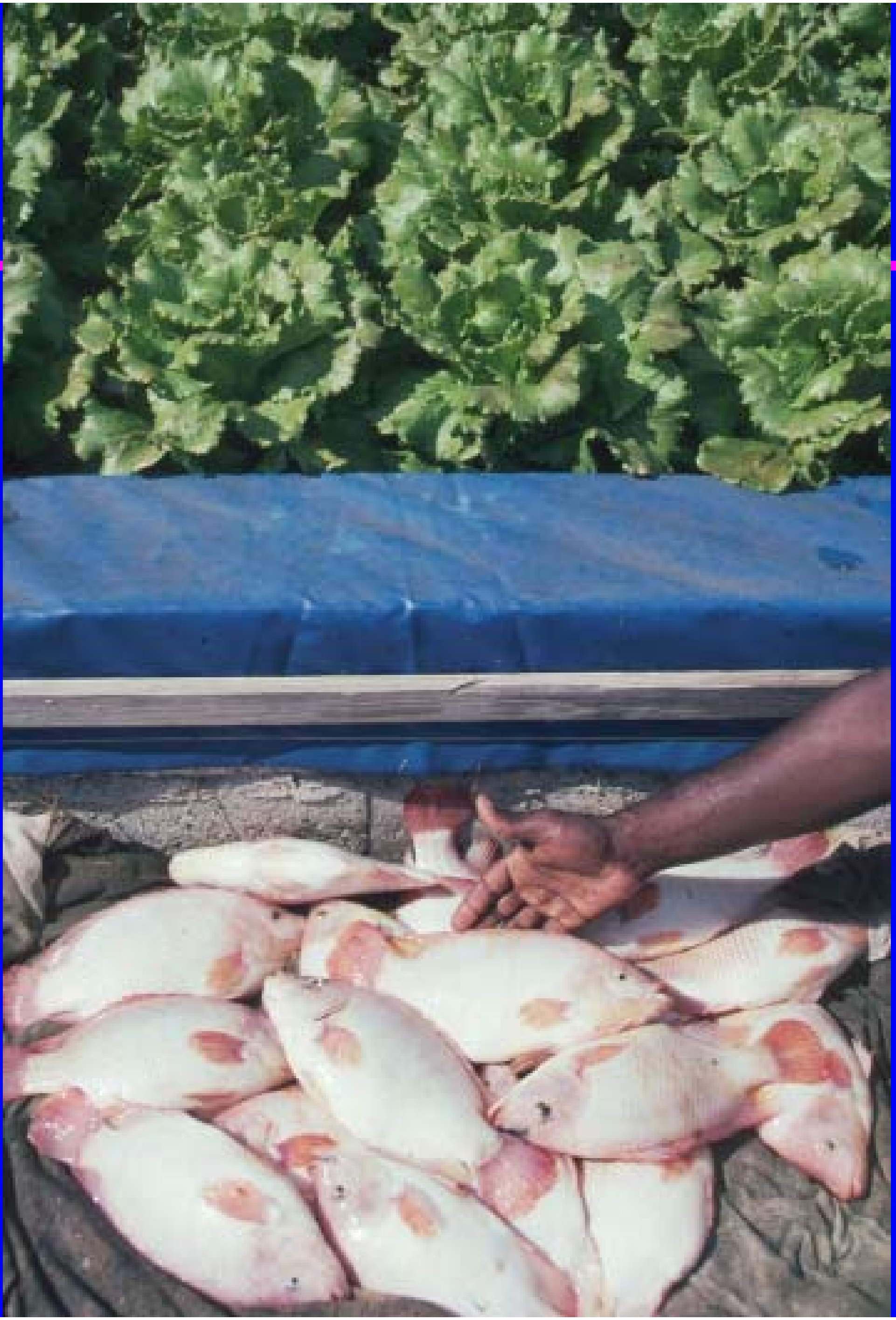
Update on Tilapia and Vegetable Production in the UVI Aquaponic System

