



Aquaponics: Fish Species Selection

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Improving Lives. Improving Texas.

Aquaponics

- **Oxford Dictionary:** A system of aquaculture in which the waste produced by farmed fish or other aquatic animals supplies nutrients for plants grown hydroponically, which in turn purify the water.

- **Farmed fish in Texas aquaponics:**

Not forgotten, but often neglected

Two Crop System

- **Aquaponics two crop agriculture system**

- Vegetables/herbs
- Fish



- **Too often fish treated as fuel, not crop**

- Fish feed is fuel – main input



- **To create maximum production, sustainability, & economic viability:**

- FISH must be treated as CROP
- SOLD generate monetary income (or eaten)

How It is Supposed to Work

- **2 crop system**

- Input – fish feed & oxygen

- Output 1 fish production

- Fish waste feed plants in turn

- Output 2 vegetable/herb production

- Plants filter water for fish

- **Fish sold to offset feed & system operation costs**

- **Vegetables/herbs sold for profit**

- Vegetables/herbs not meant to cover all costs



If You Do Not Utilize Fish

- **Do straight hydroponics instead!**

- Much cheaper

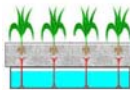
- Less pumping, aeration, tank, & start-up costs

- No fish or feed costs

- Maintain culture conditions optimal for plants

- Much easier

- Hydroponics has it down chemical formulas & nutrient ranges



If You Do Not Utilize Fish

- **Myth- aquaponics cheaper than hydroponics**

- More electric, equipment, & labor

- 32% fish feed - \$485/ton (\$12.12/40lb)

- 305 lbs nitrate fed to HSB



- Same nitrate load as 628 lbs urea (36-0-0) \$107

- Must sell the fish to cover costs!



Poor Market Species

- Can you use these species in aquaponics systems?
 - Some, but not ideal for production or profit.
- Can you sell *some* of these species?
 - Yes, but generally not will not cover cost
 - Definitely will not make a profit
 - Some product will never be marketable
 - Legal, quality, or value issues
 - Some fine for home consumption, but not system optimization

NOT Acceptable

- Any marine or brackish species
 - Red drum, cobia, flounder, Atlantic croaker, pompano, marine baitfish
 - Yes, high market value species
- Minimum culture salinity ≥ 5 ppt salinity
 - What happens to most vegetables & herbs when exposed to 5 ppt salinity?
 - They DIE!
- Unless culturing seaweed, marine species will NOT work



Extremely Poor (Unacceptable)

- Comet goldfish
 - Can it be done? Yes.
 - Does it make sense? No.
- No real market value – no cost offsetting
- Actually add costs
 - Feed costs more than fish is worth
 - Farm gate price 1.5 to 3¢ each
 - Producers don't feed – algae & zooplankton
 - Retail (Petsmart) price 15¢ small to 29¢ large
 - 6 months feed costs 30-34¢ each



Poor

- Bluegill, Redear, Hybrid Sunfish
 - Initial cost ~ 30¢/1-3" fish
 - Can be spawned - outdoors or greenhouses
 - Provide nest boxes & pea gravel
 - Can produce good market prices
 - Excellent table fare, popular sport fish
 - Sold as whole-body, fillets, or pond stockers
 - Illegal to sell as food in some states
 - Readily accept commercial diets
 - 1/8" floating pellet or smaller
 - 32% protein, 4-7% lipid



Bluegill

- Slow growing
 - 2-2.5 years to market size (1 lb)
 - Ideal species ≤ 1 year to market
 - Begin reproductive development
- Poor feed conversion & dress out %
 - 3.5-4.4 lbs feed/lb bluegill
 - Feed costs \$1.06- \$1.83
 - Total costs \$2.41- \$3.18/ lb
 - Dress out 27% = .3 lbs fillets/fish
 - Cost \$8.03 - \$10.60/lb fillets to break even on fish
- Only 1 crop every 2 years



Poor

- Channel catfish, blue catfish, or hybrids
 - Largest foodfish production industry in US
 - Widely known & market acceptability
 - Relatively low market price/input price
 - Currently costs 80-82¢/lb to produce
 - Stagnant price - 85-90¢/lb
 - Producers could not make money
 - Recent increases \$1.25/lb
 - Difficult for small production to make money
 - Will offset feed, but not system costs



Catfish



- 18 month production cycle
- Good fillet yield & dress out % whole fish
- Do not do well in tanks!
 - Slower growth
 - Begin fighting & killing each other between 0.25 - 0.5 lbs
 - Renders product unmarketable
 - Must use high densities to discourage fighting
 - Leads to water quality & management issues
 - High disease & parasite rates
 - ESC, Columnaris, Aeromonas, Proliferative gill disease
 - Disease prevalence increased dramatically in tanks

