herbs and shallow root system plants. That's also why a lot of home growers like it too! It works on the idea of floating plants on top of the water allowing the roots to hang down into the nutrient-rich water.

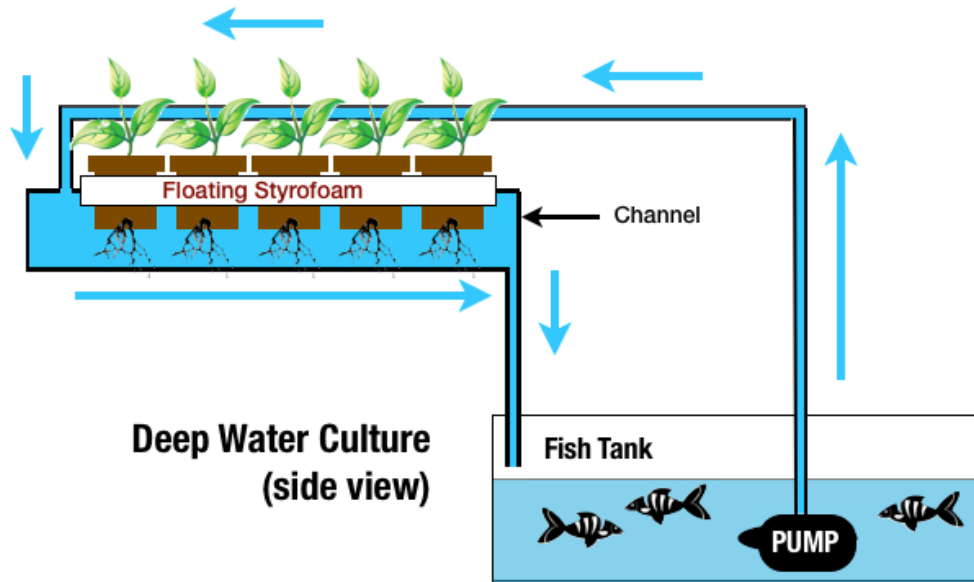
DWC can be done by floating a foam raft on top of your fish tank, making sure to allow enough space for the foam to move up and down as water levels vary (fig. 1). Depending on what kind of fish you have, you may find the fish eat your plant roots,

Most growers grow the fish separately and pump the water through a filtration system and then into pans or beds where floating rafts filled with plants float on the water's surface. (see below) Even if you use the system where the fish are separate, you still need to filter your water before it reaches your floating plants. Particulates and solids in unfiltered water will clog up the root systems of the plants, keeping them from getting the oxygen and nutrients they need to thrive.



### DEEP WATER CULTURE SYSTEM

Deep Water Culture by floating a foam raft directly on top of fish tank.



Deep Water Culture by floating a foam raft directly on top of fish tank.

These are the primary systems you'll deal with when creating your own system. While actually building your system isn't difficult if you are familiar with basic construction techniques, it can take a weekend or longer to design and set up your system, depending on the size and which system you've selected.

If you're not comfortable with generic illustrations or creating and designing your own, but prefer to have drafted and measured designs, there are literally thousands of free plans and videos on the Internet you can download, or you can buy designs from many of the larger aquaponics suppliers.

You can also purchase a complete kit that comes with instructions and walks you through the process step-by-step.

## What Kind of Container Can I Use for My Aquaponic Setup?

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Anything that will hold water without leaking is pretty much fair game for an aquaponics system, so don't be afraid to get creative. They don't have to be transparent, like an aquarium, although if you want that consider that clear sides allow your water to heat up faster, not a good thing for all fish.

Things people around the world have used for aquaponic systems:

- Bathtubs
- Barrels (wooden, fiberglass, plastic and rubber)
- Intermediate Bulk Containers (IBC)
- Rubbermaid or other "tote" containers
- Kids' swimming or wading pools
- Livestock watering and/or feed troughs
- Concrete mixing tubs
- In ground swimming pools
- Ponds
- Trash cans

Use your imagination. The only thing you'll have to think about is whether or not you can install a drain in it, or if it has a drain. It's not required, but it can make it a lot easier to get water out if you ever have to. We've seen mini-aquaponics systems consisting of a 10-gallon aquarium and a pan of herbs growing in a tray on top.

The question you need to answer is how many pounds of produce and fish do I want to produce? The larger your system, the more, theoretically, you'll produce. It doesn't matter if your system is vertical or horizontal.



Plastic in-ground ponds can be used above ground as well if you want a small system (above and below)





Children' s wading pools come in various sizes and also make good aquaponic starters as well as growbed media for a larger tank.



Steel livestock watering tanks make great starter tanks for aquaponics systems. There are also rubber versions.

Hands down though, the most popular aquaponics container for first time (and experienced growers is the IBC (Intermediate Bulk Container).

## The Intermediate Bulk Containers (IBC)

These containers seem to be the most popular among do-it-yourself aquaponics farmers doing things on any scale—from one tank to dozens. They're affordable, easy to transform, are sturdy, stackable and durable.



An IBC before being repurposed for use as an aquaponic container.

The IBC can be purchased new or used. If you purchase a used one (just Google IBC Containers. They are available used, new or already converted into aquaponic systems), make sure you know what substance was used in it before you got it. This should be on the side of the container on a label.



Check the label against the Material Safety Data Sheet or (MSDS) to make sure whatever substance was in it is not toxic to your fish, plants or you. If you do buy a used IBC you'll have to clean it out (do this after cutting the top off, it's so much easier). MSDS sheets are available online at: <http://www.msdsonline.com/>

If you buy a new IBC from a manufacturer or supplier, you can just rinse and clean it and not worry about what was stored in it before you got it.



A TableTop Aquaponics system can give new growers a chance to experience aquaponics on a small scale. Photos courtesy of <http://store.backtotheroots.com>





A TableTop Aquaponics system can give new growers a chance to experience aquaponics on a small scale. Photos

courtesy of <http://store.backtotheroots.com>

The aquaponics principles for a horizontal or vertical aquaponics system are the same, it's just the configuration of those principles that is up to you. Once you understand the principle of how the water flows and the system works, you can design any kind of system to fit your property or needs.

Until then, the basic systems and how to build them is listed below. You can also skip the do-it-yourself part and simply buy a kit that comes with everything you'll need, except the fish, worms and water.

## Building an Aquaponics Tank with an IBC (Intermediate Bulk Container)

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Food Grade, IBC Tote Container

### 10 Tools You'll Need to Convert Your Container into a Flood and Drain Aquaponics System

An IBC can be converted into any kind of aquaponics system, but the simplest, easiest and cheapest way to convert your IBC is to turn it into a “flood and drain” system, which is what we’re doing here. A pump on a timer will cycle 30 minutes on and 30 minutes off, flooding the grow bed media before draining back into the fish tank.

1. A screwdriver with a regular, hex, and/or torx head
2. Pliers or boxed or open-end wrench
3. A metal cutter (Sawzall, Dremel, Disc cutter, hacksaw, welding torch etc)

4. Drill and metal drill bits in assorted sizes
5. Hole cutter
6. PVC pipe for plumbing your system
7. Zip ties (varying lengths from 12-inches to 24-inches)
8. Sharpie or other permanent marker
9. Metal snips
10. Plumbing and Fixtures

## Step One—Obtain a Food Grade IBC

Obtain a food grade, Intermediate Bulk Container Tote. (IBC). These food containers are used to ship everything from motor oil to olive oil, toxic chemicals, wheat, sugar and all matter of bulk items, including food and/or chemicals. Look on Craigslist, eBay, the Internet and anywhere people sell used items. You can also buy them new from various manufacturers if you absolutely want to ensure you get a safe, non-toxic, food grade container. A used IBC container will sell for anywhere from \$25 to \$150 and up, depending on the condition, the seller and whether you pick it up or have it shipped to you.

If you buy a used IBC make sure you get a FOOD GRADE container. You can tell if it's food grade by looking at the label that comes on the metal panel of the cage. If you can't tell what was in the container, or the label is missing, pass on it. Find another one. They're not rare that passing up one with unknown ingredients is a loss. It's your health.

Make sure the container has its cap and that the cap is not cracked, chipped or broken, as this will be the cap you use to drill a hole in and insert the plumbing and stand pipe of your system through.

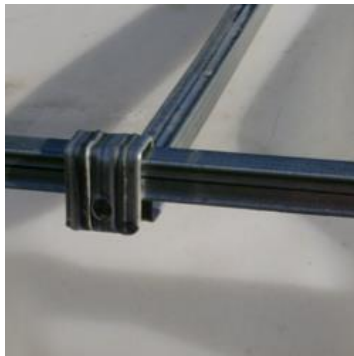
A cracked cap will leak or fail, meaning you'll have to find another. If possible check the tank over as thoroughly as possible for cracks, punctures, soft spots or suspicious areas that may fail. Some IBCs are treated more harshly than others so take your time looking them over if you can. If you can't look it over, then ask the seller to guarantee it's leak free and in good condition.

If you're buying a used IBC, ask that the original shipping label be left on it to ensure you're getting a container that was used for food grade materials. There's no guarantee someone didn't swap them out, but it's not likely. Steer clear of any containers in which you have no way of determining what was shipped. Better to

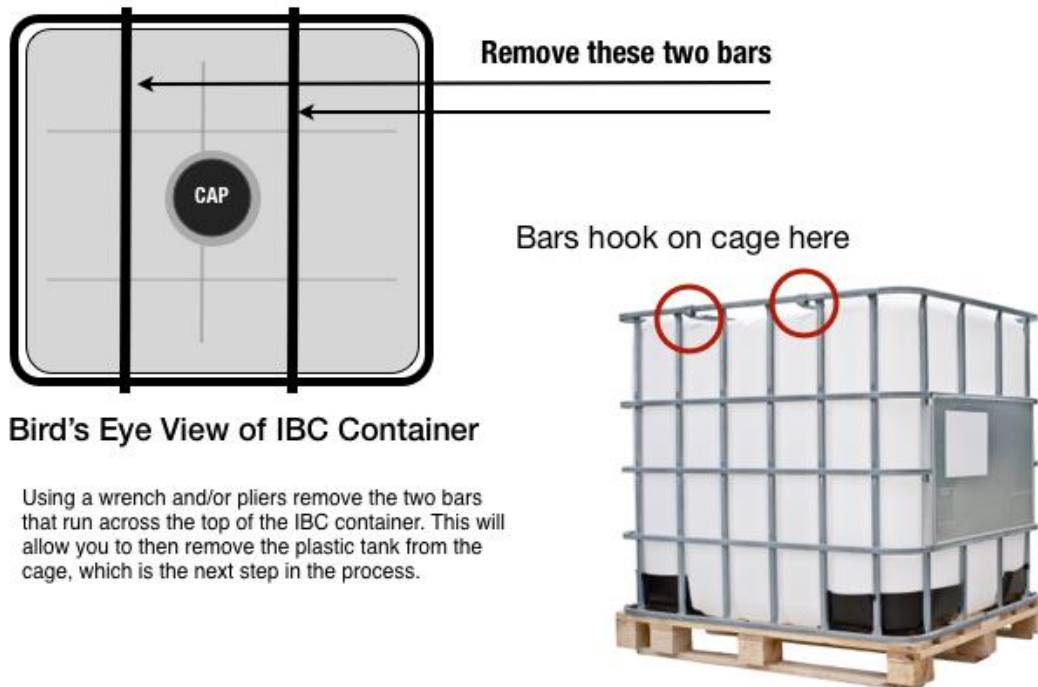
avoid any toxic substances which could leach out of the plastic into the water, the fish and ultimately into you through your ingestion of fish and plants.

## Step Two—Remove Top Bars/Brackets

**R**emove the two upper bars that run across the top of the tank, holding the plastic tank in the cage. You'll need pliers, or a wrench, and a screwdriver (possibly a Torx or other type of screw drive. (See fig. 1. A bolt goes through the bar resting on the top of the cage)



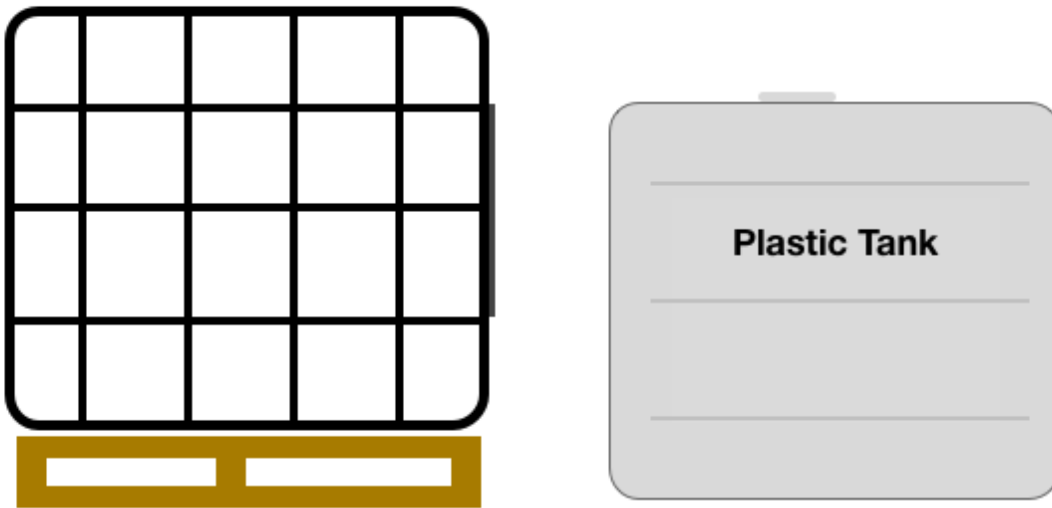
One of the two bars that must be removed.



### Step Three—Remove Plastic Tank from Cage

Once you have the bars off of the top of the IBC cage the next step is easy. Just pull the plastic tank out of the cage and set it to one side. This is best done by turning the IBC on its side and pulling the tank out rather than trying to lift it out. Don't worry about scuffing the tank as that won't hurt it.

### Side View of IBC Container



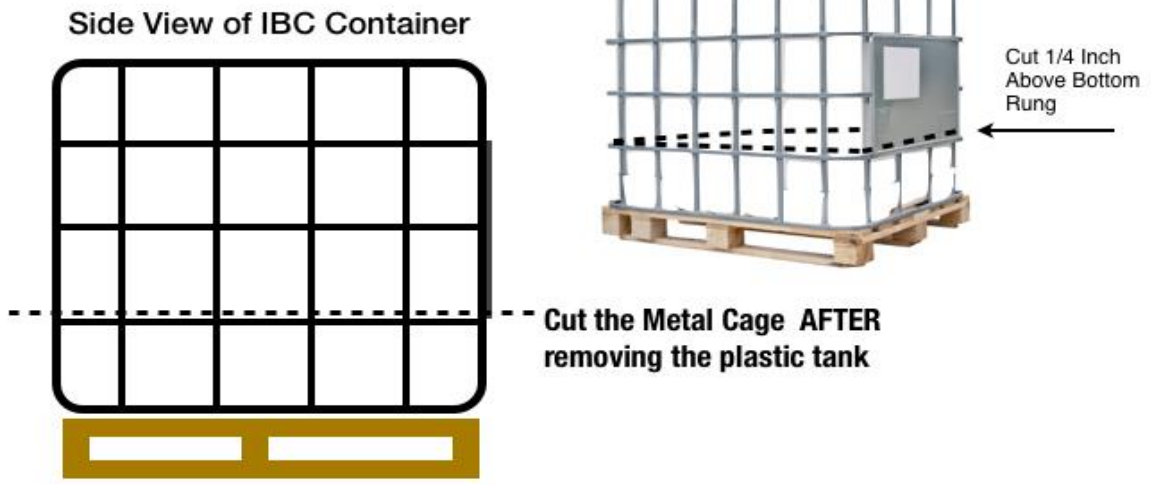
Pull the Plastic Tank Out of the Metal Cage and set it to one side while you move to Step Four: Cutting the bottom off of the Metal Cage.

## Step Four—Cut Bottom of Cage Off

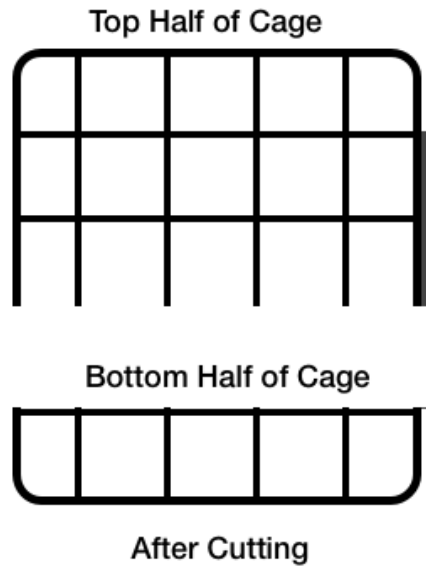
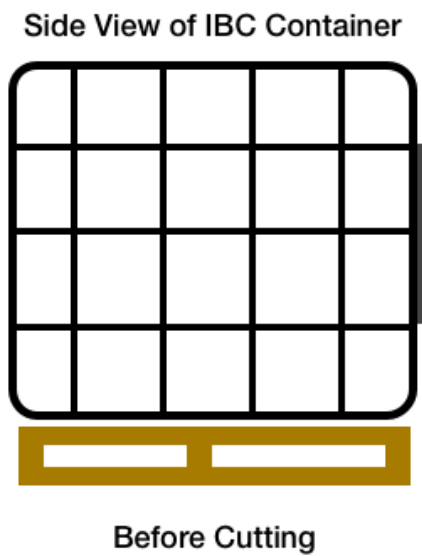
Once you've removed the plastic container from the metal cage, use a sawzall, hacksaw, Dremel tool, disc grinder or whatever your favorite tool for cutting aluminum bars is.

Cut off the bottom section of the cage right above the bottom rung. Many of the videos you will see online will show people cutting off the top half of the cage, but this just means you have to grind down the sharp edges and then fashion some sort of railing or surface on that edge.

By cutting off the bottom of the cage the cut parts will rest on the ground, concrete pad, gravel or whatever surface that your cage and pose less of a hazard. This also leaves you with a level surface on which to rest your grow bed.

