

Fish Operations




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Fish Husbandry

You are responsible for the health and welfare of your fish.

They are depending on **YOU!** Therefore, you must ensure that you are prepared to manage their health and needs every day!



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Fish Inputs and Outputs

Inputs

- Feed
- Oxygen
- Water

Outputs


- Urine
- Ammonia
- Carbon Dioxide
- Feces
- Uneaten Feed



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Tilapia

- *Oreochromis* (over 30 species)
- Most common aquaponics fish
- Prefers warm water 74 - 83°F (23.3C - 28C)
- In Aquaponics 68° - 75°F(20 - 23.9C)
- Tolerates pH shifts, temp changes, high ammonia, and low dissolved oxygen
- Omnivorous - pellet fish food, duckweed, veggies from the system, bugs
- Grows to plate size in about 12 - 18 months
- Males grow faster than females
- Species grow out at varying rates
- Mouth brooding reproduction
- Cook head on whole body, big bones



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Tilapia Considerations

- Dozens of varieties available - Mozambique, Nile, red, white, blue, orange (over 100 subspecies)
- Check for state (county) restrictions
- Some southern states don't allow tilapia if they could survive in local water (overwinter), because they become invasive and overtake native populations
- Ideal to get only male fish to avoid issues with aggression, not all vendors sort fish based on sex, but some vendor hybrid breed for all male offspring
- Males also grow fastest and put on the most meat

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Channel Catfish

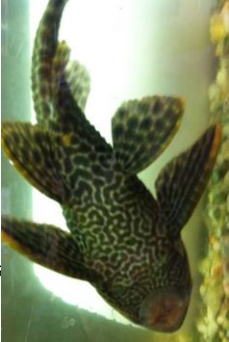
- *Ictalurus punctatus*
- Great for aquaponics
- Warmwater 74-83°F (23.3 - 28C)
- Negatively buoyant (they sink due to large head, small swim bladder)
- Tolerates pH shifts, temp changes, high ammonia, and lower DO
- Will bottom or top feed, omnivore, will eat pellets, algae, insects, tank detritus
- Great growth rates
- Happiest with places to hide
- Remove skin, good for fillets, no deboning required



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Plecostomus

- *Loricariidae*
- Part of the catfish family
- Heavy armored body
- Plecos – Tank janitors, garbage disposals
- Add several to every tank
- Eat algae, feces, tank detritus
- Attaches sucker to hard surfaces
- They can get really big



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Hybrid Striped Bass (HSB)

- *M. chrysops x M. saxatilis*
- Cross of striped bass and white bass (aka wiper)
- Hybrids tolerate recirculating systems
- Carnivorous, 40-45% protein, will eat other smaller fish, eggs & fry
- 12-18 month grow out
- Popular with chefs
- Significantly more sensitive to stress, DO, temperature changes
- Cook whole body, bone structure similar to trout




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Koi & Goldfish

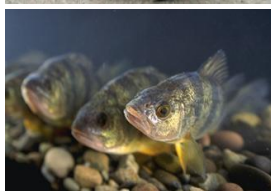
- Great aquaponic fish
- Produce a lot of ammonia
- Eat tilapia solids, clean water
- Cohabitate with tilapia and other aquaponic fish
- Typically not considered edible
- Koi are fancy (expensive) carp
- Temperature 65-75°
- Omnivorous – flake or pellet foods, bugs, plant roots
- Sold for "pets" or to show based on color, shape and scale patterns. High dollars \$\$




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Yellow Perch, Bluegill, others

- Cohabitates with other fish
- Can be used in recirculating systems
- Likes cooler water (68-74*)
- Tolerates lower dissolved oxygen, adjusts to pH
- Eats common pellet fish foods and veggies
- Grows to plate size in about 9 months
- Not very exciting fish, non-social, not high price point