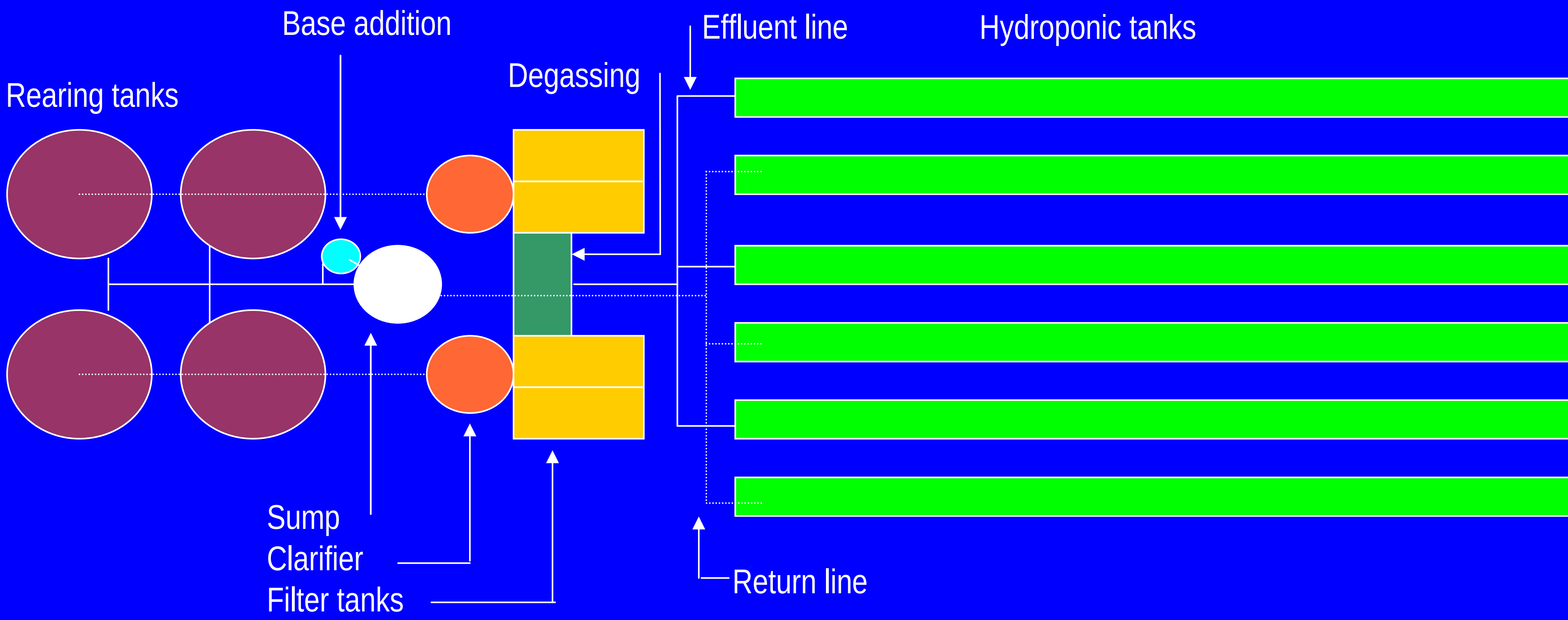
James Rakocy, Donald Bailey
Charlie Shultz and Eric Thoman
University of the Virgin Islands
Agricultural Experiment Station
St. Croix, U.S. Virgin Islands



Advantages of Aquaponics

- Fish provide most nutrients required by plants
- Plants use nutrients to produce a valuable by-product
- Hydroponic component serves as a biofilter
- Hydroponic plants extend water use and reduce discharge to the environment
- Integrated systems require less water quality monitoring than individual systems
- Profit potential increased due to free nutrients for plants, lower water requirement, elimination of separate biofilter, less water quality monitoring and shared costs for operation and infrastructure.