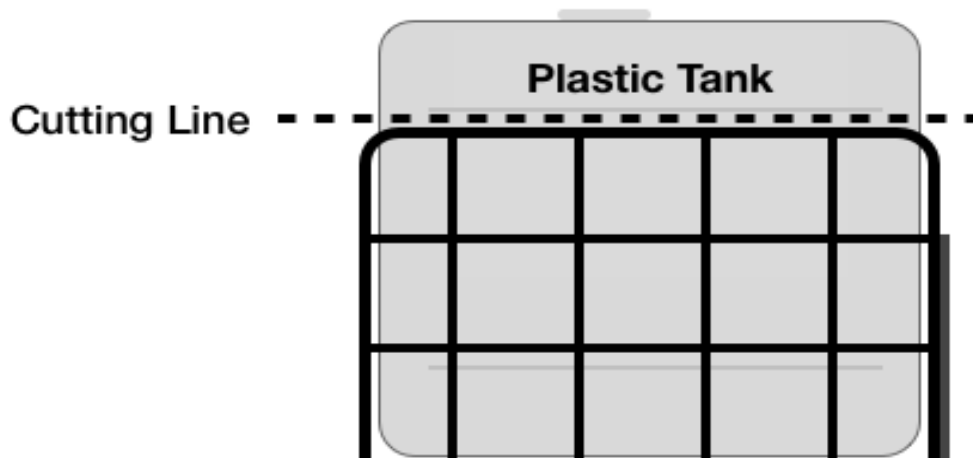


Using a hack saw, sawzall, disc grinder or similar too, cut the bottom half of the metal cage off just above the bottom rung (1/4 inch) and separate the two pieces. This bottom unit will become what holds your grow bed.



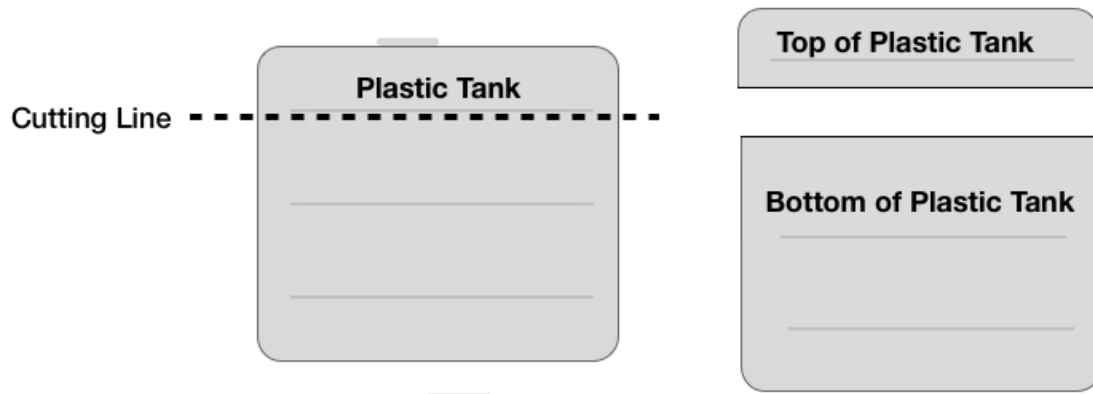
## Step Five—Mark and Cut Plastic Tank

Now that your cage is cut, it's time to put the plastic tank back into it for marking your cut line. Get your Sharpie or other permanent marker out. You can also do this by measuring the plastic outside the tank and using a straight edge (ruler or yardstick etc.) to measure and mark around the plastic, but setting it back inside the cage is more accurate and a bit faster. Notice the cage rests lower on the plastic since you've removed the bottom quarter.



Once you've drawn your line around the tank, pull the plastic tank out of the cage, or lift the cage off of the plastic and get your sawzall, knife, disc cutter or cutting tool and cut along the line you've just drawn in order to cut the top half of the tank off. When you finish you should have two halves, the top half with the lid is your grow bed, the bottom half will be your fish tank.





## Step Six—Clean Your Tank

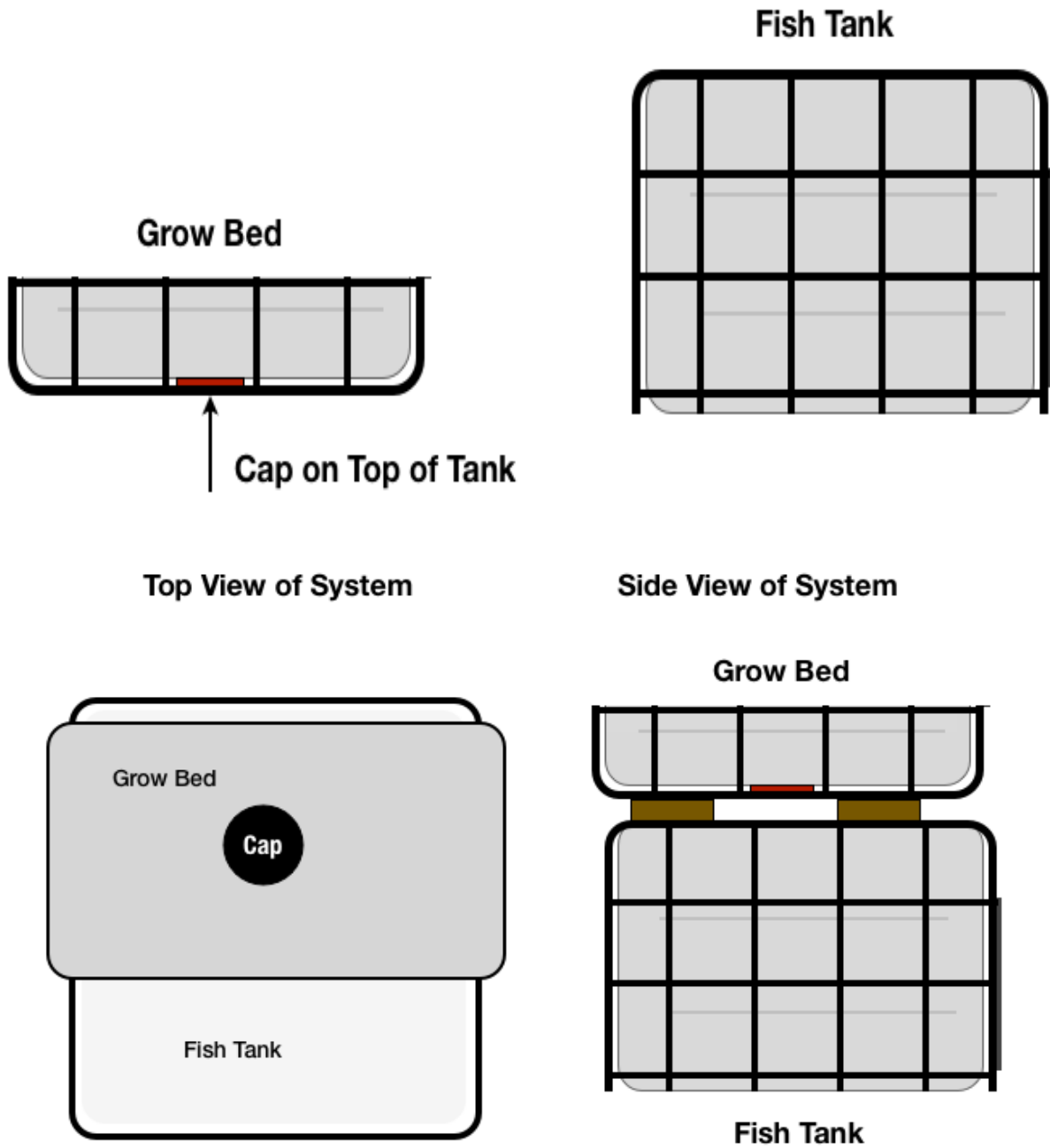
Now that you have two open, easy to access halves, it's time to clean and scrub each half out. No matter what the food or other bulk substance inside was, there is residue left on the plastic and inside the tank that needs to be thoroughly scrubbed out and the tanks rinsed well. Use a power washer if you have one.

If you don't, good old scrub brushes and scrubbing pads and lots of dishwashing soap, powdered soap and other household cleansers will work. Be careful about using bleach unless you know that it won't interact with whatever was in the tank before. If you do use bleach (vinegar works just as well), be sure and rinse your tank well and allow it to dry in the sun for a couple of days to let the chlorine gas off before adding water.

## Step Seven—Assemble the Tank

Now your IBC looks like the aquaponics system you envisioned! You can add wood railings and decorative features later, but this is what your finished project will mostly look like after you:

- Turn the top half of the plastic tank (the shorter half) upside down and place it in the bottom half of the metal cage you just cut off. This section will be your grow bed. There's still more to do with it, but this will give you an idea of what it will look like when it's done.
- Set the bottom half of the plastic tank into the bottom half of the metal cage. This is your fish tank.
- Set the grow bed assembly on top of the fish tank.



Depending on whether your IBC is square or slightly rectangular, you may have to use 2x4's to span the top of the fish tank (see illustration right) in order to rest the grow bed on top of your unit, or if the IBC is rectangular, simply turn the grow bed sideways (see illustration left) and place it on top of the bottom half of the cage.

Once you fill the grow bed with your growing media the weight of the top tank should hold it in place, but you may want to secure it in place in the meantime with some plastic zip ties so it doesn't move around while you're filling it.

Before you assemble and zip tie the top in place you have one more step to go—drilling a hole for your drain and fill fittings in the the bottom of the metal support of the grow bed tank and/or the plastic tank (IF you are not going to use the cap as a hole).

Remove the round lid to the tank. Check to see if the “O” ring in the lid is still intact. If it is not, or if it is missing replace it with a new O-ring, or simply wrap the threads with plumber's tape and/or 100% silicone to create a new seal so the lid doesn't leak.

Next it's time to create the drain hole. You have several options:

- Measure the distance to the center of your metal bottom and cut a hole (square is fine) with your metal snips, or disc cutter or sawzall that is large enough to accommodate your cap.
- Remove the lid or cap and, using a Sharpie or marker, trace a circle onto the metal through the opening and onto the metal. Cut that metal out using tin shears, a disc cutter or hack saw etc.
- Leave the cap in place and drill two holes elsewhere (usually in one quarter of the tank) and use commercially available drain and fill fittings (<http://aquaponicsstore.com>) instead of the cap.

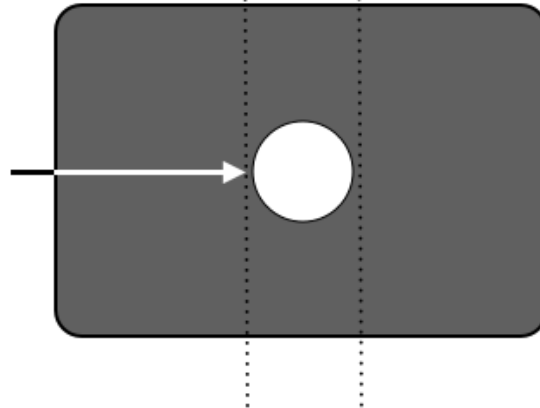
You can make your own drain and fill fittings and media guard (to keep the grow bed media from clogging your drain, or you can buy them. They're not very expensive, usually \$3.95 to \$10 depending on how elaborate you want them, or you can make your own out of PVC pipe or heavy wire mesh screen. This step is entirely up to you and your preferences.

Most lids come with a removable center. Take your lid to your local home supply or plumbing supply store and buy a length of PVC pipe (or cut a length from pipe you already have) that will fit snugly into this center hole without cracking or splitting the lid. The PVC pipe should be at least 18-inches long.

### Side View of Metal Cage Container for Grow Bed

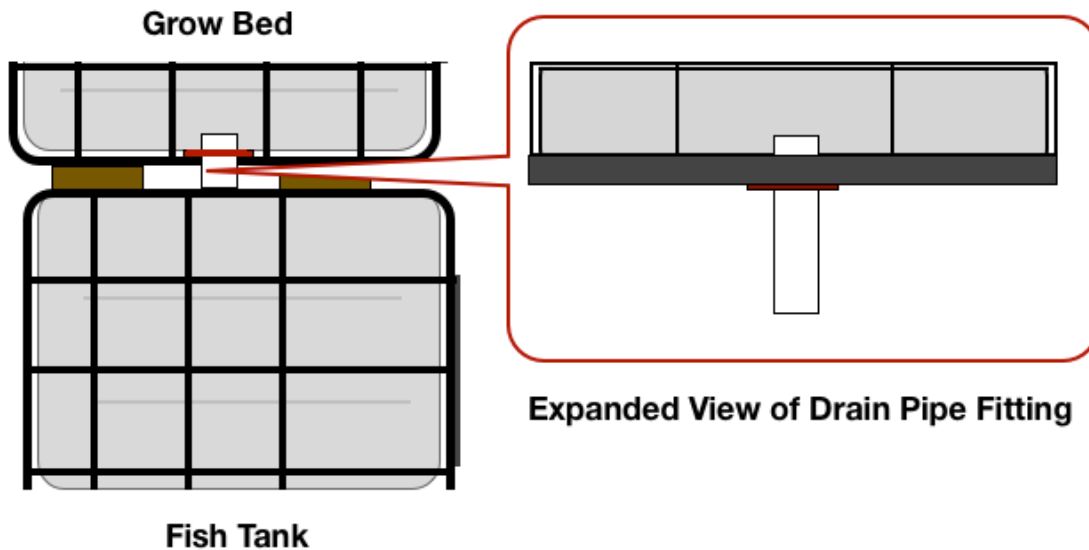


Remove the plastic IBC tank cap (see red rectangle above right) and using your marking pen and the opening, trace a circle on the metal cage below. Then cut the metal out using snips or a drill bit or hole cutter bit. This will be where your stand pipe and drain hole will go.



### Step Eight—Insert Your Drain Fittings

Once you have your hole in place, insert your drainpipe and/or fittings into the grow bed. Make sure the cap (or other filters if you use a commercial system) do not leak.



After you have your drain fittings in place you want to make sure that your grow media does not clog your drain system. Cut a Piece of PVC pipe that's at last

four times the width of your drain pipe. Either use a saw and cut horizontal cuts in it, or use a drill and drill holes in it to allow water to drain through it. Make sure your holes are smaller than your grow media so the grow media does not clog the drainage holes.

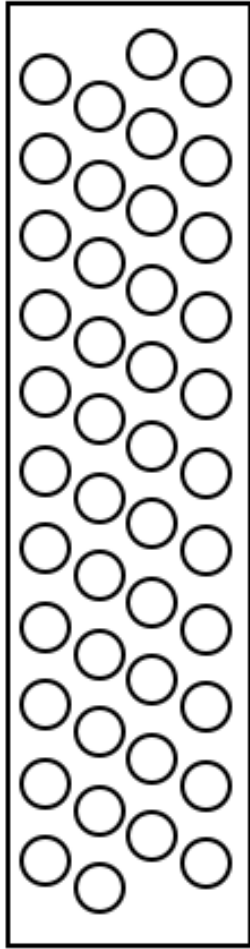
Add a circle of drain holes around the top of the standpipe too, to allow faster draining.

## Step Nine—Insert Your Standpipe Filter

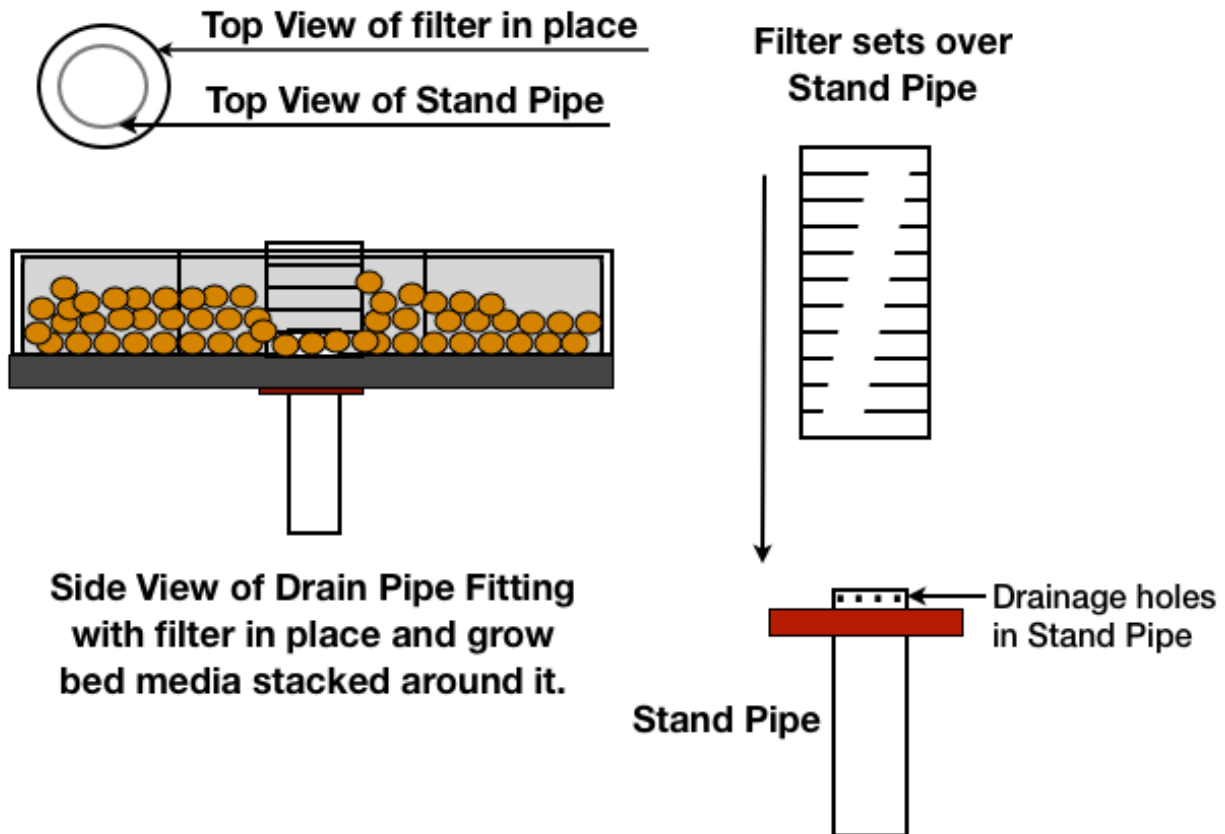
Once you have your drain system (Standpipe) in place. You're almost ready to add your grow media. The problem with grow media is that when you fill your grow bed it will tend to wash down the drain pipe into the fish tank below, often taking some of your worms with the water.