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Salmon and Trout

- Requires cold water (below 60°) which is difficult to maintain in greenhouse environment
- We grew out 8" trout from September to May, harvested at 13"
- Can be grown out in aquaponics with high levels of water quality and dissolved oxygen
- Higher 40%+ protein feed requirements



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Barramundi

- *Lates calcarifer*
- Also known as Asian or Australian Sea Bass
- Brackish water required to spawn and develop
- Undergo sexual inversion changing male to female after first spawn
- Grow out in 12-18 months
- Difficult to get fingerlings but may get easier in the future as demand and aquaculture stocks in the US increase



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Other fish and aquatic creatures

- Sturgeon – Have been grown in aquaponics, they get really big (7-12 ft), egg production (caviar) in 8-10 years
- Freshwater prawn, shrimp, giant river shrimp, Malaysian prawn – requires brackish water to reproduce, issues with aggression, cannibalism, high mortality, & shedding
- Bivalves – freshwater clams, oysters, muscles, scallops



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Fish Selection

- Decorative vs edible?
- Appropriate water temperature for selected species
- What you can "legally" raise (state regulations?)
- What you can easily purchase and get delivered?
- Price for fish species and delivery?
- What your customers (and you) like to eat?
- Price point your customers are willing to pay?
- Seasonal availability and sellability (pond season)?
- Fish species cohabitation

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Water Quality

- Temperature – stay within appropriate range for species
- Dissolved Oxygen (5 to 8 mg/l depending on species)
- DO levels decline shortly after feedings
- < 1ppm Ammonia and <.5 Nitrites
- Ammonia production is directly related to feeding rates, quality of feed, fish size and temperature
- Ammonia generally peaks 4 to 6 hours following feedings
- Reduce or stop feeding if water quality falls below acceptable levels

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Temperature and Growth

- CMAX= Max. feeding rate
- SDA = Digestion (specific dynamic action)
- F = Feces, urine production (egestion)
- U = Ammonia production (excretion)
- ΔB = Change in fish weight
- Opt. coolwater temp. = 23 C (73 F)
- R = Respiration
- Max. = 28 C (82 F; starvation)
- Coldwater fish = 14-16 C (57-61 F)
- Warmwater fish = 28-30 C (82-86 F)

Species: Yellow Perch
 Bill Mancini - Fisheries Technology Associates
 www.ftai.com

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RANGE OF TOLERANCE FOR DISSOLVED OXYGEN IN FISH

PARTS PER MILLION (PPM) DISSOLVED OXYGEN

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Before You Get Fish

- There are no leaks – plumbing, tank, window, etc
- You can walk and work around components
- The water temperature is within range for the fish species and temperature is stable within a few degrees
- Fishless cycling is completed (if performing that step)
- Bottled nitrifying bacteria on hand to manage ammonia spikes (keep out of excessive heat or cold)
- Aeration and filtration are working properly
- There is some way to cover the tanks
- You are going to be ready to feed and monitor fish
- Water is free from Chlorine/Chloramines, ammonia and nitrite

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Quarantine

A temporary tank for new fish that is NOT connected to the aquaponic system.

- Always exercise good hygiene and biosecurity—prevention, avoidance, selective access, and common sense.
- Monitor fish health for at least two weeks
- Adding salt bath at 1 - 3ppt helps stabilize osmoregulation
- Do not use quarantine for sick fish and newly transported fish at the same time.

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Fish vs Fishless Cycling

Preparing your tank and filtration for fish
Establishing the biofilter (nitrifying bacteria)

<p>Fish Cycling</p> <ul style="list-style-type: none"> • Low stocking density • Add bacteria as needed • Minimize feed input • Test and monitor water for ammonia and nitrite • Perform 1/3 water changes as needed 	<p>Fishless Cycling</p> <ul style="list-style-type: none"> • Add ammonia to simulate fish • Add bacteria to convert ammonia • Monitor water quality • Add fish when cycle is complete
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Adding Fish to Your Farm