System Layout

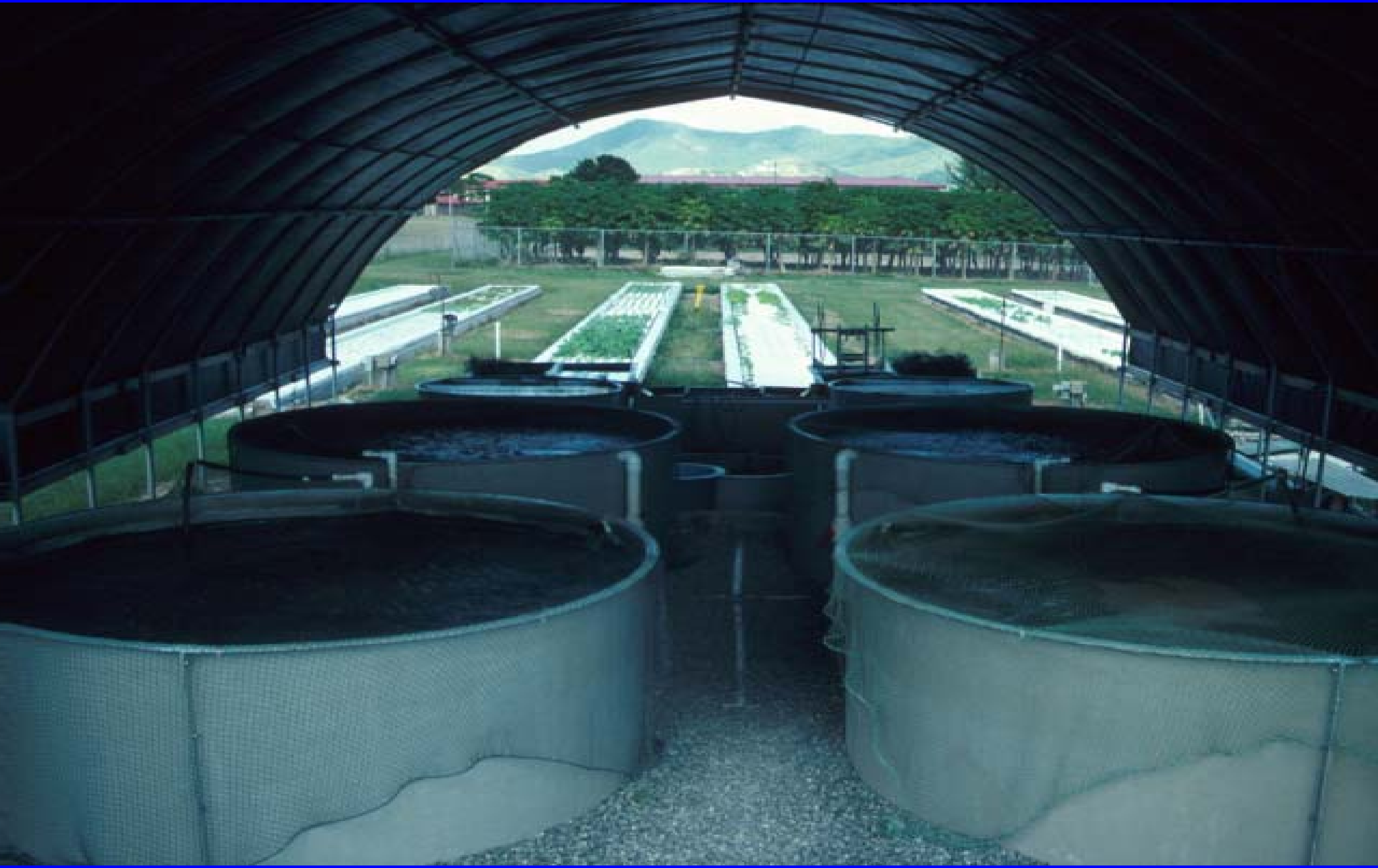


Total water volume, 110 m^3

Land area - 0.05 ha

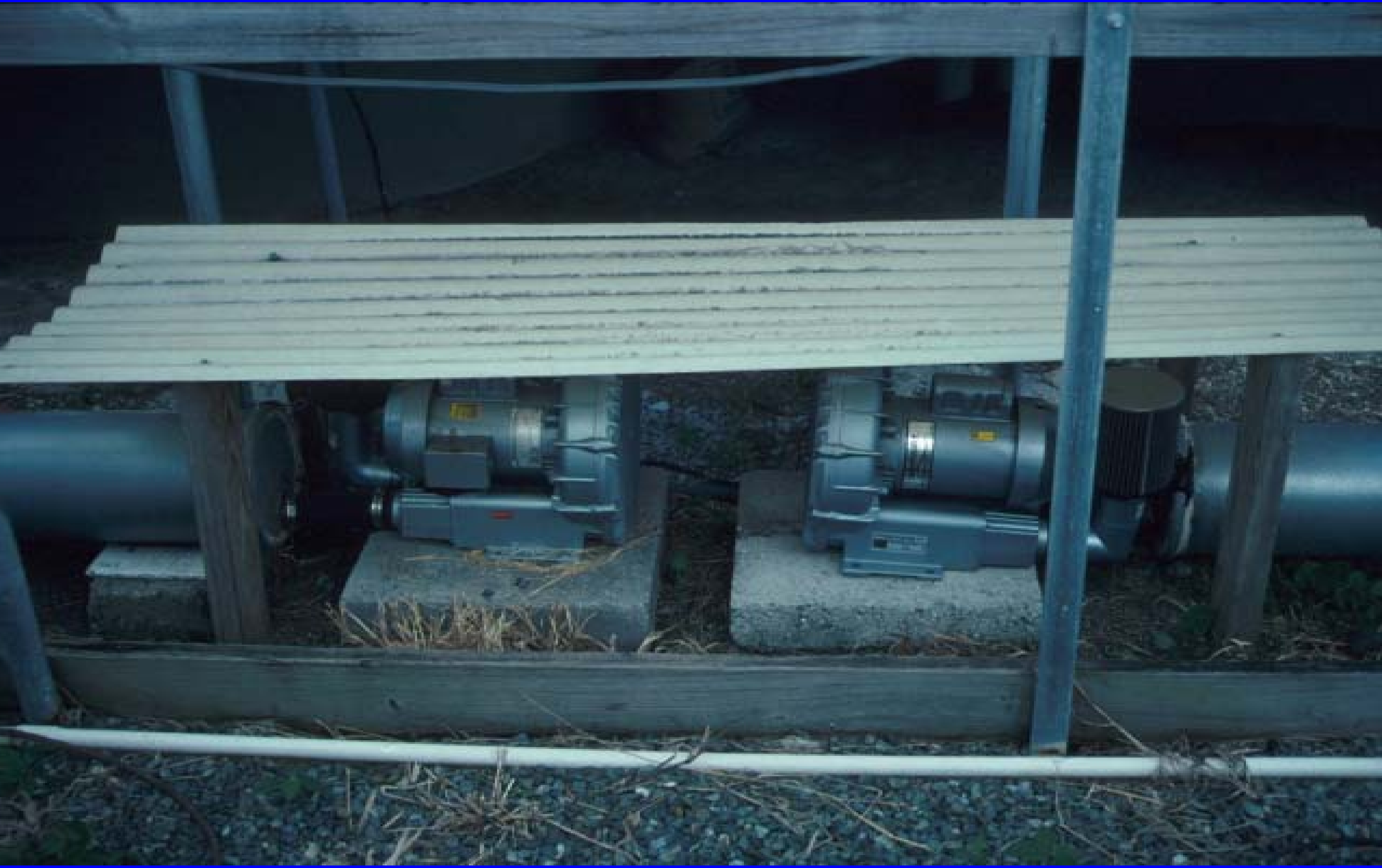
System Design

- Four fish rearing tanks, 7.8 m^3 each
- Two cylindro-conical clarifiers, 3.8 m^3 each
- Four filter tanks, 0.7 m^3 each
- One degassing tank, 0.7 m^3
- Six hydroponic tanks, 11.3 m^3 each
- Total plant growing area, 214 m^2
- One sump, 0.6 m^3
- Base addition tank, 0.2 m^3
- Total water volume, 110 m^3
- Land area - 0.05 ha



Treatment Processes

- Air stones, 88 in rearing tanks, 144 in hydroponic tanks
- Solids removal, three times daily from clarifier, filter tank cleaning one or two times weekly
- Continuous degassing of methane, CO_2 , H_2S, N_2
- Denitrification in filter tanks
- Direct uptake of ammonia and other nutrient by plants
- Nitrification in hydroponic tank
- Retention time: rearing tank, 1.37 h; clarifier, 20 min, hydroponic tanks, 3 h



Important Principles

- Optimum feeding rate, 60 - 100 g/day/m^2 of plant growing area prevents nutrient accumulation or deficiency
- Slow removal of solids increases mineralization
- Frequency of filter tank cleaning controls nitrate levels through denitrification