The fish certainly appreciate the worms, but it tends to ruin your system as the grow media will eventually fill up the fish tank. The solution is simple. Put a filter around your drain pipe that lets water, but not grow media or worms through as the water drains.

You can configure PVC pipe any way you like, or purchase a filter already configured to allow drainage. You can drill holes in your PVC pipe, or cut horizontal slits all the way through the pipe to create drainage. Make enough holes and slits that the water drains quickly and doesn't sit in the grow bed for hours. Your system should drain almost as quickly as it fills up.



Drill out holes in your PVC pipe, or use a circular saw or disc cutter to make grooves to create drainage that will allow water in, but will not clog with grow media.



You're almost done!!

## Step Ten—Assemble Your Entire System

**A**ll the really hard work is done. Now it's time to assemble your entire system. Feel free to change the design, or tweak or use flexible tubing rather than rigid tubing if you like. It's your system. As long as the principles to running it stay the same (Fill and Drain) and you're using a fish, worms, bacteria, water loop, things should work.

Go ahead and site or place your tank where you want it to live. Remember, once it's filled with water it's hard to move. If you think you may want to move it, build a very strong platform, complete with wheels and place your tank on top of that before you fill it with water.

Water weighs about 8.25 pounds per gallon, so a 125 to 350 gallon fish tank filled with another 50 pounds or so of fish, and a grow bed filled with rocks is going to be very, very heavy.

Place your fish tank where it will spend the next year or so. Then put the grow bed on top of the tank and:

- After you've placed the grow bed on top of the fish tank add your grow media. You should clean your grow media prior to putting it in the grow bed. If you forget you can rinse it down thoroughly to clean all the dust and debris off of it and then drain the fish tank before adding clean water for your fish.
- Add your water and let it sit to allow any chlorine (if you're using city water) to evaporate. Let it sit for 48 to 72 hours before adding fish or ammonia and starting your cycling (see chapter on cycling and preparing your tank for fish).
- Put your pump in the water, then plug it in to make sure it works after adding water. If your pump comes with an aerator or air stone, attach it and place it in the water as well.
- Once your water has set, wet your media down thoroughly and add your worms. Just place them directly on the grow media. They will quickly find their way into the media as worms hate light. Add your plants, either seeds or seedlings or plants into the grow media.
- Adjust your timer so that your water pumps water into your media, filling your media bed until it's about 1-2 inches short of the top of your grow bed media. You do NOT want the water to fill so high that it covers the top of your grow media. That will encourage the growth of algae, which you do NOT want. Allow the system to drain. Once the grow bed is nearly full the pump should cut off, allowing the water to drain.
- Watch your system cycle through several fill and drain cycles to make sure everything is working correctly and is on a good fill and drain cycle.
- Cycle your water and once you've got a good pH balance and good water levels, order your fish.
- Once your fish arrive, transfer them to your water. Give them a few days to rest, check pH levels, nutrient levels and temperature frequently the first week or so to ensure everything is balanced. Make adjustments as needed (such as adding rain water or nonchlorinated water as needed to raise water levels from water loss due to evaporation, or to balance your levels (Your test kit will come with instructions on what to use to do this.)

That's it! You're now officially an aquaponic farmer!



## Where to Site Your Tank

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**S**iting your aquaponics tanks is critical to the health of your fish and plants. Some fish, like Tilapia require high temperatures, and some fish, like Bluegill, tolerate high temperatures. There's a difference! Think about your own comfort. Tolerating a temperature, versus needing a certain temperature to be healthy, are two different things.

### 13 Common Places to Put Your Aquaponics System

1. Porch
2. Deck
3. Greenhouse
4. Shed
5. Garage
6. Basement
7. Inside your home (beware, high humidity may be an issue)
8. Driveway
9. Garden
10. Henhouse
11. Under a tree
12. In the yard (side or back yard next to the house)
13. Sunroom

If you put your aquaponics system inside your home, be aware that you may have issues with high humidity, depending on where you live. Some climates may make the high humidity a welcome thing; others may find they begin to have problems with mold.

## 10 Critical Things to Consider Before Deciding Where to Place Your Aquaponics System

**B**efore you can decide where to site your tank (where to place it), you need to determine several things:

1. What kind of fish do you plan to grow and what temperatures do they prefer and what can they tolerate? If you plan on growing Tilapia, consider placing the tank where it will get full sun and the water will stay above 82 to 86 degrees, or at least around 78 degrees (for spawning), 24 hours a day. Trout, catfish and other fish require much cooler temps and do better in shady or dark areas.

You may even want to sink your tank in the ground to ensure cooler temps in summer and warmer temps in winter. Check with your county extension agent or with any online source to determine what temperature zone you're in. Look at year-round temperatures. It's going to cost a lot less energy electrical wise to raise tilapia in Hawaii than it is to raise them in Minnesota. Pick fish for your climate, or be prepared to pay for the power to heat or cool their water.

2. Will you be able to control the temperature and other conditions (like putting the tanks in a garage, greenhouse, shed, outdoor structure, or will the tanks pretty much be forced to adapt to the ambient temperature they're in—such as under trees, on a deck or back porch or in the driveway or beside the house?

3. How large a tank do you plan to have? A small 20-to-30 gallon system isn't going to be as heavy or hard to find a site to set up on as a 500-gallon system will. Make sure to site your system in a place where you can move all the way around the tank to tend to leaks, check for cracks, make repairs or get to dead fish or adjust netting and covers.

4. How far away from your living quarters are you willing to walk every day, or night, to tend to the feeding and care of the tanks, temperature monitoring, and the check on your plants and structures?

5. How close is your power source? Your pumps will require electricity, even if it's from a solar source. Most people depend on their standard household power, but either way, you've got to have a power source close enough to the tanks to run your pumps. Without a heat source, and in an open area, most systems will rapidly chill below what most fish can tolerate. Can you heat the tank with a solar system or electric system? Can you insulate the tank in some way where you have it? That might include wrapping it in Styrofoam or some other system.

Be aware of how you will maintain optimal temperatures easily and how you'll be able to check those temps. If you need to physically check on the tank temp, is it close enough to walk to, or will you put off checking it because it's on the other side

of the yard? There are remote temperature gauges you can buy, but consider that option.

6. How close are you to a water source? Aquaponic systems don't need much water once you get them running, but they will require at least a gallon or more per day. The only water you'll replace is that lost to evaporation, but that can be more than you'd expect.

7. What kind of predators do you have in your area? Someone in a rural area may have more kinds of predators, but even in the city there are raccoons, hawks, cats, coyotes and dogs. Most predator problems can be resolved with heavy bird netting, a slatted wood or wire lid or a fence around your system. Place or site your system where you can see it under security lights at night, or where it would be difficult for predators, including the human kind, to access it.

A greenhouse, shed or outbuilding makes a very secure site for an aquaponics system. You can also put a well ventilated lid on the tank at night to ensure raccoons, who have a sixth sense when it comes to easy fishing, aren't able to sample your fish.

8. Depending on the size and configuration of your system, some city zoning codes may consider your system a "pool" and require you place a fence or other safeguards around it. Some may simply not care, or consider it a garden feature or the equivalent of a "hot tub." Place your system where small animals and children exploring the area won't fall in and drown. Remember, a child can drown in a bucket of water, so make sure your system is childproof.

9. Weight is a critical factor when it comes to deciding where to place your tank. Water weighs 8.34 pounds per gallon, (about 3.79 kg). If your tank holds 100 gallons, that's 834 pounds. If you're an apartment or condominium owner, make sure your deck, porch or wherever you are placing the tank can hold that much water, plus the weight of your growing medium, your tank and your plants.

Estimate at least 1,600 pounds of weight (gravel or growing medium, tank, pump etc.) plus your maintenance and growing equipment, the weight of people likely to be working around the tank, and any hoses, buckets and storage.

If you don't know how to calculate how much weight your deck or porch will safely support, call an expert, or site your tank someplace else, like the ground, or a driveway or concrete pad in the yard, or on a level graveled area in the yard.

10. In case of a leak, crack or other problem, where will the water go if you need to rapidly drain it? Is there a way or place you can install an overflow system to direct water away from your house and into the yard or a drain if you do have a leak or crack? Think about all that could go wrong when picking your site.

## Water Loss from Your Tank

Where you site your tank can affect how often you have to add water to it. You won't have to replace water in an aquaponics system like you would for an aquaculture or hydroponics system—that is, due to toxicity from ammonia (aquaculture) or salt build up (hydroponics). But even the most efficient aquaponics system will lose water from evaporation and transpiration.

Depending on the size of your system expect to lose two to four gallons of water a day, more in the summer, if you're growing a lot of vegetables, less in the fall and winter. Tomatoes require a huge amount of water, as do squash and melons and strawberries. They suck up the water and throw it out through their leaves (transpiration) and the sun and wind and temperatures will drive the normal loss of water through evaporation.

If you're looking for a comparison, consider this: an acre of corn gives off (loses) about 3,000-4,000 gallons (11,400-15,100 liters) of water each day.

You won't lose nearly that much water, but the percentages are similar. You will lose a gallon or more every day as your garden grows. The amount of water you'll lose also depends on the temperature in the water and the temperature in the air.

Factor in the actual humidity of the air and the velocity of the air above the surface (is it windy most of the time or not) to get an idea of what your loss might be. A 90-degree day in an area with 10% humidity will cause your system to lose more water than a system in a region with 70-to-80% humidity.

If you have a small exposed water surface, and you have a slatted lid or plants directly over the water, you may have a reduced evaporation rate. But you'll still need to check your water levels daily and add water from time to time. Chlorinated water won't do. You need rainwater or treated water (no chlorine). So, make sure you place your system next to an easily accessible water source, or where it's not a pain to haul water out to several times a week.

If you can site your tank(s) somewhere out of direct sun, out of strong winds or breezes and in a fairly protected area (A greenhouse, shed, deck or porch is best) you can reduce water loss. If you are finding a need to fill the tanks up every day, consider filling up buckets with water the night before and letting them off gas chlorine for 24 hours before adding them to your tank.

Don't use this method to replace all the water in the tank, but for refilling the evaporation loss 24 to 48 hours in an open bucket is enough time for the chlorine to be dispersed.

## Which Fish to Raise?

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Fish are cold-blooded creatures. That means their internal body temperature is regulated by their environment, just like a snake, or frog's system is. Still, every species of fish has a different optimal body temperature at which they will thrive or die. Unlike humans or other mammals, they can't expend energy to alter their body temperature. They're completely at the mercy of the temperature of the water they're in. If that temperature gets too cold or too hot, they'll stop eating, mating, swimming become susceptible to diseases or just die.

While some farmers do reduce the temperature to control a fish's growth, a technique called "cold banking," it's very stressful and should only be done when you know how to monitor the temperature and understand the reasons for it.

When selecting the breed of fish for your tank, you must consider the temperatures the fish will thrive in, versus merely survive in. Consider what kind of tank you'll have, the temperatures you can consistently and easily maintain, and what kind of water environment the fish will have.

Think about whether you're raising the fish to eat, to sell or simply to provide fertilizer for your plants, or as ornamental elements of an aquaponic system.

It's not just fish you have to consider. Your plants must also be cold water tolerant if your fish are cold-water fish. It's possible for your fish to thrive and your plants to suffer because of temperatures!

Most fruits and vegetables do not grow well in salt water, so select only fresh water fish for your aquaponics system. Make sure your vegetables are cold or warm water plants because the water in your fish tank will be going fish to plants at about the same temperatures.

Water environment matters since the water is in a closed system loop. Also by water environment we mean: do you have still water like a pond, or flowing water with a current like in a trout or fingerling tank? Fish that typically live in ponds or lakes will be stressed if you put them in a long tank run with streaming or moving water.

Lake and pond fish don't like water movement. Still water fish, or pond and lake fish, include Tilapia, Bluegill, Perch, and Bass. On the other hand, river fish, like trout and catfish, are stressed when the water in their tank doesn't move.

**Light Stress** – Has anyone ever wakened you from a sound sleep by switching on the lights or opening the curtains to full sunlight? It shocked you awake right? Fish respond the same way to your flipping on a light switch. In a fish's world the sun comes up slowly and light appears over time. Their natural world does not go from sudden darkness to full on sunlight. If your tank is situated outside where the sun

naturally illuminates their world, great. If you site your tank inside, be aware that a dimmer switch that allows you to simulate the sun rising is much less stressful than a standard light switch.

If you insist on flipping on a switch, don't be surprised if the fish start banging on the walls of the tank or leaping out of the water in an attempt to escape the sudden light. Not only are you stressing the fish, you're making the flesh of the fish less tasty and you're risking your fish injuring themselves with their escape attempts.

**Tapping Stress** – Go to any pet store and you'll see the signs on the fish tanks that ask you to please NOT tap on the tanks. Why? Because fish feel vibrations over their entire body. Tapping on an aquarium or an aquaponic's tank is like yelling through a bullhorn at arm's length to a human. It's painful and extremely stressful. Tapping to get them to "feed" doesn't teach them to come when you tap. That frantic circling is a fish in pain. If you must train them to come when called, consider putting your fingers in the water instead and make small motions like an insect that's fallen in the water.

**Chemical Stress** – When you first set up your aquaponics system expect to stress your fish for the first few weeks or so until you get the hang of testing and adjusting the water to the perfect PH levels. Maintaining the quality of the water in your tank takes practice. Too much ammonia in the water is stressful, as is too low a PH level. Not having enough dissolved oxygen is stressful, as is poor filtration of solid waste. It's a good idea to start with just a few fish until you get the hang of consistent water levels.

**Biological Stress** – Just when you get the water quality levels figured out you may find you're combating the worst stressors of all—viruses, bacteria, fungi, and parasites. The good news is that these stressors only affect fish in the same way they only affect humans—when other conditions have weakened the immune system.

You may have fish with a strong immune system, but if your kids, or your dog's wagging tail are tapping on the tank every day, or you're flipping the light switch on in the garage or basement three or four times a day, you've probably stressed your poor fish enough that their immune system is weakened and the viruses, bacteria, fungi and parasites already present see their chance to attack and do. Keeping your fish happy, calm and relaxed means they'll be healthy, tasty fish.

There are dozens and dozens of fish around the world that do well in an aquaponic system. Different countries have different fish that have proven to fare well and are available in each country for that climate. Commercial growers tend to rely on fish that are the most profitable given fluctuating demands of the fish market.

Private growers have the luxury of raising fish that suit their personal tastes or situations, as long as the fish is allowed in their state, province or country. In the United States you can find this list of restrictions by going to the USDA website.

## How Many Fish Can I Put in My System?

One of the most common questions new growers have is about how many fish they can put into their system. The simple, one fish per gallon or five gallons of water isn't much help because a fingerling doesn't take up the same amount of water as a full-grown fish. Instead of asking about how many fish per gallon/litre a much more accurate standard is to determine how many kilograms of fish per 1,000 litres or how many pounds per 265 gallons of water you can add.

The weight of fish that can be kept in an Aquaponics tank will depend on the following factors:

- the size of the tank matters. Larger tanks generally provide a more stable fish rearing environment.
- the size of the fish— a hundred fingerlings in a 5,000 liter or 1,320 gallon tank will hardly register while a hundred 500 grams (1,102 pounds) of fish in a 1,000 liter (265 gallon) tank will be a real handful.
- the species of fish— some fish are relatively tolerant of poor water quality where other fish, like trout and bass, will be less tolerant. Less active fish can be stocked in higher numbers than other species.
- the Dissolved Oxygen levels— trout require high oxygen levels; catfish and perch less so.
- the bio-filtration capacity of your system—you must be able to handle the peak ammonia levels that can happen in your system. The total capacity of fish should take into account the likelihood that you'll occasionally overfeed your fish, or that they won't eat all you feed them, or that temperatures are likely to fluctuate given weather, power outages etc.
- the ability of your system to remove nitrates from the water. Nitrates aren't as toxic as nitrites or ammonia, but they can be a problem at high levels.
- the level of risk you can tolerate—you will be getting less sleep if you run 60kg per 1,000 liters (132 pounds to 265 gallons) than if your tanks contain 20kg per 1,000 liters (44 pounds to 265 gallons)

Theoretically, the number of fish you can raise in any system is only limited by how well your system can convert ammonia and nitrites to nitrates, and how effectively you can maintain appropriate levels of dissolved oxygen in the water. The real world doesn't work quite like numbers on a calculator. It works on risk, unknown

or unforeseen events and Murphy's law; meaning that if you cut your ammonia/nitrate removal and oxygen levels to the point that any error or problem can throw your system into melt-down, then you're likely to lose a lot of fish and plants if and when things do go wrong. Build in a better buffer for temperature fluctuations and problems and you're less likely to have problems if something does go wrong.

The better you get at managing your system and the better your equipment, the more you can safely stock and raise. Keep your fish levels around 40 to 50 fish per the appropriate water levels (1,000 liters or 265 gallons) to begin with. You can always add more, but dealing with the die-off of 50 fish can be pretty overwhelming.

Go slow and grow your system as your skills and experience grow. There's nothing wrong or shameful about having a five or even ten fish system until you get the hang of keeping your water oxygenated and your pH levels managed.

## Selecting Your Fish

There are cultured fish that do well around the globe, as well as those who are more well known in their own region or country. Some are hardy fish that can survive the attempts of new fish farmers better than others. Others are finicky, high maintenance and temperamental and require much more skill than a newbie fish farmer may have. Pick fish that can tolerate your inexperience, at least for the first year, if you want success with your system.