- Different species in each tank – they will all "taste" the same

Tilapia

Catfish

Koi

Bass

- Different species cohabitating in the same tank
- Same species, staggered stocking 3-4 month rotations

3 months

6 months

9 months

12 months

- Same species, static stocking – all the same age
- Same species, full stocking, different age cohorts

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Determining Stocking Density

- Fish species
 - Tilapia - .25lb per gallon or roughly 1lb per 5 gallons
 - Trout and bass - .10lb per gallon -> 1lb per 10 gallons
- Sex – Mixed or selected (YY Super Males)
- Grow out rates – growth limiting hormone factor
- Fish harvest size – plating at 1.25lbs to 2lbs
- Tank size – number of gallons/lbs per gallon, then divide by harvest weight
- Keep stocking density appropriate to plant production
- When in doubt, keep stocking density low

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Finding a Fish Vendor

- Check with State Licensd Fisheries (some may only be allowed to stock state waters)
- Requirements for licensing, and possibly import certificate
- Check for local fish farmers or pond producers
- Many states don't have local tilapia producers
- Locate and research fish vendors on the web
- Some vendors would prefer to sell mixed populations
- Research vendors on the web

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Questions to Ask a Fish Vendor

- Issues with disease – every fish stock has a certain amount of disease, it often "presents itself" after transport
- The standard temperature and pH of the vendor's water – to make sure to make the temps/pH match in your tanks
- Process for transport – date and method of delivery
- Age, species, size and sex of fish
- Expected growth rate to plateable size
- Type of feed (vendor may send some feed)
- Mortality replacement policy

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Transport

Fish are shipped bagged, totes, trucks

- Transport less than 12 hours
- Aeration and temp control
- Salt added to minimize transport stress
- Avoid feeding before, during or after transport to minimize solids waste, ammonia buildup and digestive stress

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Acclimating

Moving fish from transport into quarantine

- Keep temperature within 2° delta
- Keep pH within .2 - .4 between transport and system
- Ammonia can build up in transport
- Maintain oxygen or aeration at all times
- Avoid putting water or nets from vendor into Aquaponic system, quarantine less of a problem

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Acclimation Process

When new fish are received and ready to add to quarantine

- Open transport container and observe contents
 - Note temperature, pH, live and dead fish count
 - Take a picture to help count number of fish
- Provide aeration immediately, transport oxygen depleted or removed when opening the container
- Check water temp and pH of quarantine, adjust if necessary
- Remove 1/3 water from transport container
- Add 1/3 water from quarantine tank, wait 30 minutes
- Repeat if necessary. Add fish when temp and pH match

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Bagged Fingerlings

- Float transport bags to normalize temperatures
- Keep them closed to contain transport oxygen
- Pour bags into quarantine
- Or, if putting into aquaponic system, net fish to move



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First Stocking

- When stocking fish for the very first time, some people acclimate and move directly into system (avoid moving transport water or salt)
- Just make sure that you are confident in the fish health and source provider
- It is difficult to see small fish in a large tank



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Handling Fish

- Fish have a delicate mucous layer (aka slime coat) to help protect them
- Minimize damage to the slime coat when handling, use wet hand or preferably fish glove
- Try to avoid handling the fish if possible
- Fish can experience long term immune suppression in 15 seconds out of water
- Watch for sharp spikes from tilapia fins

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Monitor and Maintain

- Watch for signs of disease, swim balance issues, disorientation
- Remove sick or dead fish and immediately dispose
- 5 – 10% mortality after transport is common
- Maintain water high quality, temp, pH
- After a bout 2 weeks, if fish remain health, acclimate into aquaponic system

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Fish Feeding

- Feed high quality food with the proper protein, carbohydrates, and fats for the age and species of fish
- Feed measured amount 3 -4 times a day
- Feeding rates will vary with fish size, water temperature, light levels, breeding behavior, and water quality, and any stress conditions
- Fish feed is available in conventional and organic
- Choose pellet size appropriate to age of fish