Production Management

- Feeding: three times daily *ad libitum*
  32% protein, floating, complete diet
- Stocking rate: Niles, 77 fish/m^3; Reds, 154 fish/m^3
- Stagger fish production, 24 week cycle, harvest every 6 weeks
- Plant production – staggered or batch
- Use biological insect control
- Monitor pH daily, maintain pH 7-7.5 by alternate and equal additions $Ca(OH)_2$ and KOH
- Add chelated iron (2 mg/L) every 3 weeks
- Add makeup water daily, about 1.5% of system volume

Energy Consumption

- One blower for fish and degassing, 1.5 hp
- One blower for hydroponics, 1 hp
- One water pump, ½ hp
- Total energy consumption, 3.0 hp

Objectives

- Determine the long term productivity of tilapia.
- Compare the staggered production of basil in an aquaponic system with field production.
- Compare the production of okra in an aquaponic system with field production.

Tilapia Production – 20 harvests

Tilapia	Harvest Weight per tank (kg)	Harvest Weight per unit volume (kg/m^3)	Annual Production (mt/0.05 ha)	Initial Weight (g/fish)	Final Weight (g/fish)	Growth Rate (g/day)	Survival (%)	FCR
Nile	480	61.5	4.16	79.2	813.8	4.40	98.3	1.7
Red	551	70.7	4.78	58.8	512.5	2.69	89.9	1.8

Methods – Basil Experiment

- Variety – ‘Genovese’
- Density of transplant – 8 plants/m^2
- Culture period – 28 days
- Staggered production – ¼ of system and field planted each week.
- Harvested twice at a height of 15 cm
- Applied cow manure (2-1-2) to field at a rate of 5.9 mt/ha
- Irrigated as needed with well water and drip system
- Sprayed plants twice a week with Bt
- Feeding ratio – 99.6 g/day/m^2

Staggered Production of Basil

	Aquaponics	Field
Yield (kg/m^2)		
First harvest	1.3a	0.3b
Second harvest	2.4a	1.0b
Weight/plant (g)		
First harvest	167.4	49.8
Second harvest	327.1	159.1

Annual Basil Production

Production Method	Annual Yield (kg/m^2)	Annual Yield ($kg/214\ m^2/yr$)	Mean Plant Weight (g)
Aquaponic	23.4	5,008	247.1
Field	7.8	1,669	104.4

Methods – Okra Experiment

- Variety – ‘Clemson’
- Density of transplants – 2.7 plants/m2
- Culture period – 11.7 weeks
- Harvested pods over 8 cm three times weekly
- Replications per treatment: 6
- Applied straw mulch to field plots after transplanting
- Applied gypsum to soil at 4 mt/ha
- Applied fertilizer (21-7-7) at 100 kg/ha
- Four foliar applications of micronutrients (Fe, Mn, and Mo) to field plots
- Applied Sevin twice to field plots to control ants
- In last 6 weeks sprayed $KHCO_3$ once or twice weekly to control mildew
- Feeding ratio – 95.6 g/day/m^2

Pod Yield (kg/m^2)