Marginal Species

- Largemouth Bass
- Widely recognized, but not common foodfish
- Illegal to sell as foodfish in some states
 - Illegal in Texas – sportfish
 - Sell as high end sport fish - \$10-25/lb live weight
 - Only \$4-6/lb as live foodfish
- Do not handle small tanks well
 - Minimum recommended tank size 1,200 gallons
- Extremely cannibalistic
 - Must size grade at least 1x month when small


Largemouth Bass

- Very difficult to pellet train
 - Revert to piscivory or cannibalism
 - Very expensive
 - 2-4 X more expensive (NCRAC 2000)
 - 1-2" 35¢, 2-4" 68¢, 4-6" 94¢, 6-8" \$2.07
 - 1-2" 85¢, 2-4" \$1.65, 4-6" \$2.43, 6-8" \$6.19
- Very expensive to produce
 - 1.25 lbs – 18 months
 - Require high protein - ≥ 40%
 - \$775-850/ton

Largemouth Bass

- Poor production conversion (UAPB)
 - 1.2 lb LMB
 - 60-74% survival
 - Feed conversion 2.0-2.6 lbs feed/lb fish
 - \$4.17/lb to produce
 - \$4.54/ lb break even price
- Market sporadic – sportfish
- Disease & parasite prone in tanks
 - Columnaris!!!!, some aeromonas
 - Otherwise very few specific diseases to LMB




Best Species

- Tilapia (king)
 
- Hybrid Striped Bass (new kid)
 
- Koi (non-traditional)
 



Tilapia

- Many species (>300)
 - 3 legal in Texas
 - Mozambique (*Oreochromis mossambicus*)
 - Nile (*Oreochromis niloticus*)
 - Blue (*Oreochromis aureus*)
 - Blue & Nile preferred due to market size of 1 lb
 - Both require TPWD exotic species culture permit
 - Tolerant of poor/marginal water quality
 - pH 5-10, 6-9 optimal
 - High water temp, low DO, high ammonia
 - Most species tolerate 50-55F for a few days
 - Blue tilapia tolerates 48F




Tilapia

- One of most widely cultured foodfish worldwide
 - Market acceptability & recognition
 - Also, low price & lots of competition
 - Utilize niche marketing
- Reproduction can be a problem
 - Can over-reproduce – may need to be thinned
 - Mouth brooders – lost production
- Adapt very well to tanks
- Tolerate high stocking densities (3/4 lb/gallon)

Tilapia

- Very good production characteristics
 - 6-8 months crop
 - Low protein requirement
 - 26-32% protein, 4-6% lipid
 - Very good feed conversion
 - 1.3-1.8 lbs feed/lb fish
 - Good dress out percentage
 - 86% with head, 66% without head, 33% fillet
 - Often sold whole gutted
 - Low production costs
 - (Ponds) 51-60¢/lb
 - (Tanks) \$1.51-1.79/lb – already priced out of market
 - \$4.57-5.42/lb fillets – break even or niche markets



Tilapia

- Diseases uncommon

DISEASE	AGENT	TYPE
Mottle Aeromonas Septicaemia (MAS)	<i>Aeromonas hydrophila</i> & related species	Bacteria
Vibriosis	<i>Vibrio anguillarum</i> & other species	Bacteria
Columnaris	<i>Flavobacterium columnare</i>	Bacterium
Edwardsiellosis	<i>Edwardsiella tarda</i>	Bacterium
Streptococcosis	<i>Streptococcus iniae</i> & <i>Enterococcus</i> sp.	Bacteria
Saprolegniosis	<i>Saprolegnia parasitica</i>	Fungus
Ciliates	<i>Ichthyophthirius multifiliis</i> ; <i>Trichodina</i> & others	Protozoan parasite


Hybrid Striped Bass

- Hybrid between striped bass & white bass
 - Best traits of parent species (SRAC No. 300)
 - Improved water quality tolerance
 - 39-92 F acceptable (73- 81 F)
 - Tolerate DO 1 ppm short periods (>4 ppm)
 - Alkalinity 20-100 ppm (>100)
 - Hardness 20-100 ppm (minimum 40, >100)
 - pH 2.5 short periods, 6 no problem (7-8.5)
 - Do not reproduce
 - Must buy new fingerlings
 - 3-5" 65-70¢




Hybrid Striped Bass

- Well adapted to tanks (0.33-0.5 lbs/gallon)
 - Grow to 1.5 lbs in 150 gallons – flow through
 - ≥400 gallons recommended for aquaponics
- High market value species
 - \$2.58-3.02/lb whole fish in bulk
 - Fillets \$8.99-9.99/lb
 - Niche markets \$6-8/whole fish
 - Market not well defined – not much competition
 - 81% shipped whole on ice to East coast
 - Not seen in Texas grocery stores