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Fish Feeding

- Scoop out any uneaten feed after 20 minutes, don't overfeed, it wastes food and impacts biofilter
- Automatic feeders can clog or dump, neither is good
- Personally feed your fish to observe health and activity
- Tilapia may mouth breathe at surface "piping" aids in digestion and allows them to bring in more oxygen
- Supplement with alternate feeds – insects, vegetables scraps, sun-dried duckweed (none are considered complete foods in a recirculating system)

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Do NOT Feed Your Fish

- Other animal feeds
- Spent grains or mash from brewing
- Human food
- Algae or live duckweed
- Animal waste
- Seeds, insects, leaves, grass clippings or "pond weeds"

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Stage 1 – 8 mm – 1" – 2.5" fish
 Crude Protein50.00 %
 Crude Fat12.0 %
 Crude Fiber3.0 %
 Phosphorous1.0%



Stage 2 – 1.7mm – 2.5" – 4" fish
 Crude Protein40.00 %
 Crude Fat9.00 %
 Crude Fiber1.70 %
 Ash 8.70 %



AquaOrganic –
 4mm – 10mm pellets

Crude Protein (min)....34.000%
 Crude Fat (min)..... 3.0%
 Crude Fiber (max)..... 10.0%
 Lysine (min)..... 1.7%
 Calcium (Ca) (min)..... 1.3 %
 Calcium (Ca) (max)..... 1.8 %
 Phosphorus (P) (min)..... 0.8 %

Non-GMO, No Fish Meal, No Soy





Stage 3 – 2.5mm – 4" – 6" fish
 Crude Protein37.00 %
 Crude Fat10.00 %
 Crude Fiber2.20 %
 Ash 11.00 %



Stage 4 – 5mm – Growout6" fish
 Crude Protein 35.00 %
 Crude Fat 4.00 %
 Crude Fiber 4.90 %
 Ash 8.00 %

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Organic Feed Ingredients

Organic Rice Bran, Organic Canola Meal, Organic Whole Corn, Organic Dehydrated Alfalfa Meal, Organic Linseed Meal, Dicalcium Phosphate, Calcium Carbonate, Dried Lactobacillus Acidophilus Fermentation Product, Ferrous Sulfate, Choline Chloride, Manganese Sulfate, Organic Oat Groats, Zinc Oxide, Sulfur, Diatomaceous Earth, Reed-Sedge Peat, Attapulgite Clay, Copper Sulfate, Monosodium Phosphate, Calcium Pantothenate, Organic Dried Kelp, Bentonite, Salt, Thiamine Mononitrate, Biotin, Sodium Aluminosilicate, Magnesium Oxide, Magnesium Sulfate, Yeast Culture, Sodium Selenite, Ethylenediamine Dihydrochloride, Ascorbic Acid, Zinc Sulfate, Vitamin E Supplement, Sodium Sulfate, Potassium Chloride, Manganous Oxide, Zinc Hydroxychloride, Vitamin B12 Supplement, Manganese Hydroxychloride, Cobalt Carbonate, Organic Lecithin, Basic Copper Chloride, Organic Garlic, Organic Fenugreek, Niacin, Citric Acid, Folic Acid, Potassium Sulfate, Riboflavin, Vitamin A Acetate, Organic Apple Cider Vinegar, Organic Feed Grade Dried Milk, Organic Egg Product, Pyridoxine Hydrochloride, Organic Cloves, Organic Barley, Vitamin D3 Supplement, Cobalt Sulfate, Beta-Carotene, Calcium Hydroxide, Organic Dandelion, Organic Parsley, Magnesium Chloride, Organic Althea Root, Organic Dried Tomato Pomace, Yucca Schidigera Extract, Organic Horseradish, Organic Licorice, Organic Sweet Orange Peel, Organic Aloe Vera Gel Concentrate, Organic Peppermint, Organic Calendula, Organic Ginger, Organic Coconut Oil, Organic Sage, Organic Common Fennel, Organic Thyme, Organic Lemon Grass, Organic Elder Flowers, Organic Papain, Organic Basil, Organic Violet Leaves, Organic Coconut Flour, Organic Juniper Berries.