Variety	Aquaponics	Field
Clemson	2.67a	0.15b

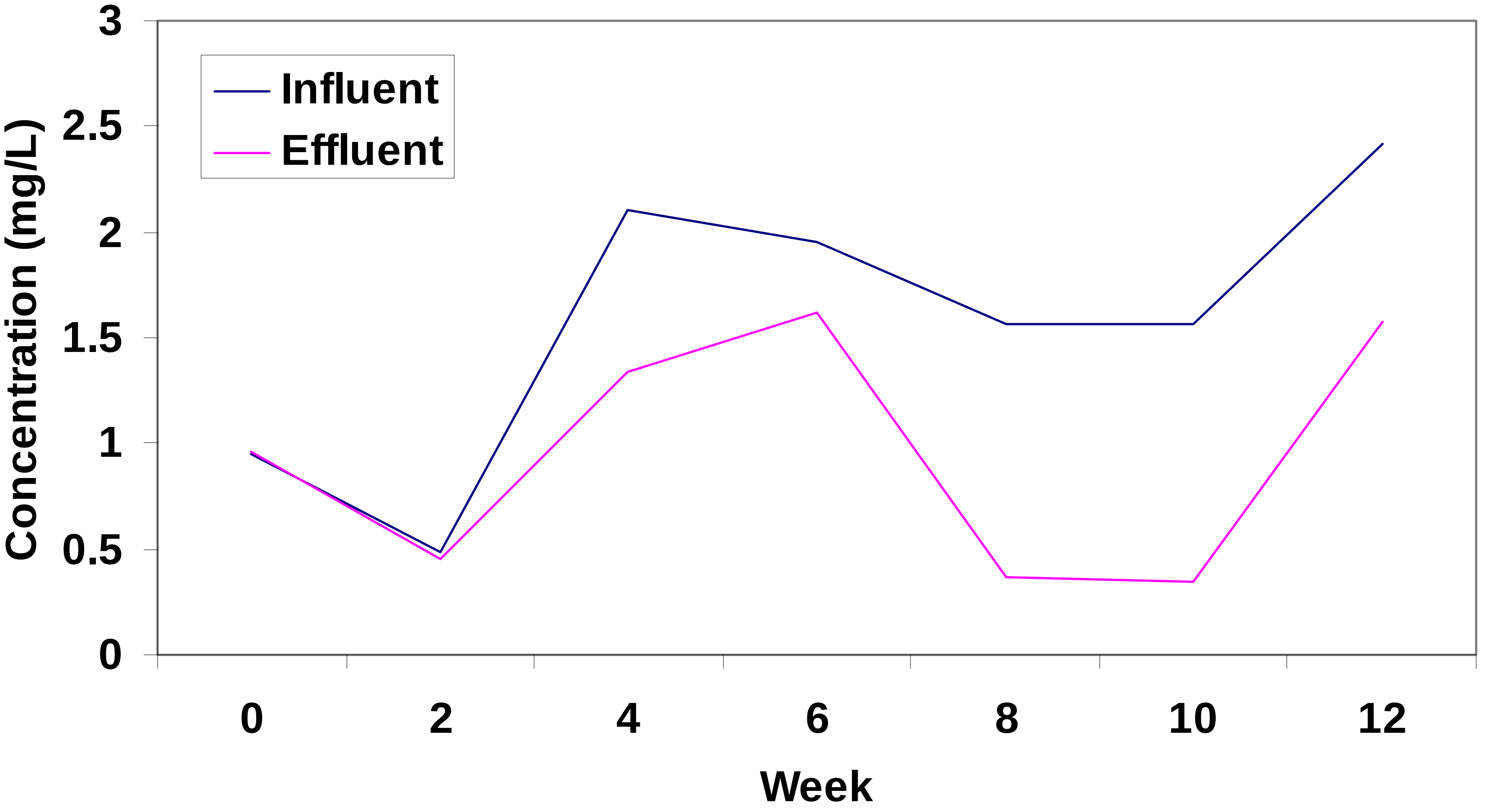
Macro-nutrients
Hydroponic tank influent and effluent

Parameter (mg/L)	Influent (mean)	Effluent (mean)
EC (mS/cm)	0.5	0.5
TDS	235.7	235.7
TAN	1.58	0.95
NO_2-N	0.43	0.21
NO_3-N	26.34	27.51
Ortho-Phosphate	15.03	15.25
Ca	24.4	24.3
Mg	6.0	6.0
K	63.5	64.6
SO_4	18.3	18.8