The most commonly grown globally available and mostly tolerant fish are:

- Tilapia (Nile tilapia, *Oreochromis niloticus niloticus*)
- Channel catfish (*Ictalurus punctatus*)
- Largemouth bass (*Micropterus salmoides*)
- Crappies (*Pomoxis*)
- Rainbow trout (*Oncorhynchus mykiss*)
- Pacu (*Colossoma* spp)
- Carp (*Cyprinus* spp)
- Goldfish (*Carassius* spp)
- Perch (*Perca* spp)
- Arctic char (*Salvelinus alpinus*)
- Barramundi (*Lates calcarifer*)
- Murray cod (*Maccullochella peelii*)





Barramundi fish

The selections can seem overwhelming for a first time fish farmer. If you're not sure which fish to grow, stick with the tried and true five basic and easy to raise aquaponic fish such as:

1. Tilapia
2. Trout (requires cold water and pristine water conditions)
3. Bluegill
4. Catfish
5. Bass

Once you have your aquaponic system in place and you understand the process and demands of the water and PH balances etc., then you can try more exotic and high maintenance fish. It's possible to grow 50 pounds of fish, and hundreds of pounds of vegetables within six months in an area about the size of your average carport, about 10x5 feet. Some of the most common species of fish worldwide:

- Abalone (red, *Haliotis rufens* and Japanese, *Haliotis discus hanai*)?
- Aquatic snails (*Pomacea* sp.)?
- Carp (*Ctenopharyngodon idellus*, *Hypophthalmichthys molitrix*)?
- Catfish (*Clarius fuscus*)?
- Freshwater ornamental fish and aquatic plants (various species)?
- Broodstock and juvenile shrimp (*L. vannamei*, *L. monodon*, *L. stylirostris*)
- Freshwater prawns (*Macrobrachium rosenbergii*)?

- Giant clams (*Tridacna* sp.)?
- Japanese Flounder (*hirame*, *Parlichthys olivaceus*)?
- Kahala (amberjack, *Seriola rivoliana*)?
- Lobster (*Homarus americanus*)?
- Marine ornamental fish and plants (various species)?
- Marine ornamental invertebrates (various species)?
- Marine shrimp for food (*Penaeus vannamei*)?
- Microalgae (*Spirulina* sp., *Hematococcus* sp.)?
- Milkfish (*Chanos chanos*)?
- Moi (Pacific threadfin)?
- Mullet (*Mugil cephalus*)?
- Seahorses (various species)?
- Seaweed or sea vegetables (*Gracilaria* sp.)?
- Seed clams (*Mercenaria mercenaria*)?
- Seed oysters and clams (*Crassostrea gigas*, *Ostrea edulis*,? *Mercenaria* sp.)?
- Seed pearl oysters (*Pinctada fucata*, *P. margaritifera*)?
- Tilapia (*Tilapia* sp.)?



Carp

You don't have to grow the same kind of fish year round. You can grow something like Rainbow trout in the winter (they prefer cooler temps), and then switch to Talipia during the summer (they thrive in water with 80+ temps).

Before deciding what fish you want to grow, consider:

- What do you want from your system? Do you want to eat your fish or not?
- How often do you plan to harvest your fish? Annually? Monthly? Quarterly? Pick a fish that can be harvested when it's convenient for you. Many fish take a year or more to reach harvestable size.
- What's available? Stocking your fish, especially in a large system, involves transporting your breeding stock to your system. You need to be able to buy broodstock to stock your tanks, even if you're getting a species that breeds easily, grows quickly and tastes good—like Tilapia, the number one aquaponic fish in terms of grower preference.

## More on the Most Popular Aquaponic Fish

### Barramundi

If you're American, don't let the name throw you. Barramundi is a popular fish in Australian aquaponics systems, but growing in popularity around the world. They're better known as "Asian or Australian Sea bass," and have an exceptionally clean crisp taste when grown in an aquaponics system. The name "Barramundi" means "large river fish with large scales."

They're considered one of the more majestic or royal species of fish and are in high demand in the pricier restaurants around the world that serve it. In terms of fish familiar to the United States, they're often called a "Perch." They're very popular in Malaysia, Thailand, Australia, the Philippines and Vietnam. In the US they're mostly found in Florida and Western Massachusetts. Many farmers like them because of the "strike" and violent water slapping action when feed is put into their tank.

They are carnivorous and will eat smaller fish, including siblings and other barramundi. If you're going to buy them, buy larger, more mature fish in the 3-to-6-inch range.

Commercial, and private owners too, will buy more mature stock in order to harvest larger fish at the end of the season.

Preferred Temperatures: Between 26C and 28C or 78.8F and 82.4F

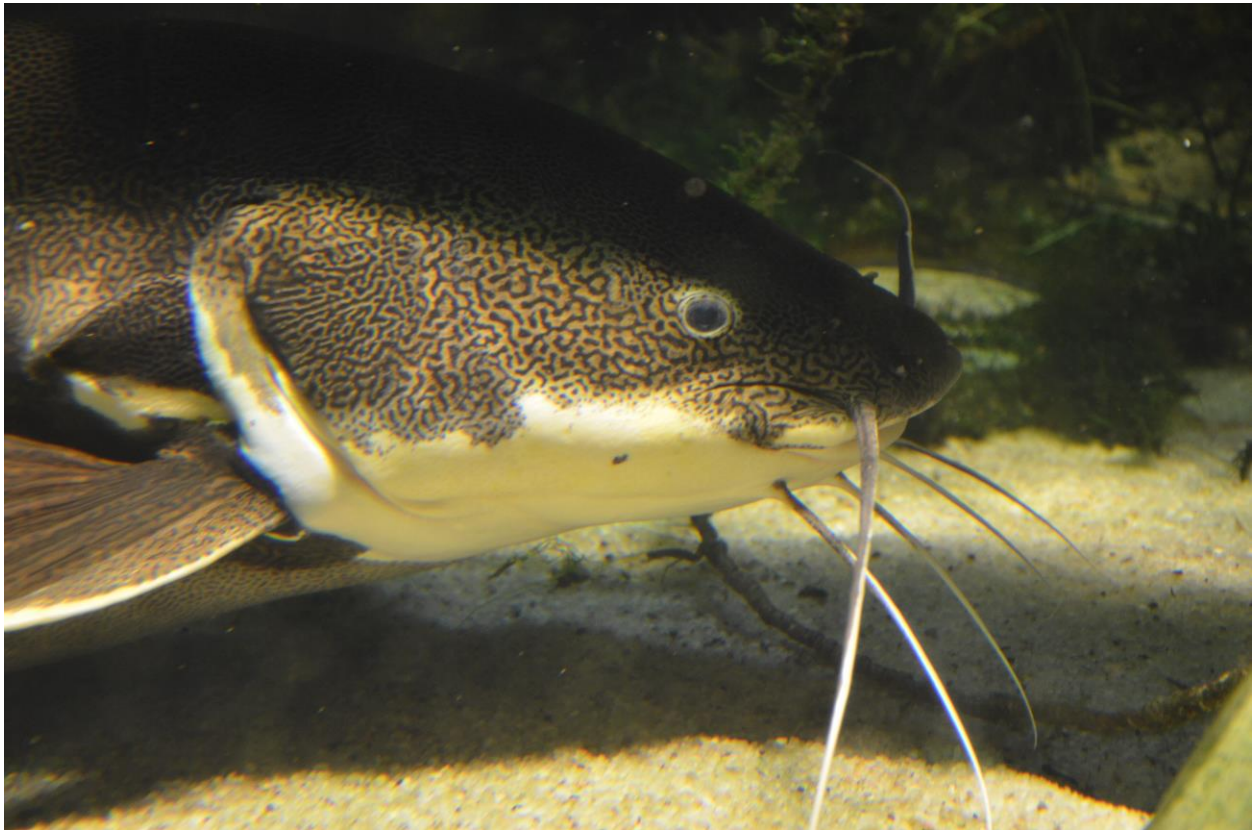
River or Pond: Barramundi prefer large tanks with slow, continuously moving water.



**Food Preferences:** Small live, fresh fish, but will eat vegetarian pellets and frozen food

**Water per Fish:** the recommended GPK (gallons per Fish) rates are based on their size:

- Small (2" - 8"): 100 - 150 gallons
- Medium (8" - 14"): 250 - 300 gallons
- Large (14" - 24"): 400 - 500 gallons
- Jumbo (24" - 36"): 750 - 900 gallons



Catfish

## Catfish

Catfish live and thrive on every continent in the world, except Antarctica. So chances are pretty good they'll grow where you're farming them too. Catfish are highly disease and parasite resistant when not stressed and kept in a clean tank. They're bottom feeders, which means they're a low-density fish when raised alone.

Better to raise them with Bluegill or a similar species of fish that can occupy the upper levels of water and give you a better fish per gallon density. With hundreds of species of catfish around the world, all you need to do is pick a species you prefer.

Channel catfish are the mostly widely farmed, but those with a taste for blue catfish will do just as well. Because catfish don't have scales they need to be skinned before freezing or preparing. Still, they're a fast growing fish and have a good food conversion ratio.

Preferred Temperatures: 75F to 85F (24C to 29C) but can survive temps from just above freezing to 100F. They prefer about 80F or 27C.

River or Pond: Still to slowly moving water

Food preferences: insects, clams, worms, snails and crayfish. These can be dead or alive; it doesn't matter, as the catfish will eat them anyway.

Water per Fish: the recommended GPK (gallons per Fish) rates are based on their size:

- Small (2" - 8"): 100 - 150 gallons
- Medium (8" - 14"): 250 - 300 gallons
- Large (14" - 24"): 400 - 500 gallons
- Jumbo (24" - 36"): 750 - 900 gallons

## Carp

Carp make for hardy aquaponic fish. They have a strong reproductive system, and readily adapt to many temperatures and conditions around the world. While this makes them good aquaponic fish, it also makes them noxious pests in many rivers and natural bodies of water, so they are often hard to obtain and some states and countries will fine you or charge high fees to keep them. Most western cultures consider them "garbage fish" and do not eat them, although carp is still the most widely cultured fish in the world as it's grown throughout most of Asia.

Preferred Temperatures: Carp can survive 34F to 90F but do best at 50F to 70F

River or Pond: Pond. Carp prefer still water

Food Preferences: Carp are notorious for eating anything, but insects, clams, worms, snails and crayfish make them happy. These can be dead or alive; it doesn't matter, as the catfish will eat them anyway. Add a high quality fish pellet as well.

Water Per Fish: the recommended GPK (gallons per Fish) rates are based on their size:

- Small (2" - 8"): 100 - 150 gallons
- Medium (8" - 14"): 250 - 300 gallons
- Large (14" - 24"): 400 - 500 gallons
- Jumbo (24" - 36"): 750 - 900 gallons



Koi fish

## Koi

Yes, they have a fancy name, brilliant coloring due to centuries of genetic breeding, and can cost from \$50 to \$3,000 or more per fish as decorative ornamental garden pond features, but they're still just another species of carp. Not everyone eats the fish they raise and Koi are one species that people find perfect for aquaponics systems where the fish will not be harvested. They have a very Asian flair and sense about them.

If you love Koi, and want to avoid the cost and effort to simply have a hydroponic system (plants only), then an aquaponic system is a great proposition for creating an aquaponics system that feeds the soul rather than the body. As beautiful as they are though, they can still be eaten and are said to be quite tasty, and far better tasting than their river carp cousins. The oldest living Koi was reportedly 226 years old (and died in 1977). But the average Koi lives from 4-to-20 years.

Preferred Temperatures: Koi can survive 1C to 32C (34F to 90F) but do best at 10C to 21C (50F to 70F)

River or Pond: Pond. Koi prefer still water

Food preferences: Koi are omnivorous, meaning they will eat about anything. They love plants. The larger ones will uproot and eat any aquatic plants you have.

Water Per Fish: The recommended GPK (gallons per Koi) rates are based on their size:

- Small Koi (2" - 8"): 100 - 150 gallons
- Medium Koi (8" - 14"): 250 - 300 gallons
- Large Koi (14" - 24"): 400 - 500 gallons
- Jumbo Koi (24" - 36"): 750 - 900 gallons



Yellow perch fish

## Yellow Perch

The Yellow Perch is only native to North America, and then not to every state. There are states who consider them a nuisance fish and do not want them in the public waterways, so they restrict farming of the fish in some ponds.

Most fish of the yellow perch size should be used with the ratio of one fish for every five to six gallons of water - the fish deserve to have a decent amount of space to live in comfort if you are confining them to a closed aquaponic system. Unharvested, Yellow Perch live 9-10 years and grow to about 4-to-10 inches. They take about 18 months to grow from fingerling to harvest size.



**Preferred Temperatures:** The optimum temperature for growth of yellow perch to be 75F or 24C. Best range is 18C to 23C (63F to 73F).

**River or Pond:** Pond. Perch prefer flowing water.

**Food preferences:** Feed them a floating diet containing approximately 40% protein and 10% fat. Feed to satiation twice daily

**Water Per Fish:** One fish for every five to six gallons of water. Fish deserve to have a decent amount of space to live in comfort if you are confining them to a closed aquaponic system and will grow faster and healthier if they have that space. Or follow the average recommendation:

The recommended GPK (gallons per Fish) rates are based on their size:

- Small (2" - 8"): 100 - 150 gallons
- Medium (8" - 14"): 250 - 300 gallons
- Large (14" - 24"): 400 - 500 gallons
- Jumbo (24" - 36"): 750 - 900 gallons



Silver perch fish

## Silver perch

**S**ilver perch are a good all-around native Australian fish. They're omnivores, but will happily eat Duckweed and Azolla as well as smaller fish, invertebrate prey and worms, bugs etc. They grow within a wide temperature range, though they're not as fast growing as many other fish, taking 12-18 months for fingerlings to grow to plate size. One fish for every five to six gallons of water. Fish deserve to have a decent amount of space to live in comfort if you are confining them to a closed



aquaponic system and will grow faster and healthier if they have that space. Silver, Jade and Yellow Perch are all pretty much intolerant of overcrowding or poor water quality.

**Preferred Temperatures:** The optimum temperature for growth of Silver Perch is 12C-to 32C (53.6F to 90F)

**River or Pond:** Perch prefer flowing water.

**Food preferences:** Feed them a floating diet containing approximately 40% protein and 10% fat. Feed to satiation twice daily

**Water Per Fish:** One fish for every five to six gallons of water. Fish deserve to have a decent amount of space to live in comfort if you are confining them to a closed aquaponic system and will grow faster and healthier if they have that space.

The recommended GPK (gallons per Fish) rates are based on their size:

- Small (2" - 8"): 100 - 150 gallons
- Medium (8" - 14"): 250 - 300 gallons
- Large (14" - 24"): 400 - 500 gallons
- Jumbo (24" - 36"): 750 - 900 gallons



Jade perch fish

## Jade Perch

The Jade Perch is a native Australian fish. If you're American, it's much easier to find the native to America perch, the Yellow Perch. If you're a perch lover you might want to consider getting some Jade Perch however. Jade Perch have the highest levels of omega three oils of any fish species in the world. High omega three oils are both good and bad. They're great for your heart health, but bad for commercial breeders who are trying to breed the oil out of them. The oilier the fish, the less tasty some people find them. And people that don't like oily fish don't buy oily fish. If your primary concern is health, not taste give them a try. Perch of any kind require warm water and eat an omnivorous diet. They do well in aquaponic systems, grow quickly and fingerlings are readily available in most areas.

Preferred Temperatures: Perch can survive but do best at 10C to 22C (50F to 70F)

River or Pond: Pond. Perch live in ponds in the wild and prefer still water

Food preferences: Duckweed, chook pellets, Chia and green pellets

Water Per Fish:

Most perch should be grown with the ratio of one fish for every five to six gallons of water - the fish deserve to have a decent amount of space to live in comfort if you are confining them to a closed aquaponic system.

The recommended GPK (gallons per Fish) rates are based on their size:

Small (2" - 8"): 100 - 150 gallons

Medium (8" - 14"): 250 - 300 gallons

Large (14" - 24"): 400 - 500 gallons

Jumbo (24" - 36"): 750 - 900 gallons



Murray cod fish (credits: "Fir0002/Flagstaffotos" ; this image is released under the GFDL 1.2. More details here:

[http://en.wikipedia.org/wiki/GNU\\_Free\\_Documentation\\_License](http://en.wikipedia.org/wiki/GNU_Free_Documentation_License) )

## Murray cod

While Murray cod can grow to enormous sizes in the wild, they still make a great aquaponics fish. They do best grown in recirculating aquaculture systems, but can also be grown in aquaponic systems. They're a fast growing fish with a great taste. One of the down sides to raising Murray Cod is that they're aggressive carnivores and in the wild are considered a predator fish since they mostly eat other fish. If you don't keep them well fed and in high stocking densities to prevent territorial aggression. If not kept sated with food they will cannibalize each other.

**Preferred Temperatures:** Murray Cod can survive but do best at 16C to 24C (60F to 75F)

**River or Pond:** Pond. Murray Cod prefer moving or recirculating water.

**Food Preferences:** Murray Cod REQUIRE high protein foods

**Water Per Fish:** Murray Cod should be grown in denser than average populations. This keeps them from becoming territorial and aggressive and from eating other fish.



Nile Tilapia Fish

## Tilapia

Tilapia are the second most cultured fish in the world. They are very popular with private and commercial Aquaponic growers because they're a tough fish (not taste wise, but just overall hardy and adaptable). They are easy to breed, spawning about every 4-6 weeks, fast growing, can withstand very poor water conditions, consume an omnivorous diet and are extremely good eating. The only downfall for some people will be that Tilapia require warm water. If you live in a cool area you are far better off growing a fish species that will grow well in your temperature range, rather than trying to heat the water. Tilapia are also a declared pest in many areas.