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Fish Food

- Feed fish appropriate quantity and quality
 - Feeding more food than necessary or using feed high in corn or soy fillers may grow fish faster, but
 - Fish will be lower quality (increase in bad fats)
 - More solids management maintenance and waste
 - More cost for fish feed input
- Store fish food in cool, dry place, inside sealed container
- Avoid rodent and pest issues, clean up spilled feed
- Fish food can be put in cooler/freezer to maintain quality
- Use fish food in 3-6 months, or oils will become rancid

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Daily Feed Rate

Table 2. Example of daily feeding allowances for different sizes of tilapias at 28°C (82°F). Source: National Research Council. 1993. Nutrient Requirements of Fish. National Academy Press, Washington, D.C.

Size of fish (grams)	Amount of daily feed (% of fish weight)
0-1	30-10
1-5	10-6
5-20	6-4
20-100	4-3
larger than 100	3-1.5

Source: North Central Regional Aquaculture Center

Feed at a rate appropriate to water temperature and plant production

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Feed Conversion Ratio (FCR)

- The feed-conversion ratio is a measure of the amount of feed needed to produce a unit weight of the culture species.
- Farms can calculate and record FCR yearly using the following equation:
- Feed-conversion ratio = Annual feed use (lbs) ÷ Fish harvested (lbs)



Additional information: <http://www.gaalliance.org/bap/standards.php>



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Fantastic Fish FCR

The average pounds of feed to produce 1 pound (.45kg) of meat

- Fish – 1.7lbs (.77kg)
- Chicken – 2.4lbs (1.08kg)
- Turkey – 5.2lbs (2.36kg)
- Pork – 4.9lbs (2.22kg)
- Goat – 8.0lbs (3.62kg)
- Beef – 9.0lbs (4.08kg)

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Fish Growout

The rate that fish grow out is related to:

- Fish feed quantity and quality
- Temperature and metabolic processes
- Stocking density – growth regulation hormone
- Fish breed and species – various tilapia grow differently
- Sex of fish – some males grow faster, sometimes females
- Most fish growth has a mathematical relationship:
 - Length to weight
 - Predicted growth over time

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Why Fish Die


- Harvesting is the BEST way – your time, your choice
- Culling – the act of removing stunted or damaged fish
- Overly long or problematic transport, poor acclimation
- Diseases, pathogens, stress, illness, immune issues
- Aggression, especially during breeding, alpha male issues
- Cannibalism (as baby fish) or carnivorous fish
- Lack of oxygen, low dissolved oxygen, other gases
- Water or air contaminants – ammonia, nitrite, chlorine, chloramine, pesticides, oils, soaps, smoke, CO, CO2, sulfur dioxide, copper, certain metals, etc.
- Rapid water temperature or pH changes
- Predators kill them for fun or food
- Electrocutation – water and electricity are deadly together
- Unnecessary netting, disrupting the tank, grading and moving fish
- Power outage – lack of oxygen, water quality issues, water flow problems
- Contaminated fish food, moldy or rancid, improper nutrition, autofeeder dumps

"You're not a fish farmer 'til ya kill a million fish" said a bunch of anonymous fish farmers

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Pests and Predators

- Vertebrates – birds, cats, dogs, rodents, raccoons, squirrels, reptiles, frogs, snakes, bears, alligators (This includes pets!)
- Other fish – even that same species will kill each other
- Food safety issues
- Worker safety issues
- Snails and scuds in the water
- Algae, duckweed, invasive plants, consider them weeds
- People....