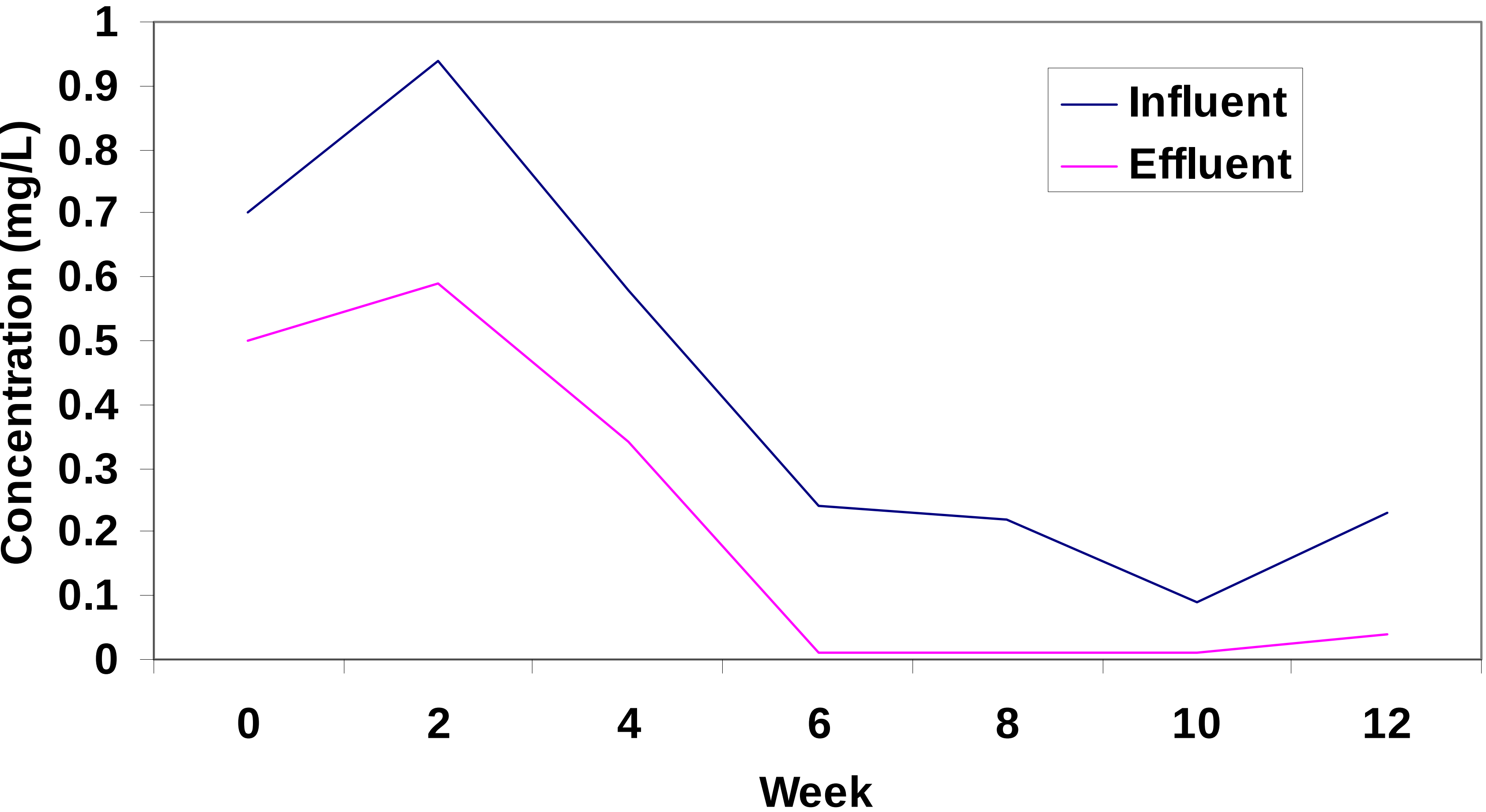
Micro-nutrients
Hydroponic tank influent and effluent

Parameter (mg/L)	Influent (mean)	Effluent (mean)
Na	13.7	13.7
Cl	11.5	11.5
Fe	1.3	1.3
Mn	0.06	0.05
Zn	0.34	0.34
Cu	0.03	0.03
B	0.09	0.09
Mo	0.01	0.01