Preferred Temperatures: Tilapia love warm water and thrive in 28-30C. (82F to 86F)

River or Pond: Pond. Tilapia prefer still water

Food Preferences: Duckweed (they love it) and plant detritus, food pellets

Water Per Fish:

The recommended GPK (gallons per Fish) rates are based on their size:

Small (2" - 8"): 100 - 150 gallons

Medium (8" - 14"): 250 - 300 gallons

Large (14" - 24"): 400 - 500 gallons



Jumbo (24" - 36"): 750 - 900 gallons

## Trout

**T**ROUT love cold water. It also has to be pristine, meaning very, very clean. If you're not able to keep your system's water crystal clear and cold, then move along. They can be temperamental fish to grow. However, in spite of their high maintenance care, they're a great fish for aquaponic systems because of their extremely fast growth rates. They have extremely fast growth rates and excellent food conversion ratios.

**Preferred Temperatures:** Trout love cold water and grow best in water that's between 10 and 20C (50F and 68F).

**River or Pond:** Pond. Trout prefer moving water

**Food Preferences:** Maggots and worms mostly, but commercial feed and corn work well

**Water Per Fish:** Stock around 20-25 fish for every 500 gallons of grow bed media in your system. The grow beds must be at least 25-30cm deep.

## Harvesting Your Fish

**Y**OU've spent months feeding, caring for and growing your fish, now it's time to harvest them. The temptation may be to lunge in with a net to scoop out as many as possible. But don't. Savor the moment and harvest your mature fish without stressing out the fish you aren't harvesting.

Drop your net into the tank and wait. Fish tend to freak out at new things in their tank, so let the net sit there until they're used to it and convinced it's not a threat. After a few minutes they'll ignore it and resume their regular swimming. As you're waiting for them to do that, pick out a likely candidate for harvest. Let that fish come to you. It's a small tank, eventually they will.

Once they've approached the net and are within range use a quick wrist action to scoop the fish into the net. Lift it out of the water quickly and smoothly. You can transfer it into a bucket or cooler for processing. By catching one fish at a time you don't damage the gills of smaller fish, or fish not quite ready to harvest. You don't want to stress your fish because stress can kill them and you want them to grow to harvest.

Some people, usually those with larger systems, will harvest all their fish at once using larger nets or a net casting system. It's up to you.

## Introducing Fish to Water

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Instead of trying to learn all the systems and rules and options, I suggest just learning the basic principles of how nature works and how aquaponics recreates that system on a small scale.

Aquaponics can be as complex or as simple as you want to imagine it. There are many different kinds of systems, some more elaborate than others, and some so simple a child can design and assemble them. What frightens people is the idea they may fail, and destroy or mess up something.

The fact is, almost everyone who starts an aquaponic system does fail. It's how you learn. The good news is if you've been able to build, design or buy and set up your tanks and pumps and plants, the cycling process (preparing your water for your fish) is going to seem easy.

If you're intimidated or frightened by the thought of creating a large system, like an IBC container system as large as your car, try a smaller system, like a standard aquarium with goldfish and some lettuce or other plants growing on top.

It's small, a mini-version of the "real" deal that takes up 4x6 feet or more of your porch, yard, driveway or garage. An aquarium is small enough to manage, yet still very much an environment in which to practice testing and adjusting ammonia and nitrate levels.

If you lose a few .99 cent goldfish in the learning process it's far less traumatic than investing hundreds of dollars in trout or tilapia fingerlings, or bass, or perch and even more in plants only to have them stressed and dying while you try to wrap your mind around what to do next to balance the water system.

So start small and grow bigger later, or accept that a few dead fish and plants are just part of the learning curve for everyone. Learn from them and move on. Don't get discouraged if it's not perfect the first time you set up your tank.

Once you master the small system, you can build larger systems. That's what most aquaponic farmers do anyway—even if they start out big. Why? Because it gets addictive and pretty soon you're joining three, then six then eight IBC containers together and building a separate greenhouse to hold it all.

Like they say, a journey of a thousand miles starts with one step. Your step can be a small aquarium or an IBC container. Whichever it is, understand that everyone struggles and most fail at some point along the way. It's normal.

## Getting Started

**The basic principle of aquaponics:**

*Fish, worms, bacteria and plants combine with water to provide a system that keeps the water clean, the plants fertilized and the fish healthy in a clean water environment.*

This process of setting up your tank and getting the bacteria going is called “cycling.” It’s a totally necessary part of creating a successful aquaponics system.

## Why You Need To Cycle Your System

In concentrated quantities ammonia in their water is toxic to fish. In the wild nature, plants, bacteria, worms and circulating water, and the fish moving around naturally take care of the ammonia by turning it into nitrates, then nitrates which plants then consume. In an aquaponics system you have to recreate that system.

## Steps to Launching Your Aquaponics System

### Short Version of the Steps

1. Design and build, or buy and assemble your aquaponics system.
2. Fill the completed tanks with de-chlorinated water. You can buy chemicals to de-chlorinate the water, or you can let it just sit for a week and de-chlorinate naturally.
3. Add plants to your grow media.
4. Add plain old red earthworms to your grow media. (Just dump them onto the media. They know what to do.) Worms hate light and they’ll quickly burrow into the grow media once they’re placed on top.
5. Establish the nitrifying bacteria by adding a few (not all your fish) to the system. Nitrifying bacteria turns ammonia and fish waste into yummy fertilizers. You can establish these bacteria by simply introducing live fish into the system and hope they survive your experimenting with balancing the ammonia and pH levels, or you can introduce a chemical form of ammonia and practice with it.

Most growers use a few fish, often goldfish, which tolerate this process well, and then add their regular fish once the system has cycled. You can also simply add ammonia from other sources.

### Long Version of the Steps



Design and build, or buy and assemble your aquaponics system. Add plants (seedlings), worms and de-chlorinated water. Start your water pumps. Easy right?

So, now that your grow bed is filled with the grow media, plants and worms and the fish tank is full of de-chlorinated water it's time to move into the living elements of your system; starting with establishing the nitrifying bacteria by adding a few fish to your system. The good news is your fish will do what fish do naturally; foul perfectly clean water with their waste products from respiratory and other bodily functions.

The good news is that the ammonia in their waste attracts nitrosomonas, the first of the two nitrifying bacteria that will eventually populate your system. Nitrosomonas convert the ammonia into nitrites (NO<sub>2</sub>). Nitrites are even more toxic than ammonia, but fortunately the presence of the nitrites attracts the bacteria you're really after—"nitrospira." It's the nitrospira that will convert the toxic nitrites into nitrates—which plants love.

The nitrates are harmless to fish and great for plants. By testing your water several times a day you'll be able to determine how far along this natural process is. Once you see that nitrates in the water, and ammonia and nitrite concentrations below .5 or lower, your system is operational and you're now running a bonafide aquaponics system.

Don't start feeling intimidated. It sounds complex, but all you're doing is letting nature do what nature does—break down ammonia waste with bacteria.

## Testing Tools

Because you can't see, taste or smell where you are in the cycling process, you'll need some tools to measure ammonia and nitrite and nitrate levels so you know what your levels of each, and your pH levels as well, so everything is in a range your fish can thrive in. The cycling process generally takes four-to-six weeks and these tools will let you know where you are in the cycle so you can know when to add your fish if you haven't done so already, or when you can add more fish if you have some fish already.

Don't worry, once you learn how to monitor your system and you get to the point where your system is fully cycled, you will need to do much less monitoring. Set up is the most labor intensive. So remember that as you're going through the cycling process. Think about the days you'll be reaping the fish of your labor.

Testing Tools you'll need:

- A submersible thermometer

- An aquaponics measuring kit. Most growers' use a kit made by Aquarium Pharmaceuticals called the API Freshwater Master Test Kit ([theaquaponicsstore.com](http://theaquaponicsstore.com)) It's inexpensive, easy to use and specifically designed for monitoring levels in aquaponics systems.

## Introducing Your Fish to Your System

**B**reeders will, or should, give you all the pertinent information on the breed and size of fish you're ordering. In addition to detailed instructions about water pH and temperature, they'll give you the details for making sure their fish survive your aquaponics system. In general your water's pH should be between 6.5 and 8.5 depending upon the temperature of the water.

You should strive for a pH level of between 6.0 and 7.0, as it is less stressful for your fish. This is where you learn to balance the amount of fish you have, the ammonia they're producing, and the salts and things you need to add to keep the chemical levels balanced. (Chemicals refers to the natural process of ammonia etc. and not to manmade chemicals)

As we've said before, introducing fish into their new home is more than just putting the fish into the water. You need to "cycle" your water to create the bacteria/water balance that will convert ammonia from the fish into nitrates your plants can use.

## What Happens When You Add Fish

As soon as the fish are in the water they'll begin generating waste, primarily ammonia waste (which comes through their gills as part of their respiratory process) and solid waste (poop) that will need to be converted to nitrites (toxic to fish and plants), and then into nitrates (which plants love).

This process is accomplished naturally with two kinds of bacteria (which you can't see) and common old red worms, the kind you might fish with. It's the bacteria and worms that make your aquaponic system work. Without them you can't balance your pH and ammonia levels and both your plants and fish will die.

Fish are added to de-chlorinated water, immediately creating water with ammonia in it because fish release ammonia into the water as they breathe. It's part of their respiratory process. This ammonia, which is hazardous to fish, even in small quantities (.04 mg/l), must be removed. Because the toxicity of ammonia increases in relation to pH and temperature the aquaponic system must be monitored—meaning

temperatures regulated and water quality measured and maintained, or adjusted to reduce levels to acceptable numbers.

The bacteria needed to break down or ultimately convert the ammonia into nitrates are naturally attracted to the ammonia and seek it out as it appears in the water. These bacteria live in the growing medium. All you have to do is wait for them to appear and grow usually about 10 days to three weeks after the ammonia appears in the water.

The higher the ammonia the faster the bacteria appear and grow. Of course the higher the ammonia, the more stressed the fish and the more likely they are to die until you get levels to tolerable levels. The two kinds of bacteria are (1) nitrosomonas, which convert ammonia into nitrites, and (2) nitrospira which converts the nitrites into nitrates which the plants then absorb as water levels rise and are pumped into the growing medium.

Water is cleansed and filtered as it flows through a growing medium that contains bacteria and plain old worms. The growing media is often made of expanded seashells, crushed gravel or a special, non-soil rock or coconut fiber that allows the water from the system to drain through.

Regular garden worms live in this growing medium and feed on the dead leaves, decaying roots and solid fish waste that is flushed through the system. The worms do not drown because there is no soil to hold and trap the water that would drown them.

The worms can easily access oxygen in this system. If you're wondering how that can be, since after a heavy storm worms flee the earth and crawl onto the sidewalk right, it's simple. Worms crawl out of the ground because they can't get oxygen in water trapped in clay and soil.

In a grow bed, or in a growing medium where there are plants, there is water but it's oxygenated water and it drains quickly, leaving the worms with plenty of food, oxygen and a good growing environment. It doesn't drown them. It's just business as usual, just like a light rain doesn't bother the worms in nature, the flush of water through the growing media doesn't affect them either.

The worms move around the root systems of your plants, eating the decaying and growing matter that is sloughed off the plants daily. They convert this to worm poop, which stimulates the germination of seedlings and fertilizes your plants.

The nitrate, phosphorous, and potassium which result from this two bacteria process and the worm excrement are food for the plants and algae which remove these nutrients from the water the fish live in.

As plants grow they need more nitrates, which the fish are producing as they grow and produce more nitrites, and so the cycle continues.

This entire process of introducing ammonia, then converting it and attaining acceptable levels of nitrates and bacteria is known as the “Nitrogen Cycle.” When the system is in balance, the water will be crystal clear and ammonia and nitrite levels will be zero.

What you’ll be doing:

- Adding ammonia to de-chlorinated water
- Waiting for bacteria to find your system and turn the toxic ammonia in the water into nitrites
- Waiting for bacteria to turn the toxic nitrites into harmless nitrates
- Waiting for the plants to absorb the nitrates and return clean, clear water to the fish tank

In all aquaponics systems fish are the obvious sources of ammonia since as they excrete ammonia through their gills as they breathe. If that ammonia isn’t taken out of the system or converted into harmless nitrates, the fish (and your plants too since they hate ammonia) will die.

## Two Options for Cycling Your System

You have two options for cycling your aquaponic system for the first time— (1) fishless cycling, or (2) cycling with sacrificial fish (such as goldfish or a few of the fish you plan to ultimately raise in the system).

Fishless cycling, means getting ammonia into your system without fish. There are advantages and disadvantages to this system. The biggest advantage is there’s much less stress on the fish, and on you since you’re not likely to kill your fish because you can’t balance your system fast enough. With a fishless system you can focus on the process of adjusting your water levels and your pH.

You’re just concerned about numbers in a notebook, or your computer, as you learn how to keep your pH in a range that facilitates cycling.

Another advantage of cycling your system without fish is the whole process goes faster because you can raise the toxic levels of ammonia higher than any fish could tolerate, or that would be safe for them. So, you can get your system online in ten days to three weeks rather than the four to six weeks it would take you if there were fish you had to consider.

A higher ammonia concentration in the fishless cycling means a healthier and hardier bacteria base. So you can fully stock your system without having to bring the whole system up to greater levels with a gradual introduction of fish. If you’re growing carnivorous fish, or fish that must be densely populated to avoid

territorialness or aggressiveness, this is also a good thing. If fish are all introduced to a system at the same time, they're less likely to form obnoxious little fiefdoms and fight each other for the corners in a round room.

But best of all, you precisely control the amount of ammonia in your system. You can monitor ammonia levels and increase or reduce the levels based on what is happening in the water, and not on what the fish need to survive. If you have fish you can't do this. Your priority is keeping them alive. Fish don't stop making ammonia just because there are no bacteria.

Of course the easiest, most common way to add ammonia to your water is to just add a few fish and let nature take her course, but if you're impatient and ready to get your system rolling now, there are some non-traditional ways to add ammonia to your water without putting any fish at risk. You're the only one who can decide what will or won't work for you.

## Fishless Cycling

Fishless cycling is using ammonia from other sources than fish to set up your system. It requires no fish. Fish are added after the system is established and stable.

## Use Plain Old Liquid Ammonia

Liquid Ammonia or pure Ammonium Hydroxide has a very serious chemical ring to it, but you've probably got some in your house right now. It's very popular with people who like streak free plate glass windows, as it's a very effective cleaner. Yes, we're talking about the old fashioned cleaning product many of us grew up with and that many commercial building cleaners still use today because it's such an effective cleaner.

Only use the 100% ammonia, or 100% ammonia cut with water (usually 5 or 10% by weight). Avoid any ammonia with fragrances added (lavender or lemon etc), and do not use anything with surfactants or colors, soaps or perfumes or other additives. Check your ingredients list first, and then shake the bottle. If it foams, there's something more than ammonia in it. Look for labels that say, "Clear Ammonia, Pure Ammonium Hydroxide or Pure Ammonia, or 100% Ammonia." If it doesn't meet those criteria, walk away and try someplace else.

**Pros:** It's very inexpensive, about \$10 to \$20 for a gallon of the stuff. What you don't use to cycle your system can be used to scrub your toilet, mop your floors and make your windows sparkly clean. When you buy straight ammonia you know exactly what you're putting into your system—ammonia and water. You can order it online; get it at your closest grocery store, hardware store or cleaning supplies store.

**Cons:** If you're buying enough to cycle a medium to large system, the government might assume you're making bombs or methamphetamine. Neither assumption bodes well if they decide you're up to no good. Ammonia can also be hard to find. If you have a cleaning store or commercial facility around that stocks it, it can be easier to obtain, but again, there's that whole nefarious association with weaponry you want to avoid.

## Ammonium Chloride (crystallized ammonia)

Crystallized Ammonia is the same substance as liquid ammonia, just easier to find. You can get it through aquarium supply stores, as well as soap, photography and hair supply stores, and chemical houses. It's concentrated and in dry form so it's cheaper, less expensive to ship and little doubt it's pure.

## Human Urine

Often called "Peeponics" by those who use it, human urine is another potential source for ammonia in your system if you don't want to buy or use commercial ammonia. It can introduce pathogens and disease into your aquaponics system because of bacteria or germs you may be harboring in your urine, so it's a more complex environment than just plain ammonia.

Yes, we're talking about you peeing in your aquaponic system. Humans pee in chlorinated swimming pools all the time and we adjust that pH. So it's not that weird. Human urine is easier than finding, ordering and using liquid or crystallized ammonia, but it is a little more work.

You can't just pour your pee into the water. In order to go from urea (urine) to ammonia, you should bottle your pee in a sealed bottle for a few weeks to "mature," or season. You could just urinate straight into the fish tank but since it takes human urine a while to turn into ammonia you will have no way of telling just how much potential ammonia you have in there.

If you're testing regularly and daily, as you should be, your ammonia levels will be very low. Then one day they'll suddenly skyrocket as your urine finally becomes ammonia.

## Other sources of ammonia

Dead animals off-gas ammonia. So, you could put a dead fish into your water. Sure, it's easy and cheap, but the downside is whatever killed the fish could end up in your water as well. Other bacteria and chemical compounds are also given off in the

decaying process, so there's a chance they could mess with your fish later on down the road.

If you're in a survival situation and there are no other sources of ammonia, these are things you might consider, but for now, you're better off using liquid or crystallized ammonia just to ensure the safety and controllability of your system.

## Instructions for Fishless Cycling

Okay, you've got your ammonia and you're ready to start the cycling process. Here's all you have to do, follow these simple instructions.

1. Add the ammonia to the tank a little at a time. Add a little, and then use your testing kit to get a reading. Keep doing this until you obtain a reading from your ammonia kit of -5 ppm.
2. Record the amount of ammonia that it took to get this reading and then add that amount to the water daily until the nitrite appears (0.5 ppm)
3. Once nitrites start to appear, cut back the daily dose of ammonia to half the original volume.
4. Once nitrates appear (5 -10 ppm), and the nitrites have dropped to zero, you can add your fish.

Simple eh? We thought so too. But what do you do to bring ammonia levels down once fish are introduced? You can't really control their ammonia as easily. So you have to adjust the pH levels by increasing alkaline levels. This is necessary because pH is important not just for the fish, but for your plants too. Plants in aquaponics systems prefer a pH in the 5.8 to 6.8 range, or even a slightly lower range. Fish prefer a little higher pH and to keep them both happy you have to pay close attention to your levels and adjust them as needed.