Hybrid Striped Bass

- Expensive to produce
 - Market size – 1.5-2.5 lbs
 - 12-14 month production
 - Require 36-40% protein, 10-12% lipid
 - \$775-850/ton
 - 70% of production costs is feed
 - Feed conversion 2.5-2.8 lbs/ 1 lb fish
 - \$0.97-1.19/lb fish in feed costs
 - \$2.10-2.39/lb total production cost
 - Dress out 45%
 - \$4.66-5.31/lb fillets (market \$8.99-9.99/lb)



Hybrid Striped Bass

- Few disease issues if water quality maintained
 - Bacterial
 - Columnaris
 - Motile aeromonad septicemia (MAS)
 - Streptococcus iniae

Hybrid Striped Bass

- Bloat
 - Water temps > 86 °F
 - Sometimes observed floating upside down
 - Presumably caused by inability to digest food efficiently at high temps
 - Gas from partly digested feed accumulates
 - Food may not pass normally
 - Recovery depends upon feed composition, fish size, & duration of water temp
 - Insert pencil (eraser end) into mouth will release gas from stomach & intestine
 - Reduce feed above 86F

Koi

- Non-traditional – novel
 - Can be high value species – not world class
 - Sold as large individuals for ornamental ponds
 - Small individuals little value
 - Farmgate 20-45¢ 1-3" pond run
 - Retail small \$5.99 (PetSmart)
 - Market size 1-3 lbs
 - Value \$20-65/fish, possibly more
 - Poorly defined & highly variable market
 - Must wait for right buyer - marketing
 - Typically only sell 1-2 fish at a time



Koi

- Tolerate poor water quality
 - Temperature 32-95 F (65-75 F)
 - Tolerate DO 2 ppm short periods (≥ 5 ppm)
 - pH tolerance 5-9
- Cheap to produce
 - Grow rapidly
 - 28-32% protein (finish diet with pigments)
 - 1.8-2.4 lbs feed/lb fish
 - 53-70¢ feed costs produce 1 lb fish (+\$1.60 finish)
- Unlike goldfish can be sold at profit



Koi

- Koi many infectious diseases & parasites
 - Parasites
 - Anchor worm, fish louse, & monogenetic trematodes
 - Protozoan parasites - Ich, *Trichodina*, *Chilodonella*
 - Bacteria
 - Koi ulcer disease *Aeromonas salmonicida*
 - Causes open sores - kills up to 50% of population
 - Two viral diseases
 - Koi herpes virus & spring viremia of carp

Water Quality for Fish

- Most fish species

	Acceptable	Desirable
• pH	5.5-10	6.5-9.0
• Alkalinity	20-400 ppm	50-150 ppm
• Calcium	>10 ppm	>20 ppm
• Hardness	>20 ppm	50-150 ppm
• Iron	any ppm ferric	<1 ppm ferric
• Chloride	10 X nitrate	10 X nitrate
• Nitrate	<90 ppm	<50 ppm
• Nitrite	1:10 chloride	<0.1 ppm
• Ammonia		

Total Ammonia Nitrogen

pH	Exposure time			
	Acute (1 hour)	Chronic (days)		
		Water temperature (°F)		
		64	75	86
7.0	36.0	5.5	3.2	2.2
7.5	20.0	4.0	2.4	1.6
8.0	8.4	2.2	1.3	0.9
8.5	3.2	1.0	0.6	0.4
9.0	1.3	0.4	0.3	0.2

Water Quality for Bacteria

- Fish excrete ammonia (NH₃; highly toxic)
- *Nitrosomonas*
 - Convert ammonia to nitrite (NO₂; very toxic)
- *Nitrobacter*
 - Convert nitrite to nitrate (NO₃; low toxicity)
- Plants utilize nitrate
 - Remove it from system
- Entire production cycle depends on bacteria
 - What about water quality for bacteria?

Water Quality for Bacteria

- Chemistry
 - Alkalinity
 - Provide carbon source for bacteria
 - CO₂ from fish respiration
 - But need carbonate & bicarbonate (alkalinity)
 - Add sodium bicarbonate (NaHCO₃)
 - Alkalinity 150 ppm – *Nitrosomonas*
 - Alkalinity 200-250 ppm – *Nitrobacter*
 - Decrease when established
 - System will consume alkalinity over time

Water Quality for Bacteria

- Chemistry
 - pH
 - Can not push pH too low
 - 6.8 to 7.2 is best nitrifying
 - Nitrifying will decrease below pH 6.8
 - Stops below pH 6.5
 - Bacteria collapse below 6.0
 - Ammonia virtually non-toxic below 6.5
 - Fish are OK
 - Plants – no nitrate
 - Sudden increase in pH – all fish die!

•Questions?????