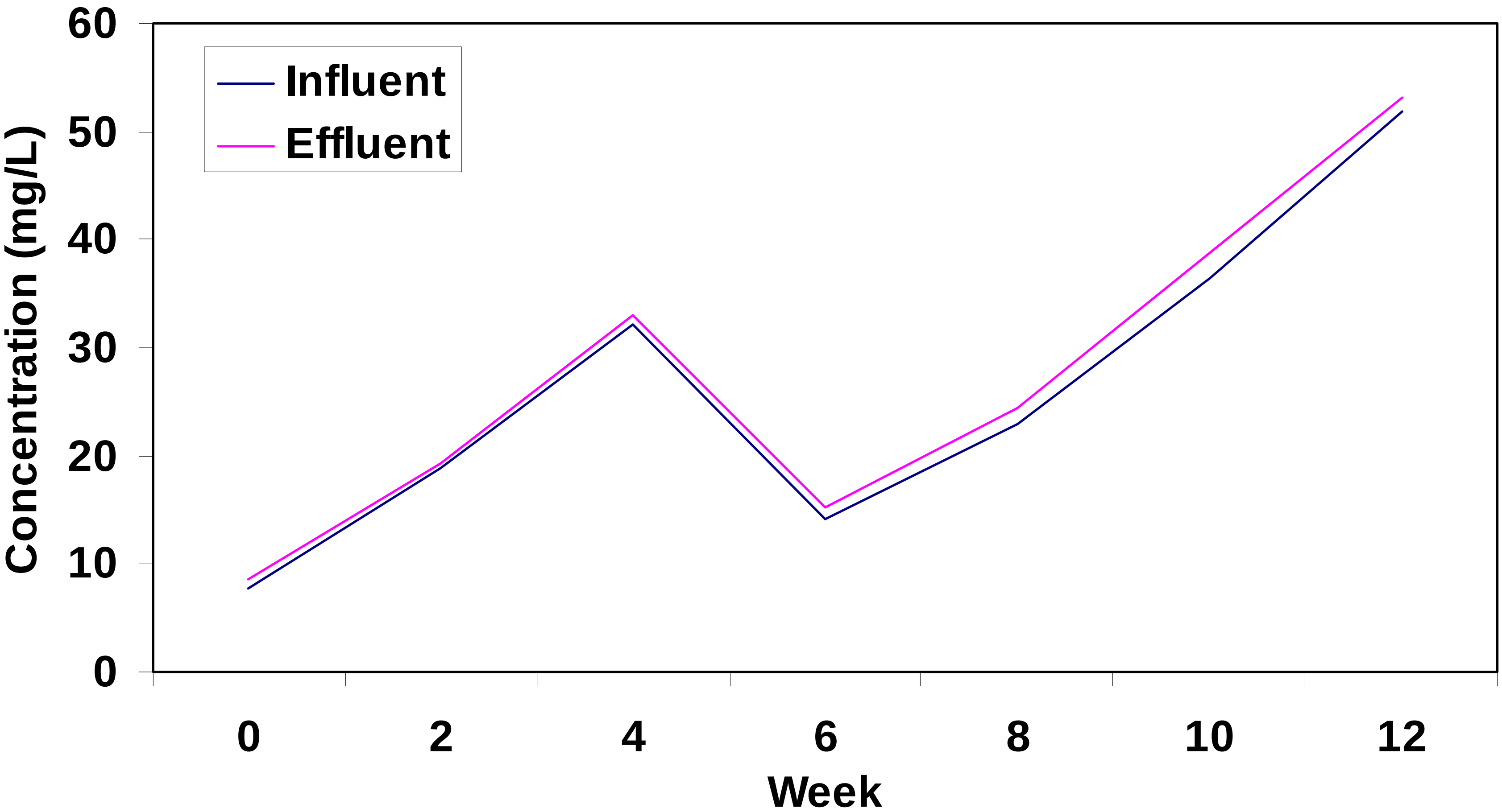
TAN
Hydroponic tank influent and effluent



Nitrite-Nitrogen Hydroponic tank influent and effluent



Nitrate-Nitrogen
Hydroponic tank influent and effluent



Conclusions

- High levels of tilapia production were sustainable.
- Closer attention to *ad libitum* feeding would increase annual production.
- Production of basil was three times greater in aquaponics than in soil.
- Production of okra was 18 times greater in aquaponics than in soil.
- Low okra production in soil may reflect poor soil quality or the need for a longer establishment period. Treatment differences may decrease substantially with high quality soil or a longer production cycle.
- Crop management is simpler in aquaponics than in soil.

Perspective on UVI Aquaponic System

- The system represents appropriate or intermediate technology
- It conserves water and reuses nutrients
- The technology can be applied at a subsistence level or commercial scale
- Production is continuous and sustainable
- The system is simple, reliable and robust
- Management is easy if guidelines are followed