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Methods for disposal

- Sanitary disposal of dead fish and entrails – depends on quantity, size and state health department guidelines
 - Trash, composting, burying, biopod, biodigester
 - Avoid leaving out in the open, encourages predators
 - Unsanitary, smelly, flies (which can transmit disease)
- Don't eat sick fish, or fish where time of death is unknown due to aggression or oxygen deprivation
- Do consider eating fish that were killed because of power outage, if caught quickly, fish are still good

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Integrated Fish Health Management

- **Prevention** – biosecurity, water quality, low stress
- **Removal** – move sick fish to quarantine, remove dead fish
- **Identification** – determine disease, virus or cause of sickness or mortality
- **Treatment** – determine best mode of treatment in **quarantine**, ensure it is appropriate for edible fish
 - Increased temp, salt bath, medicated feed, MinnFinn
 - FDA approved listing for aquaculture pharmaceuticals
- **Documentation** – keep records of fish disease and death

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Fish Health

*The best defense is your fish's own immune system.
Provide a **low-stress** environment*

- Keep pH stable 6.5 – 7.5, not shifts more than .2 - .4
- Ammonia and nitrites are very toxic to fish
- Fish need oxygen (they can die in minutes without it)
- Stocking density critical to growth rate
- Remove fish that are exhibiting signs of illness such as ; Listing, lethargy, scraping gills, cloudy eyes, pop eye, not swimming with others, etc...

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Managing High Ammonia


- Stop feeding (until ammonia levels drop to .5ppm)
- Check for dead fish (they don't always float and might be stuck to pump housing, gravity water drains, etc.)
- Check Un-Ionized ammonia level using TAN table to determine the toxicity of ammonia based on pH and temperature
- Determine what is causing ammonia increase
- Source water filter may need replacement if it is allowing chlorine/chloramine through
- pH, oxygen or temperature may be issue as well

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Managing High Nitrites

- May be caused by denitrification cycling
- Acidifying conditions (low pH) can kill off bacteria
- Temperature swings can slow or stop nitrification
- Lack of oxygen or carbon dioxide – increase oxygen
- Nitrifying bacteria out populated by heterotrophic bacteria – clean the filter of solids
- Maintain proper temperature, pH and alkalinity
- Introduce additional bacteria inoculant to biofilter
- Prevent killing bacteria with cleaning agents, chlorine/chloramine, pest regiments, etc.

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See fish disease reference document in resources folder

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Purging Process

Purge 3 – 5 days to remove off-flavors before harvesting

- Off-flavor caused by algae, iron, feed, metabolic compounds
- Withhold feed for 24 hours before moving, never feed in purge
- Setup purge tank with fresh, same temperature, de-chlorinated water, add salt at 1 – 3ppt, proper aeration
- Replace 100% of purge water with fresh water after 1 day
- Replace 50% with fresh water day 2, 25% day 3 – 5
- Salt should be replaced with each water change, do not put salted purge water into aquaponic system
- Test for off-flavor, by cooking fish without any seasoning
- Fish weight will be reduced to “dressing weight” 35 to 40%

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Harvesting

- Ice slurry quickest method to cease metabolic processes
 - Tilapia are VERY hardy, ice bath may take 30+ minutes
- Oxygen deprivation, electrical shock used in industry
- Avoid physical force or trauma
- Fish should be harvested and sold per guidelines with State Department of Health
 - Sold whole, live and uneviscerated (not gutted)
 - Customer responsible for gutting, cleaning, descaling, de-heading and disposing of entrails and carcass

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Fish Operations Summary

- Have a fish stocking rotation plan based on your system design, temperature, grow out time, and harvest plan
- Feed fish 3 times per day and monitor eating behavior
- Test water weekly, and maintain the best water quality
- Transport, stock, quarantine, feed, growout, purge and harvest fish as necessary

You are responsible for the health and welfare of your fish.

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Don't Stress the Fish

- Water quality and flow
- Proper temperature
- Dissolved Oxygen
- Proper feed quality and quantity, FCR
- Stocking density
- Light & shade
- Adequate filtration
- Pest, disease and predator prevention
- Transport, handling, shelter, reproduction



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