Lowering pH levels when they become high is important. pH is a measure of the acidity or alkalinity of a solution. The level is measured on a scale of 0 to 14. The nitrification process going on in your system causes it to become more acidic over time. But it can go up as well.

If your pH is low, that means the system is acidic. To make it normal increase the alkaline level by adding Calcium Hydroxide ( $\text{Ca}[\text{OH}]_2$ ), or Potassium Hydroxide. Add some of the chemical to a bucket of water. Over the course of the day, or a few hours of the day, slowly transfer it into your system. Don't dump the chemical in all at once, as it is very alkaline and can harm your fish and plants.

You can also use specific chemicals, such as a hydrochloric or muriatic acid buffer that helps reduce the pH level of the water. The right quantity of acid to be used depends on the buffering capacity of the water. Many products that say 'pH-

Down' are used to lower pH levels. These products contain phosphoric acid that keeps the pH level low. However, they may stimulate the growth of algae in the water tank.

Balancing the pH is perhaps the most challenging and confusing part of aquaponics for many growers. It's not hard, but it just takes practice to learn, sort of like cooking and knowing how much of each ingredient to add to make the perfect cake. It is very important to know the content and the accurate levels before using these acids, as they are very dangerous. Check and treat the water before adding it to the aquaponic system.

A safer and easier way to lower the pH level is to simply add distilled water or rain water to the tanks. If you can't do that, then try bubbling carbon dioxide through the water tank. As the carbon dioxide dissolves in the water and partly turns into carbonic acid, the pH level also decreases.

In addition to lowering pH levels, carbon dioxide also stimulates plant growth in the aquaponic system. If all this sounds really confusing, visit any local pet store that sells fish tanks and aquariums and ask someone to explain it further.



## Where Do I Buy My Fish?

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There are more places than you can imagine to buy fish, prawns and seafood for your aquaponics system. Start off with a Federal fish hatchery, breeder or regional fish nursery. Check to see if your state has an aquaculture program, either the extension office in your county, or through the state agriculture department.

You can also find fingerlings (baby or juvenile fish) on eBay and hundreds of websites across the web. In the United States expect to pay, for instance, about \$1 per Tilapia fingerling (includes shipping) or more depending on the species. Most hatcheries have a minimum order too. Remember that even the best farmers lose 10% of their fish in transfers and for other reasons so order 10-20% more fish than you want or expect to survive.

Google your state and the word “aquaculture” for a list of hatcheries, breeders and farms.

There are 70 Federal fish hatcheries in the United States:

<a href="#"><u>Alchesay-Williams Creek National Fish Hatchery</u></a>	Arizona
<a href="#"><u>Allegheny National Fish Hatchery</u></a>	Pennsylvania
<a href="#"><u>Bears Bluff National Fish Hatchery</u></a>	South Carolina
<a href="#"><u>Bozeman National Fish Hatchery</u></a>	Montana
<a href="#"><u>Carson National Fish Hatchery</u></a>	Washington
<a href="#"><u>Chattahoochee Forest National Fish Hatchery</u></a>	Georgia
<a href="#"><u>Coleman National Fish Hatchery</u></a>	California
<a href="#"><u>Craig Brook National Fish Hatchery</u></a>	Maine
<a href="#"><u>Creston National Fish Hatchery</u></a>	Montana
<a href="#"><u>D.C. Booth Historic National Fish Hatchery</u></a>	South Dakota
<a href="#"><u>Dale Hollow National Fish Hatchery</u></a>	Tennessee
<a href="#"><u>Dexter National Fish Hatchery</u></a>	New Mexico
<a href="#"><u>Dworshak National Fish Hatchery</u></a>	Idaho
<a href="#"><u>Eagle Creek National Fish Hatchery</u></a>	Oregon
<a href="#"><u>Edenton National Fish Hatchery</u></a>	North Carolina
<a href="#"><u>Ennis National Fish Hatchery</u></a>	Montana
<a href="#"><u>Entiat National Fish Hatchery</u></a>	Washington

<a href="#"><u>Erwin National Fish Hatchery</u></a>	Tennessee
<a href="#"><u>Garrison Dam National Fish Hatchery</u></a>	North Dakota
<a href="#"><u>Gavins Point National Fish Hatchery</u></a>	South Dakota
<a href="#"><u>Genoa National Fish Hatchery</u></a>	Wisconsin
<a href="#"><u>Green Lake National Fish Hatchery</u></a>	Maine
<a href="#"><u>Greers Ferry National Fish Hatchery</u></a>	Arkansas
<a href="#"><u>Hagerman National Fish Hatchery</u></a>	Idaho
<a href="#"><u>Harrison Lake National Fish Hatchery</u></a>	Virginia
<a href="#"><u>Hiawatha Forest National Fish Hatchery</u></a>	Michigan
<a href="#"><u>Hotchkiss National Fish Hatchery</u></a>	Colorado
<a href="#"><u>Inks Dam National Fish Hatchery</u></a>	Texas
<a href="#"><u>Iron River National Fish Hatchery</u></a>	Wisconsin
<a href="#"><u>Jackson National Fish Hatchery</u></a>	Wyoming
<a href="#"><u>Jones Hole National Fish Hatchery</u></a>	Utah
<a href="#"><u>Jordan River National Fish Hatchery</u></a>	Michigan
<a href="#"><u>Kooskia National Fish Hatchery</u></a>	Idaho
<a href="#"><u>Lamar National Fish Hatchery</u></a>	Pennsylvania
<a href="#"><u>Leadville National Fish Hatchery</u></a>	Colorado
<a href="#"><u>Leavenworth National Fish Hatchery</u></a>	Washington
<a href="#"><u>Lehontan National Fish Hatchery</u></a>	Nevada
<a href="#"><u>Little White Salmon National Fish Hatchery</u></a>	Washington
<a href="#"><u>Livingston Stone National Fish Hatchery</u></a>	California
<a href="#"><u>Makah National Fish Hatchery</u></a>	Washington
<a href="#"><u>Mammoth Spring National Fish Hatchery</u></a>	Arkansas
<a href="#"><u>McKinney Lake National Fish Hatchery</u></a>	North Carolina
<a href="#"><u>Mora National Fish Hatchery and Technology Center</u></a>	New Mexico
<a href="#"><u>Nashua National Fish Hatchery</u></a>	New Hampshire
<a href="#"><u>Natchitoches National Fish Hatchery</u></a>	Louisiana
<a href="#"><u>Neosho National Fish Hatchery</u></a>	Missouri

<a href="#"><u>Norfolk National Fish Hatchery</u></a>	Arkansas
<a href="#"><u>North Attleboro National Fish Hatchery</u></a>	Massachusetts
<a href="#"><u>Orangeburg National Fish Hatchery</u></a>	South Carolina
<a href="#"><u>Ouray National Fish Hatchery</u></a>	Utah
<a href="#"><u>Pendills Creek National Fish Hatchery</u></a>	Michigan
<a href="#"><u>Pittsford National Fish Hatchery</u></a>	Vermont
<a href="#"><u>Private John Allen National Fish Hatchery</u></a>	Mississippi
<a href="#"><u>Quilcene National Fish Hatchery</u></a>	Washington
<a href="#"><u>Quinault National Fish Hatchery</u></a>	Washington
<a href="#"><u>Richard Cronin National Salmon Station</u></a>	Massachusetts
<a href="#"><u>San Marcos National Fish Hatchery</u></a>	Texas
<a href="#"><u>Saratoga National Fish Hatchery</u></a>	Wyoming
<a href="#"><u>Spring Creek National Fish Hatchery</u></a>	Washington
<a href="#"><u>Tishomingo National Fish Hatchery</u></a>	Oklahoma
<a href="#"><u>Uvalde National Fish Hatchery</u></a>	Texas
<a href="#"><u>Valley City National Fish Hatchery</u></a>	North Dakota
<a href="#"><u>Warm Springs National Fish Hatchery</u></a>	Oregon
<a href="#"><u>Welaka National Fish Hatchery</u></a>	Florida
<a href="#"><u>White River National Fish Hatchery</u></a>	Vermont
<a href="#"><u>White Sulphur Springs National Fish Hatchery</u></a>	West Virginia
<a href="#"><u>Willard National Fish Hatchery</u></a>	Washington
<a href="#"><u>Willow Beach National Fish Hatchery</u></a>	Arizona
<a href="#"><u>Winthrop National Fish Hatchery</u></a>	Washington
<a href="#"><u>Wolf Creek National Fish Hatchery</u></a>	Kentucky

Find the hatchery closest to you as it's not the fish that cost that much, but the water. At a little over 8 pounds per gallon, you'll be paying for the hundreds of gallons of water it will cost to ship your fish, unless you drive to the hatchery and pick them up yourself. Fish (and prawn) must be trucked to a location.

## Transferring Fish from Breeder to Tank

Once you order your fish they'll arrive within one to two days, so you need to have your tank ready, your water cycled and everything ready for your new arrivals.

If you've ever bought a goldfish or had an aquarium you know you need to gradually acclimate your fish from the fish store into your aquarium. The same principle holds true for whatever fish, prawn or creatures you plan to raise in an aquaponics system too.

The purpose of acclimating your fish is to provide a gentle transition so you don't shock the fish, which can kill them or stress them and make them vulnerable to disease. You want your fish to thrive, so start them out right.

Make sure your tank is at the right temperature and pH for the fish you're putting in the system. Then, when your fish arrive, usually in a bag, float the shipping bag on top of the water in your tank. Do not open the bag for this initial step.

Fish arrive in different containers. Some come in bags, or in bags in a Styrofoam box, or in breathable bags. However they arrive, the point is to get the bags to your tank to equilibrate the temperature between shipping container and tank. The bag and livestock can also be transferred to and floated in acclimation kits.

If you do get your fish in breathable bags do not float them directly in your tank. Float them in a container that is not breathable and will allow heat transfer. Temperature acclimate your fish for at least 15 minutes if the water temperature of the bag was close to the water temperature of the tank. If you notice that the temperature of the bag was extra cold or extra warm then temperature acclimate 15-45 minutes longer depending on how severe the temperature difference was.

If you notice your fish, or a fish that appears dead or severely distressed don't try to speed up the process. Slow it down. If you speed up this temperature acclimation process for a fish that is extremely stressed it will stress the fish out even more.

Place the bag into your non-chlorinated water and let the sealed bag float on top of the tank for about 15 minutes. This lets the water in the shipping bag adjust slowly to the temperature in your tank.

Remove the band or closure on the bag and roll the top edge of the bag down to create an air pocket within the lip of the bag. This lets the bag continue to float and allows air to circulate in the bag. Do not let the fish swim out.

Begin to add 1 cup of your tank water to the shipping bag every five minutes for 15 minutes (three times), holding the bag on top of the water if needed. For small bags of fish, drip the water into the bag through a hole in the bag in small increments over 15 to 30 minutes. One drip per three seconds is a good rate. When the bags are full, empty half the water (down the sink or on the ground but never in the tank) and repeat until you've filled the bag three times. This chemically acclimates the fish. Forty-five minutes to one hour is normal for this amount of time.

Then, using a net, scoop out the fingerlings (fish) and gently add them to your tank. Don't add the shipping water to your tank. It will most likely have high levels of ammonia in it from the transfer process.

Temperature and pH levels aren't the only stressors. Fish are social creatures and social acclimation should be a major consideration too. If you're getting all new fish at the same time, you won't need to separate them., but if you are adding fish to an existing system, put them in a small container in the tank that will allow your new fish to interact (see) but not touch each other. Have enough holes (screen) and flow to allow the just-shipped fish to recover in peace.

Don't rush the process. Take your time. The total minimum amount of time is about 30 minutes. Rushing can stress your fish. You don't need to add an air stone or anything else to the water during the acclimatization process.

Once the fish are all in the tank, pour the shipping bag water out away from the tank and turn off the lights or cover the tank so the fish have some darkness for a few hours. The fish may go straight to the bottom of the tank as they adjust to their new home. This is normal and doesn't mean they're sick or anything is wrong.

Depending on the fish they may not eat for several days as they get used to their new environment. Don't worry. Once their appetite returns and their stress drops, they'll eat.

Give your fish time to get adjusted and monitor your water, temperature and pH levels several times a day until you see how the fish affect the water. Feed and enjoy your new livestock. You're officially a fish farmer!

## Your Aquaponic Plants

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The hardest part of growing vegetables and flowers and plants in your aquaponic set up is not in keeping the plants alive. It's in deciding which plants you want to grow to begin with! More than 350 plants have been tested and found to be compatible with the temperatures and conditions common to aquaponics. Unless you have a large system, you're usually limited to a half dozen to dozen plants. So, what will they be?

The most popular, easy-to-grow aquaponic food is lettuce. It comes in dozens of varieties, is a fast growing plant and loves the cooler water and air temperatures of most aquaponic systems (60 to 80 degrees for air, and water temps of 70 to 74 degrees Fahrenheit). Leafy varieties of lettuce grow faster (40 days to maturity rather than the 90 days typical of iceberg lettuce) and they're more nutrient dense and healthier for you.

If you're serious about your food, and your yield, you should know that the primary advantage to aquaponics is that, all plants use a lot of water, but plants grown in the ground use the water very quickly in hot weather while plants in an aquaponic system are continuously being watered constantly through the continuous flow or flood and drain system so they never dry out.

Lettuce is planted and harvested in about 30-to-40 days depending on the variety and the nutrient levels of your system. It's delicious and nutritious and used in a variety of dishes. It's always a good choice no matter what else you're growing because it's hard to kill lettuce.



Bumblebee pollinating basil

Tomatoes, cucumbers, radishes and all the common ingredients in salads also all thrive in an aquaponic system. As a matter of fact, most vegetables thrive in an aquaponic system. According to a trial conducted by Dr Nick Savidov in Canada, aquaponic growth rates can exceed hydroponic plant growth by up to four times with some vegetables and herbs.

Herbs and green leafy vegetables are the most common aquaponic plants grown in an aquaponics system. Different areas can also produce different results. Climate is another important factor as is whether your aquaponic system is open to the elements or in a green house.

While there are literally hundreds of varieties of plants that do well in an aquaponic system, it's important to make sure your plants and your fish like the same temperature range. One way to decide what to grow is to decide which is more important to you—your vegetable harvest or your fish harvest.

If it's your fish, then pick a variety or several varieties that will fare well in the temperatures you have in your system. Then, select plant that will also do well in that same system range. If you're growing in an environment with humidity levels over 75%, (cucumbers etc.) you need to select plants that are resistant to powdery mildew.





**Strawberries are a popular aquaponic plant to grow**

Popular aquaponic plants in alphabetical order:

1. Asparagus
2. Basil
3. Beans
4. Bok Choy
5. Cabbage
6. Cantaloupe
7. Capsicum (chilis)
8. Cauliflower
9. Celery
10. Coriander
11. Cucumbers
12. Honeydew melons



13. Egg plant
14. Lemongrass
15. Lettuce
16. Mint
17. Melons
18. Parsley
19. Peppers
20. Radishes
21. Rosemary
22. Roses
23. Sage
24. Shallots
25. Strawberries
26. Squash
27. Tomatoes
28. Watercress
29. Zucchini



Big red tomato

## Tomatoes

Tomatoes require humid conditions and their ideal fruiting temperature is 78 degrees Fahrenheit (. However, tomatoes will fruit in a temperature range between 68-88 degrees. They grow best at a pH of 5.8-6.8 but will tolerate a pH up to 7.2. They love lots of light when fruiting and need from 8-12 hours per day. Their fruit production depends on their light—the more light, the faster the fruit grows.

Tomatoes also need a fairly densely stocked fish tank since the nutrients the fish are providing are essential for growing healthy, hardy tomatoes. Tomatoes go through a lot of changes during their life cycle and water and nutrients are critical to their growing cycle. All tomatoes are not equal however.

There are two varieties of tomato plants, determinate and indeterminate. The determinate tomato species, delivers fruit all at one time while the indeterminate tomato plant, staggers its fruit production and can live for several years. Many cherry (small) tomato plants are indeterminate and will produce tomatoes all year round if not killed by cold temperatures or neglect.

The determinate variety is a much smaller plant and easier to grow in an aquaponic system. Determinant tomato varieties have a much more predictable

nutrient need and are only in your system for a specific period of time. There are a lot of varieties in the determinate species to choose from, so don't feel like you're limited by your selection. You're not. If you want to grow a specific species of plant simply find out what the size of your mature plant will be so you can provide enough space for it to grow.

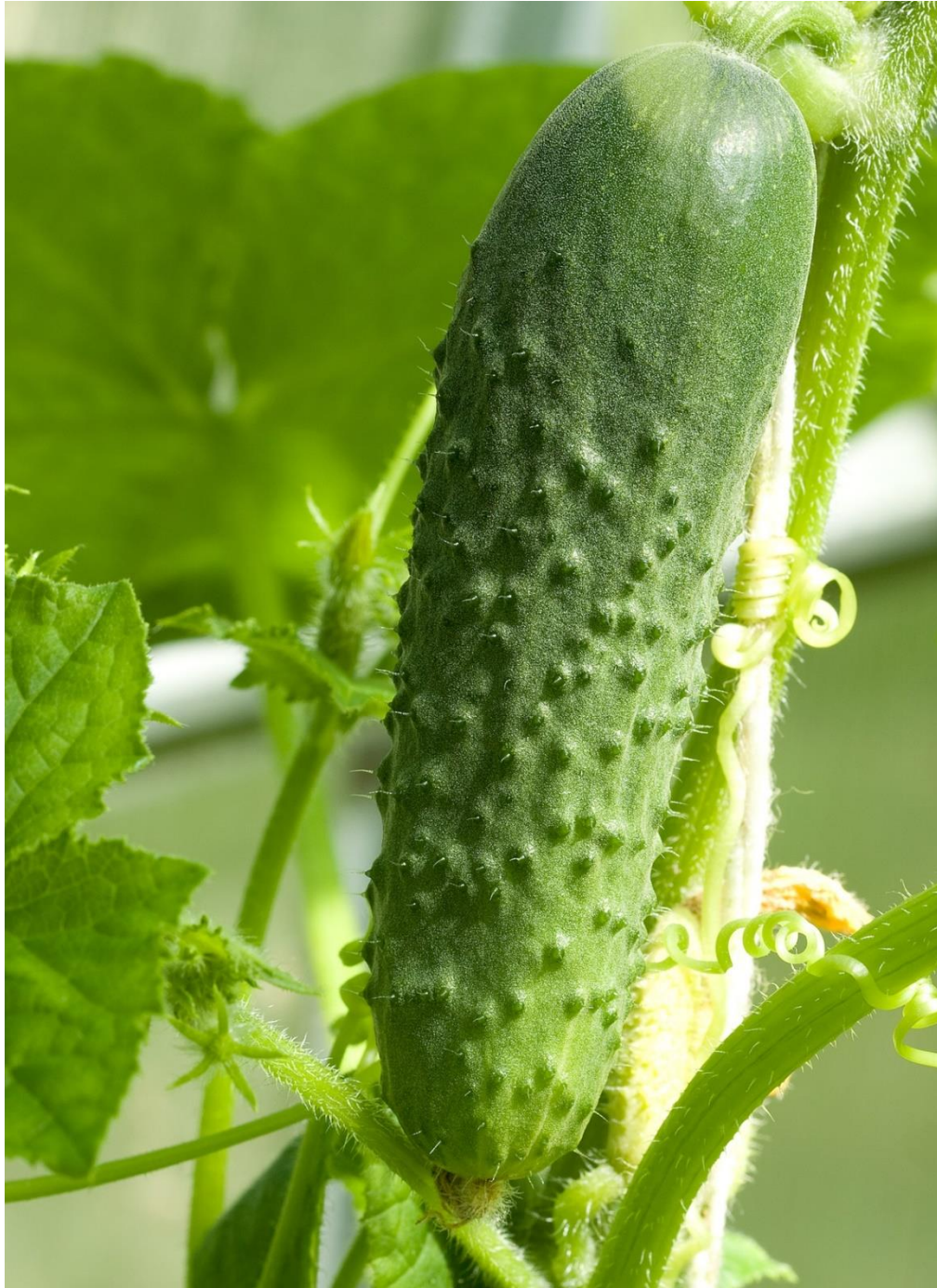
Unlike lettuce, which can be sprinkled onto the growing media, tomatoes require a separate seedling tray to germinate and grow into seedlings before being planted. Tomatoes germinate best at 77 degrees Fahrenheit with nearly 100% humidity. Allow your tomatoes to grow between 2-to-6 weeks before you transplant them into your grow bed. Stagger the planting and growth of your tomatoes if you want to pick them at various times, and so the plants don't drop their fruit all at once, unless you're planning on that for canning or sales.

When it's time to harvest them, allow the fruit to fully ripen, picking them at their peak to ensure the remarkable tomato taste you may remember from a childhood garden-raised tomato. Store your freshly picked tomatoes in a cool place, not the refrigerator. Tomatoes stored in temperatures below 54 degrees, lose their flavor.

## Cucumbers and squashes

**T**hese plants are all vine crops, so their needs, root systems and nutrient requirements are similar. How you grow them depends on your system. They can be grown vertically (on a trellis, ladder or similar framework) or just resting on the grow bed media. If your grow bed media is fully flooded you might want to consider training for a trellis or use a stand of some kind to keep the vegetable off of the media.

English cucumbers are the cucumber variety best suited for an aquaponic farmer. Ideally, cucumbers prefer a daytime temperature of 75-78 degrees Fahrenheit and a nighttime temperature of 68 degrees, and a humidity level of 75% or below.



Cucumber

From seed to ready-to-eat (about a foot long) English cucumbers take from one and a half to two months to mature. The plant itself is most productive for its first six to twelve weeks, but will continue to produce fruit for many months.

Zucchini, and Winter Squashes (Buttercup, acorn, spaghetti and watermelon etc)



Summer squashes like zucchini or yellow squash, as well as winter squashes like banana, buttercup, acorn and spaghetti squash prefer a daytime temperature of 75-78 degrees Fahrenheit and a nighttime temperature of 68 degrees, and a humidity level of 75% or below.



Honeydew melon and watermelon growing on metal shelf

## Melons, Watermelon, Cantaloupe, and Honey Dew

Melons, such as watermelon, cantaloupe and honey dew all make excellent aquaponic crops. They do best when raised in high humidity and under the same conditions as English cucumbers— a daytime temperature of 75-78 degrees Fahrenheit and a nighttime temperature of 68 degrees, and a humidity level of 75% or below.



Chinese cabbage growing in a floating medium, ebb and flow system.

## Cabbage, Broccoli, Cauliflower, Radishes and Kale

Cruciferous vegetables (cabbage, broccoli, radishes, kale, Brussels sprouts etc.) are all related. So they all grow very well in an aquaponic system. What lettuce is for Americans, Chinese cabbage is for Asians—a vegetable staple. It takes 5-7 days to germinate Chinese cabbage seeds and 45-55 days to grow a cabbage to maturity. The seeds need to be kept moist and between 60-70 degrees Fahrenheit.

At ten or more days old, the sprout can be transplanted into the grow bed. Just like lettuce, you can harvest the entire cabbage, or simply pick the outer growth as needed.

### How to plant in an Aquaponics System

If you've ever planted in soil you know you (1) can plant seeds manually, in a hole with a planter or by hand, (2) broadcast, or sprinkle the seeds or (2) germinate them in some sort of media to grow seedlings you can later transplant into the ground. In an aquaponics system starting your seed and planting seedlings is the

primary option you have pretty much the same options, the most popular being germinating or seed starting in a media, like soil, a damp paper towel, or commercial starter media:

## Broadcasting seeds

This is the easiest way to plant in soil, aquaponic or hydroponic systems. Just toss your seeds over the grow bed surface and let nature take its course. It works best for lettuce and carrots, radishes and all herbs.

## Seed Starting with Media

Not all seeds take well broadcasting (tossing seeds evenly over a media or growing surface). That's when you need some sort of media to encourage the seeds before transplanting. Spinach, chard, even melons all seem to need a little more love than say basil, tomatoes or squash. Beans, peas, and cucumbers seem to need a little more attention and care as well.

## Paper towels

If you don't want to waste grow media, but still want that extra nurturing, use wet paper towels to germinate your seeds. Things like lettuce, beans, peas, melons and cucumbers do well in a paper towel since they germinate quickly. Simply dampen or wet a paper towel, squeeze most of the water out so it's wet, but not dripping, and sprinkle your seeds on the paper towel. Once the seeds are sprinkled on the towel, seal them into a large (gallon size) zip-lock bag and set them in a dark, cool spot.

Watch them daily for signs of sprouting activity. When you see a good sized root or sprout, at least an inch long, then remove them from the bag and place them in your grow bed. If you get the towel wet enough it should stay moist long enough for the seeds to sprout, but if it dries out, add more water—enough to keep it moist.

Make sure the roots of the sprout are long enough or deep enough in your media to get wet in your flood cycles, especially if you have a 12-inch grow bed.

## Rockwool

If you don't want to use paper towels, you can use rockwool. Rockwool is the default seed starting media for aquaponics and is available anywhere you find hydroponic or aquaponic supplies, or in most hardware and home stores. Advantages



to rockwool are it's completely inert so you don't have to worry about fungus attacking your seedlings. It makes for a very sterile media and one that's easy to use.

On the down side, rockwool is made out of spun rock and is difficult to handle, much like handling fiberglass insulation. Wear gloves and wash your hands after handling. It can be prickly. It comes in sheets, or precut and performed in cubes (your best bet for easy handling).

## Peat Sponges

**P**eat sponges go by a variety of names: grow plugs, Rapid Rooter, Sun Leaves Super Starter, Sphagnum plugs and so on. They're pricey, but worth the few extra cents. On the down side they can harbor fungal gnats if the packaging has been breached before purchase or moisture has built up, but they are excellent to work with, are biodegradable and are pH neutral.

## Vermicompost

**V**ermicompost is made from the composted product of worms vegetable or food waste, bedding and vermicast (worm poop). It has the highest saturation levels of nutrients than any other starter material, and is an excellent choice of starter media for the really serious aquaponics enthusiast. This stuff just kick starts your seeds.

## Other Ways to Plant

**O**kay, you're impatient, or you started after the season started, or your first round of plantings were destroyed for whatever reason. You really don't want to wait on seeds to germinate and grow. Your other planting options are, of course, to buy seedlings from a nursery. That's perfectly okay. You don't lose brownie points for letting someone or some company start your seeds for you.

## Buying Seedlings

When you buy seedlings from a nursery or home store they come in various pots, and soil. To make the transfer from soil to water you'll need to:



- Take the seedling or plant out of its pot
- Shake the dirt off (Gently!!!)
- Check for bugs, scale, aphids etc.
- Run the plant under non-chlorinated water to remove as much soil as possible (you can also swish it around in a bucket of rainwater or bottled water)
- It's not required, but if you want to give your seedlings a boost after cleaning the roots, swish the roots around for 30 to 60 seconds in a solution of water with Maxicrop ([maxicrop.com](http://maxicrop.com)) to help prevent transplant shock.

## Cuttings

If you already have some plants started, or you have generous neighbors with a growing crop of whatever you want, consider using cuttings from those plants. Tomatoes and peppers and all herbs take rapidly to cuttings and will grow and root quickly in an aquaponic system. Just as with any seedlings, it helps to swish the roots around in a solution of Maxicrop to prevent transplant shock and to give them an extra nutrient boost.

## Issues with Plants

If you have a green thumb you probably have never even seen a plant struggle under your care. But if your gardening skills in soil aren't the best you may struggle with getting the chemical and nutrient balance you need to have to keep an aquaponics bed lush and healthy. But don't worry, it's not hard, it's just a matter of recognizing what wilting leaves and brown or yellow colors where there should only be green means. Here's a handy guide:

Plants and fish, like people, respond to their environment. If you're seeing anything besides a lush green grow bed, chances are one of seven things are out of kilter:

1. Air: Yep. Plants need oxygen too. And if they're not getting enough oxygen, chances are your fish aren't either.

2. Nutrients: You may not have the right mix of fish making the right amount of ammonia to be converted to nitrates for the plant. It's important to monitor your system daily to make sure your pH levels, oxygen and nutrient levels are optimal.

3. pH levels: Your system's pH levels are critical. Get and use a good test kit daily to ensure you're keeping a pH level that benefits both fish and plants.

4. Water: Your plant's roots may not be getting enough water because your water levels have dropped and the ebb and flow isn't drenching your roots

5. Light: You may not have enough light getting to your plants, especially if you have an indoor system and are using grow lights. Plants need lots and lots of light!

6. Temperature: Remember we said fish could survive certain temperature extremes, but thrive in the perfect temperatures? The same is true with plants. If your fish temps and your plant temps aren't in the same range, or aren't compatible, one or both is going to suffer. Double check to make sure you have compatible fish and plants.

7. Space: Yes, you can definitely grow more plants in one square foot with aquaponics than you can in the soil. But it is possible to grow too many plants in an aquaponic system. The secret is to having the right fish to plant ratio so your plants are ensured all the nutrients they need. Remember, the only place they're getting fed is from the worm castings and nitrates generated by the bacteria feeding on the nitrites generated by the ammonia and fish waste in the system.

All this sounds more complicated than it is. Like anything new there's just a lot to learn at the beginning. That's why we advise you to start small and learn to balance your system with a few fish and plants before investing heavily in a large system and 50 or more plants to begin with.



Bee in a squash flower

## Pollinating Your Plants

If you've heard the birds and the bees talk, you know gardens and plants need to be pollinated before they produce fruit or vegetables, right? Well, sort of. Not all plants need bees or insects to pollinate them. Before we get into that, let's talk about the birds and the bees and the reproductive life of plants.

## What is pollination?

**P**ollination is the transfer of pollen from the anthers of a flower to the stigma of the same flower or of another flower. Pollination is a prerequisite for fertilization. Without fertilization, you don't get vegetables or fruit.

Plant flowers actually contain reproductive parts known as essential organs. They're essential because they're needed for reproduction. The male organ is called the stamen. The female organ is called the pistil. The male organ is comprised of the long, stem-like filament that's capped off with the anther, which contains the pollen. The female organ has a receptacle with a tube called the style, which terminates in the ovary, which contains the eggs.

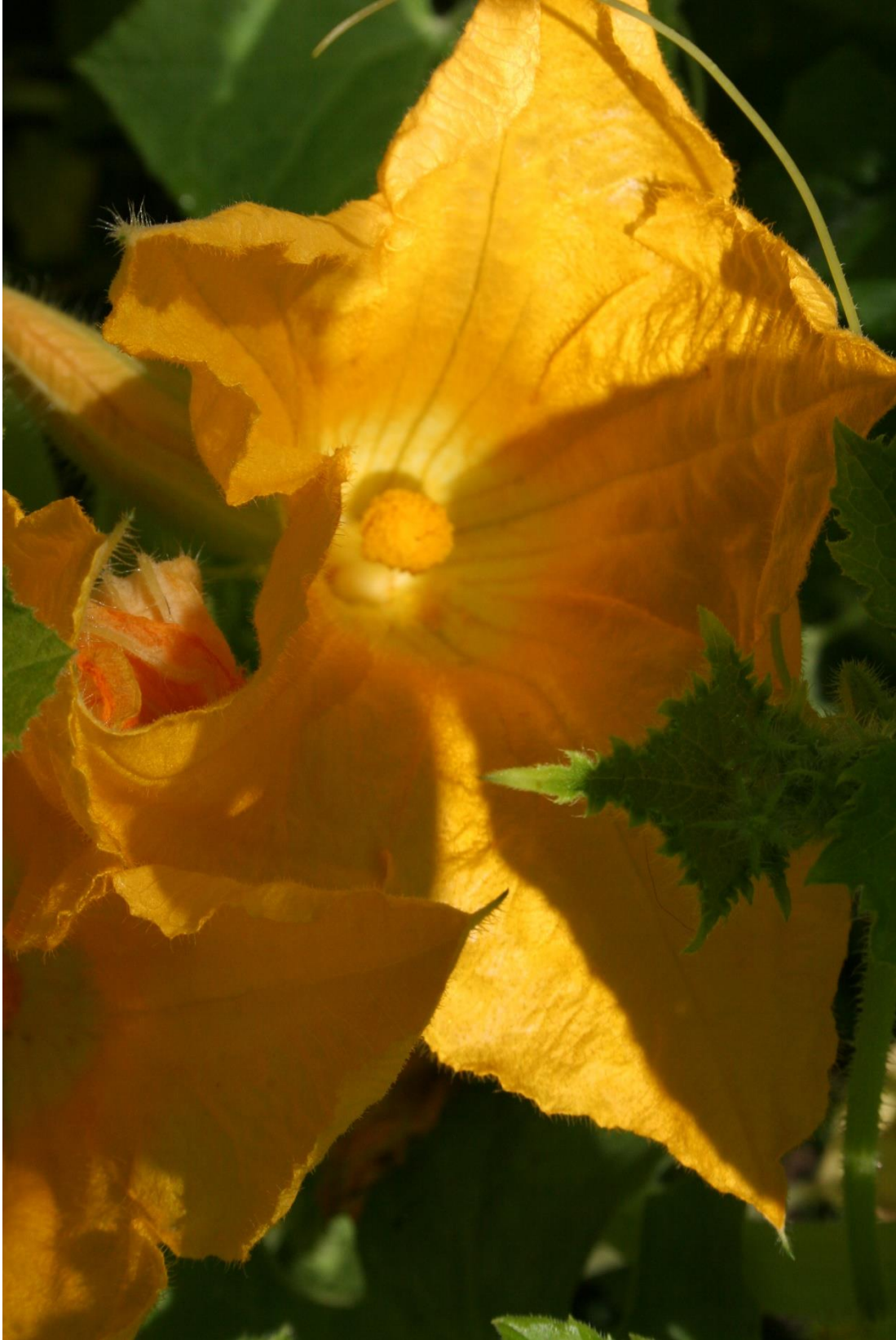
Pollination in plants is like fertilization in any animal—it's a process of getting the male's pollen to the female ovaries so the eggs can be fertilized. The plant's flower petals are utilized in the process to attract bees and insects to the plant's nectar so their movement and brushing up against the plant's sex organs assists in transferring pollen from male to female. But not all plants are created equal.

Horticulturists divide plants into four categories based on their essential organs:

1. Male and female plants
2. Plants that need pollination from an unrelated plant
3. Cross pollination
4. Self-pollinating plants



Female Squash flower



Male squash flower



## Male and female plants

Yes, plants have genders. Most notable is the eggplant, but other good examples are asparagus, spinach and some hybrid cucumbers. You only need to pollinate them if you intend to grow the plant for seed.

If you are growing plants indoors and do plan on collecting seeds you'll need to pollinate them by hand. It's not as difficult as it seems, especially on larger plants like melons, squash, cucumbers etc.

## How-to pollinate plants by hand

1. Start early in the morning when there's lots of pollen on the flowers. Begin by identifying the male and female flowers. The female flowers have the stigma, which receives the pollen, and the male ends have a stamen containing the pollen. Pollen can be any color, including a light yellow, dark yellow or white.

2. Once you've identified the male and female flowers touch the stamen of the male flower lightly. If your finger has pollen on it, the stamen is ready.

3. You don't have to use your finger, although it's the easiest. You can use a cotton swab, makeup brush, artist's paintbrush or sponge brush (something as small as a cotton swab is best). Touch the tip of the stamen, or the anthers, with whatever you're using to collect pollen.

The pollen should adhere to whatever implement you're using. Or, you can simply cut the flower off of the plant, fold the petals back, exposing the stamen, and use it directly, without using a swab. Once the pollination is done, dispose of or compost the flower. Expose the stamen, and then transfer the pollen to the female flower's sticky stigma.

4. Repeat the process. Pollinate as many of the flowers and plants as you need to.

## Plants that need pollination from an unrelated plant

The only plants that require pollination from an unrelated plant are cabbages and radishes. But you only need to pollinate them if you're growing them for seeds.

## Cross-pollination

The largest group or category of plants are the cross pollinators. In this group each plant has both male and female flowers. So, one squash plant will have male flowers and female flowers.

This group also breaks down into two sub-groups:

1. Pollinated by insects, bees etc., and
2. Those pollinated by the wind.

Plants pollinated by insects can be self-pollinating, but their yield is better if bees and insects visit the flower and disperse the pollen as well. If you're growing indoors you can hand pollinate these plants simply because the flowers are large enough to be able to do that.

Cucumbers, pumpkins, melons like watermelon, cantaloupe and honeydew are among these. Simply start pollinating early in the morning while there's lots of pollen on the flowers.

## Windblown pollination

Plants pollinated by the wind include sweet corn, carrots, onions, and beets. Only the corn needs to be pollinated for food crop production because the kernels of the cob are actually the seeds.

## Self-pollinating plants

Not all plants need bees, birds and insects to help them pollinate. They're called self-pollinating plants. These include beans, peas and tomatoes. All they need is a breeze (if outside), or some light tapping from you if they're indoors, to release their pollen and ensure optimal fruit production.

If your aquaponics system is outside, in your back yard, on a porch or in an open greenhouse where bees and other insects have free access, you won't have to worry too much about pollination as Mother Nature takes care of it. But if your setup is in your house, a closed nursery or greenhouse, or other shelter, you will need to pollinate if you want seeds (and only if you want seeds).

## Aquaponics and Predators

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**N**ot everyone with an aquaponics system will experience predator problems, but almost all farmers will if they don't have systems in place to deter them.

And while cats, raccoons and hawks might seem like they'd be an aquaponic farmer's biggest predator threat, they're not. Oddly enough, unexpected predators like tomato hornworms, squash bugs, and other pests and insects, which can skeletonize your plants like tiny piranha, are the real killers.

Other predators you can expect to find in your system are whiteflies, slugs, parasites, mites, viruses and diseases common to a typical garden. You can't use any kind of pesticide with an aquaponics system because the pesticides will end up in the fish and the vegetables and ultimately in whoever eats them. So you need to be aware of other ways to protect your system from pests. Learning how to use predator bugs that target the pests and leave your plants alone is the best way to rid your system of pests. If an aquaponics system is perfect for growing fish and plants, it's also perfect for growing parasites, mites, diseases and pests.

So, take heart. Until the shit hits the fan, your most likely predators will be bugs and pests, then cats, birds and snakes. After that, you can expect to see human predators. It's up to you to decide how you want to handle that particular mammal when that happens, but let's focus on each threat to your fish by category.

Depending on what part of the country or what country you live in, how large your aquaponic system is, and what access wildlife has, you can expect to find wolves, coyotes, bear, dogs, owls, alligators, raccoons, opossums and eagles, osprey and other predator birds like geese, herons and pelicans attracted to your system as well. You see it as your fish tank; they see it as a pond with a quick and easy dinner.

### Insect Pests

The most common bad guy pests aquaponic gardeners will encounter include:

- Aphids
- White flies



- Thrips
- Caterpillars
- Beetles
- Horn worms (On tomatoes)

Predator bugs (the good guys) that will kill almost all detrimental pests, including horn worms and caterpillars, include:

- Ladybugs
- Spider mite predators
- Lacewings
- Black parasitic wasps
- Praying Mantis.
- Beneficial Nematodes

### **Praying Mantis**

The Praying Mantis feeds on aphids, beetles, caterpillars, chinch bugs, Colorado potato beetles, leafhoppers, horn worms, leaf rollers, squash bugs, thrips and whiteflies.

### **Ladybugs or Lady Beetles (The red bugs with black dots)**

Ladybugs are an aphid's worst nightmare. One ladybug can consume 5,000 aphids a year! They also eat mites, scales, thrips and whiteflies.

### **Spidermite predators**

These tiny predators have big appetites and a real taste for spidermites. A predator mite can kill between 5 to 20 spidermites per day.

### **Beneficial Nematodes**

Beneficial nematodes feed on bacteria and can infect insect parasites that visit your aquaponic system. Since 90% of all insects spend at least a part of their life cycle in soil, having an aquaponics system means you're far less likely to encounter as many pests as you would in traditional soil garden.

You're still going to have some pests though. Because you're using a grow media like crush gravel or expanded shells, or coconut fibers it's going to be a lot

easier to spot pest infestations and to take care of them with beneficial nematodes. These nematodes will kill more than 250 different pest larvae. All you have to do is mix them with water, spray the water on the infested area and wait for the nematodes to infest and kill the pest larvae, usually within 48 hours.

## Animal Predators

### Cats

In spite of their total cuteness and viral popularity on YouTube.com, cats are about the most prolific and vicious predators out there. Housecats kill more birds in a year than windmills or wind towers, hunters, and wild prey combined. Their mythical fear of water is just that—mythical. A hungry or bored cat has no problem getting wet if it means nabbing a fish. Keep cats out of your tanks by utilizing nets, fences and wire mesh or slatted wood or ventilated lids.

### Birds of Prey

Birds of prey include hawks, owls, osprey, eagles, and yes herons, and pelicans if you live in a coastal area. Keeps netting and wire mesh over your tanks and you will deter any bird of prey. If you happen to leave the netting off, you may have an opportunistic bird fly in for a meal depending on where your system is located and how large the surface area is.

### Birds in General

Many people raise chickens and ducks along with their fish. While this doesn't pose a problem to the fish in terms of the chickens eating the fish (ducks will eat fingerlings and small fish), the birds do pose a health risk.

According to the University of Hawaii Aquaponics Workforce fowl feces (chicken and ducks) may contain a variety of microscopic pathogens that can cause secondary contamination of plants and fish in an aquaponics system. Birds and snails can increase the risk of tramatodes such as Clinostomum in tilapia, especially in earthen pond systems. There are sources of biological control if this becomes a problem.

Depending on the size of your system and where it is sited, you can expect small wild birds to use the water in your aquaponics system as a water source, and for birdbaths. They may not pose a threat to the fish in terms of eating them, but the parasites and mites they sometimes carry can be a threat. Keep them out of your tanks by providing a birdbath or pond elsewhere on the property (with running water to eliminate any mosquito larvae), and by covering your tanks with netting or mesh.

## Snakes

Depending on what country and what part of the country you live in, water moccasins and other water snakes may seek out your aquaponics system because it's a water habitat for them, especially if your system is outside and sunk in the ground. If you have plants on top of your system and an environment where snakes are naturally found, then be aware they may be there. Snakes do eat fish. They will also hang out waiting for mice and frogs to find their way into your plant. Be careful when working around an aquaponics systems if you are in a rural area, or one where you suspect there is a snake habitat (woodpiles, brush, woods etc. around the property).

## Humans

Humans pose a threat to your system to varying degrees depending on what country, city, town or area you're in because they're hungry, lazy, poor, opportunistic or just plain thieves. If human predators are a problem, lock your tanks and system up at night, construct fences or place the system in a secured structure. If the shit has hit the fan and law is not in effect, any size weapon is an excellent deterrent.

## Aquaponics Pests and Predators

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The bad news about aquaponics is you'll still have pests, even if you're growing your plants indoors or in a nursery. The good news is you'll have far, far, far fewer of them and they'll be easier to eradicate than those in your typical soil bed garden.



Mature squash bug on basil plant

### Squash bugs

If you grow cabbage, squash, zucchini, Brussels sprouts, melons and celery, but particularly squash, you're going to have squash bugs. They look like stink bugs, but they're not. When crushed or drowned (the best way to get rid of them) they may omit an odor or not. They do not bite or sting. Just knock them into a cup, bucket or pan of water with about two to three tablespoons of dishwashing soap stirred in. The soap cuts the water tension so they sink and drown. Don't worry, they drown quickly. Try not to knock leaves into the water because they'll grab them and hang on instead

of sinking to the bottom of the bucket. There are natural predators of the squash bug—the tachinid fly is the best. There is also a parasitic wasp that kills them, but unfortunately neither are commercially available.



**Drowned squash bugs in a shallow pan of water and dishwashing soap**



The best time to kill squash bugs is when they're still eggs. This means checking your plants every day for the eggs then crushing or drowning them. It won't hurt your plants if you cut off the infected leaf.



Squash bug eggs just laid on a squash leaf

Check the underside of every single squash leaf because once the eggs hatch and the juvenile bugs start moving, mating and laying eggs it's impossible to eliminate the infestation.



Left to right, juvenile squash bugs who just hatched, eggs on the right



Mating squash bugs on a dying squash leaf

Squash bugs overwinter as adults in the soil and duff on field edges, or in your garden. They emerge when warm weather arrives and begin laying their eggs. Eggs are brown to red, and are laid in midsummer on the undersides of leaves. The eggs begin to darken the closer they are to hatching. Juveniles range in color from green to gray depending on their age. Adults are about 5/8" long, gray to black in color with brown and orange stripes on the sides of the abdomen. These pests are almost impossible to control, even with pesticides, in the adult stage..





Adult tomato hornworm

## Tomato Hornworm

The tomato hornworm can reach four to five inches in length and is a terrifying sight for any gardener, aquaponic or otherwise! The pointed red “tail” looks like it could sting you into an emergency room and the other planet alien appearance is unnerving to say the least.

Yet, the tomato hornworm is perfectly harmless, except to your tomato plants. One worm can strip an entire tomato plant of its leaves, killing it, in one night. They do have a natural predator—a parasitic wasp, which penetrates the hornworm, laying eggs directly in the worm’s body, making it dinner for its young.



A young tomato hornworm covered in wasp larva



**Katydid on a tomato plant**

Katydids look fierce and like they could do a lot of damage, but they actually do very little. Mostly they're noisy and vocal, especially at night. Their relatives, the grasshopper, are much more destructive.





Grasshopper eating strawberry leaves

## Grasshoppers

Grasshoppers, sometimes called locusts, can destroy a garden with their appetite. Best control is to catch and crush. If you have chickens, let them feed around your aquaponics systems as they'll keep the grasshopper, pest population under control. Unfortunately chickens are carnivores and will eat all bugs they catch.

## Good insects

There are more good insects than bad though. Plant flowers and attract insects like dragonflies, preying Mantis, ladybugs (the red kind, not the yellow or orange kind), and parasitic wasps (small, tiny wasps, not the nest building in your eaves kind).



**Dragonfly on a post outside a greenhouse**

Dragonflies love the water. Indeed they are born in the water and spend most of their lives around the water, so if you have an outdoor aquaponics system, expect to see a lot of dragonflies. They are avid hunters and will help keep your pest population down. They eat mosquitoes, moths and anything that's not bigger than they are. Be glad when you see these delightful creatures around your system. They're helpers.



Ladybug on a weed growing near a nursery

## Ladybugs

Ladybugs are avid aphid eaters. Since aphids are bad news for aquaponic gardeners, or any gardener for that matter, seeing these little carnivores around is a good thing. They can eat 10 times their weight in aphids in a lifetime. If you have aphids and don't have ladybugs, consider ordering some from a commercial pest control company. They arrive live and hungry, ready to be let out on your aphid problem.

## Summary

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If you've spent any time at all on the Internet researching aquaponics you're probably feeling a little bit overwhelmed. There's a lot to learn and a lot of it is confusing. We've taken just the basics of all the main areas to keep the confusion down. And, in order to make even our chapters simpler, here's a brief overview:

### What is Aquaponics?

Aquaponics is a closed loop system that marries aquaculture (raising fish) with hydroponics (raising plants in water). An aquaponic system consists of water, fish, worms, bacteria and plants. They all work together to create a system that is self-adjusting and self-monitoring so you, the farmer, don't have to clean tanks, flush toxic ammonia wasted from your fish, or salts from your plants as you'd have to do if you were just raising fish (aquaculture) or just raising plants (hydroponics).

### What is Cycling?

Cycling is preparing the ammonia, bacteria, and nitrites and nitrates cycle in your water. It can be done with or without fish; with liquid or crystal ammonia. It is recommended that you do this before adding your fish in order to reduce or eliminate fish kill before your cycle is established.

### What is the Best Aquaponic System?

The best aquaponic system is one that you understand and are comfortable with, that works for you and that you enjoy working with. While "flood and drain" has been scientifically shown to be the best system in terms of nutrient delivery and plant growth, those results occurred in a lab. You may find it more rewarding to use a CHIST-PIST system or a Nutrient Film Technique.

You may love the science and the numbers and prefer a system you can monitor more closely and tweak to get the results you want. So, the "best" system depends on what you decide works for you and your family.

## Plants

There's little else on earth that compares with sitting down to a home-cooked meal with vegetables, fish and salad you just harvested and prepared fresh from your



own aquaponic garden. Selecting and planning your aquaponic garden may take a bit more research because you have to ensure your plants and fish thrive in the same temperature ranges, but it's not much more difficult than researching garden zones when you go to plant a regular garden. I've given you a brief overview of the plants that most gardeners enjoy, and I encourage you to explore and experiment with some or all of the 350 plants known to thrive in an aquaponic system.

All your favorites are there—every herb, tomatoes, strawberries, lettuce, carrots, radishes, corn, broccoli, all melons (watermelon, honeydew, cantaloupe etc); all squash, zucchini and even sunflowers, Brussels sprouts, onions and more. The big difference is you'll grow more vegetables in a smaller space. You'll harvest them faster and more frequently and the nutrition levels will far exceed anything you can grow in the ground.

## Fish

While we won't argue that it's not fun to strike out for a pond, river or stream to catch your favorite fish (salmon, trout, bluegill, catfish, tilapia, prawn/shrimp etc) we will point out it's only fun when you catch what you went out to get. It's disappointing to spend the day (and the money) traveling to the water and not catching anything at all.

There's a lot to be said for being able to go out to your own aquaponics system, harvest and eat fish you know haven't been contaminated. Yes, wild fish in even the cleanest rivers and ponds may still be contaminated with PCBs, mercury or toxic chemicals.

The fish in your aquaponics system are truly healthy and toxin free because you raised them yourself in clean, clean, non-polluted water, feeding them the best feed, grains, maggots, worms, and food possible. You know they're truly organic and healthy, and isn't that what you wanted in the first place?

If you buy your fish in the grocery store, maybe you didn't realize that more than 50% of the fish sold in our groceries today is farm raised. Commercial farms are under more pressure to keep their fish healthy, and so many of them, particularly in China, use antibiotics and chemicals to make their fish grow faster so they can be harvested sooner and make the fishery more money.

As a home farmer you're not under those pressures and stresses. You can grow and harvest fish knowing everything that has been done to them.

## **Pests, Predators and Problems**

Many people worry about predators, pests and problems. While those things are common to all farmers everywhere, the good news is with aquaponics you're less likely to experience any of them. Because your garden is off the ground, and not in the soil you eliminate most of your pest problems.

Almost 90% of all garden pests live in the soil. By eliminating soil you eliminate the majority of your pests. You'll still have things like squash bugs, grasshoppers and pests that can fly or jump, but there won't be many of those, and you can spot and crush the few pests you do see a lot easier. Nets and a closed nursery door send all your flying predators elsewhere.

The problems with deer, raccoons, rabbits and other pests are solved through having a smaller, higher and better-protected system. Never worry again about finding a snake, rat or other predator in your garden. Because the system is off of the ground those sorts of predators are much less likely to find a home among your plants.

## **Seniors and the Disabled**

If you're a senior, disabled, or otherwise unable to garden or get around easily, aquaponic gardening is perfect. There's no bending, no getting down on your knees to weed or tend to your garden either. Everything you do is at waist height. If you're in a wheelchair, you can adjust the height of your system to fit your wheelchair.

## **Farming**

Even if you're an apartment dweller, or have a small house with a tiny yard, you can still farm enough fish and vegetables to feed yourself, or a family of four with an aquaponics system.

You become part of the solution to world hunger by learning to grow and harvest your own food. Teach your neighbors, host community aquaponics tours and help educate your community about the positive aspects of aquaponic gardening. Not only are you eliminating the need for pesticides and insecticides, you're eliminating the demand for them.

## **Being prepared for economic collapse**

You don't have to read many newspapers or even pay attention to television and what's happening around us, all around the world, to know that the current global economic situation is on the verge of collapse. It won't be long until none of us

can afford grocery store prices. Not only will meat cost half a day's wages, vegetables will be scarce, and more likely to be genetically modified.

With an aquaponics system and the ability to raise, get seed from, breed and reproduce your own vegetables and fish you'll have the food you need to feed your family even if you never earn another dollar. You'll have food and fish to barter, and while those around you are surviving on pasta, beans and survival food that tastes awful, you'll have fresh salads, fish and corn-on-the-cob.

You'll be able to enjoy sweet melons, berries and salads, all part of a healthy diet, without worrying about whether you're going to run out of canned goods. You can continue to raise and can fresh tomatoes year-after-year. In fact, all you need is a small flock of chickens to supplement your fish and veggies with eggs and you'll be totally self-sufficient.

## Family Fun

If you have children there's no better way to teach them the wonder of life and how to be self-sufficient than by getting them involved in aquaponics early in life. They learn exactly where their food comes from and how to raise, harvest and prepare it. There's a lot to be said for being able to feed yourself without depending on a paycheck or cash.

## Health

While fun and self-sufficiency are some of the reasons we hear a lot, perhaps the most popular reason for raising your own fish and vegetables is health. If you live in the city, or in an area where the soil you can garden in may be part of a super-fund site, or have toxic chemicals in it, knowing you're raising vegetables in pure water, naturally filtered through bacteria and a healthy process of filters and nature's best processing is reassuring. You know the vegetables you're eating are heirloom (if that's what you buy and grow). You control whether you raise GMO seeds or not. You control what goes into your fish and into your vegetables.

I think this book gives anyone new to aquaponics a solid foundation for deciding if aquaponics is something they want to pursue or not. I've taken the complexity and fear factor out of aquaponic farming for first time users by giving you the basics you need to get started, without all the hype and information that often overwhelms the first time farmer.

There are thousands of books, videos and forums on aquaponic gardening. Spend enough time on the Internet and you can cobble together the information you'll find in here. The advantage to this book/program is you're not overwhelmed. You get

all you need to know to get started without getting a headache from information overload.

## Credits

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