Filter Feeding is Cool Aquaculture in NRCS

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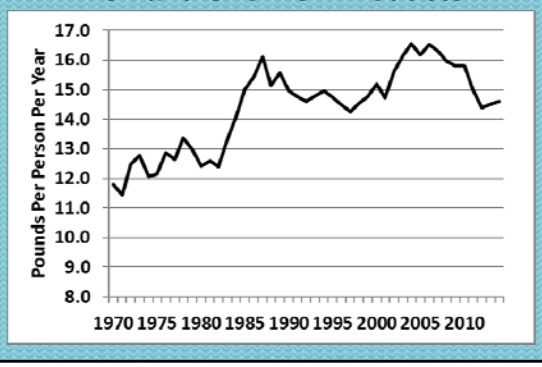
U.S. Per Capita Consumption of Fish and Shellfish Products



U.S. Top Ten Seafood Consumed, per capita consumption

	2000	Lb/yr	2005	Lb/yr	2010	Lb/yr	2014	Lb/yr
1	Tuna	3.50	Shrimp	4.10	Shrimp	4.00	Shrimp	4.00
2	Shrimp		Tuna	3.10	Tuna	2.70	Salmon	2.30
3	Pollock		Salmon	2.43	Salmon	2.00	Tuna	2.30
4	Salmon		Pollock	1.47	Tilapia	1.45	Tilapia	1.40
5	Catfish	1.00	Catfish	1.03	Pollock	1.19	Pollock	0.98
6	Cod		Tilapia	0.85	Catfish	0.80	Pangasius	0.69
7	Clams		Crab	0.64	Crab	0.57	Cod	0.65
8	Crabs		Cod	0.57	Cod	0.46	Catfish	0.52
9	Flatfish		Clams	0.44	Pangasius	0.41	Crab	0.51
10	Scallops		Flatfish	0.37	Clams	0.34	Clams	0.34

Yellow boxes represent Aquaculture Species

What is Aquaculture?

Rearing of aquatic animals

Cultivation of aquatic plants for food

Includes breeding, rearing, and harvesting of plants and animals in all types of water environments

Including ponds, rivers, lakes, and the ocean

What is Aquaculture?

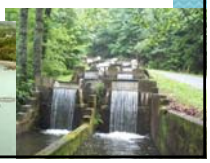
Researchers and aquaculture producers are "farming" all kinds of freshwater and marine species of fish, shellfish, and plants

- Food fish
- Sport fish
- Baitfish
- Ornamental fish
- Crustaceans
- Mollusks
- Algae
- Sea vegetables
- Fish eggs

What is Aquaculture?

Aquaculture production systems include the production of seafood from hatchery fish and shellfish which are grown to market size in:

- **Ponds**
- **Pens**
- **Tanks**
- **Cages**
- **Raceways**



What is Aquaculture?

Stock restoration or **"enhancement"** is a form of aquaculture in which hatchery fish and shellfish are released into the wild to rebuild wild populations or coastal habitats

What is Aquaculture?

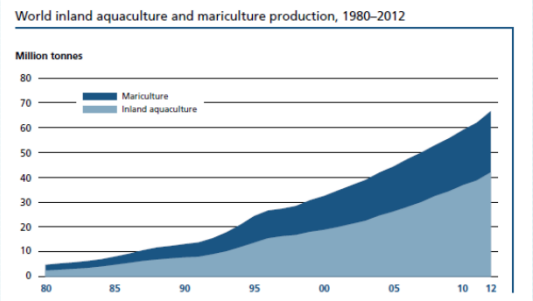
Aquaculture also includes the production of:

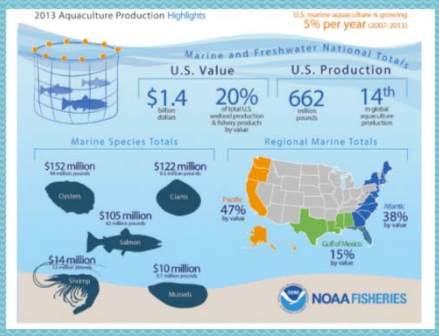
- **Ornamental fish** for the aquarium trade
- Growing **plant species** used in a range of food, pharmaceutical, nutritional, and biotechnology products

What is Aquaculture?

Marine aquaculture refers to the culturing of species that live in the ocean

- U.S. marine aquaculture primarily produces oysters, clams, mussels, shrimp, and salmon as well as lesser amounts of cod, moi, yellowtail, barramundi, seabass, and seabream
- Marine aquaculture can take place in the ocean (that is, in cages, on the seafloor, or suspended in the water column) or in on-land, manmade systems such as ponds or tanks
- Recirculating aquaculture systems that reduce, reuse, and recycle water and waste can support some marine species



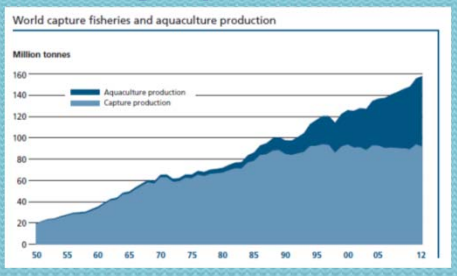


What is Aquaculture?

Freshwater aquaculture produces species that are native to rivers, lakes, and streams

- U.S. freshwater aquaculture is dominated by catfish but also produces trout, tilapia, and bass to name a few
- Freshwater aquaculture takes place primarily in ponds and in on-land, manmade systems such as recirculating aquaculture systems

Why Aquaculture?



Source: FAO/UN 2014 The State of World Fisheries and Aquaculture – Opportunities and Challenges

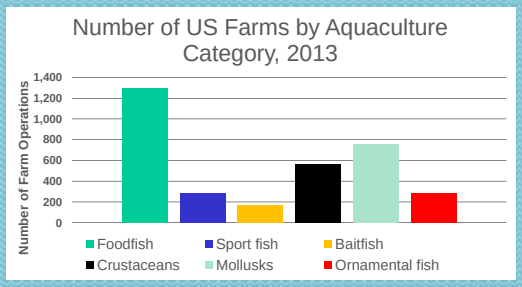
Trade Deficit

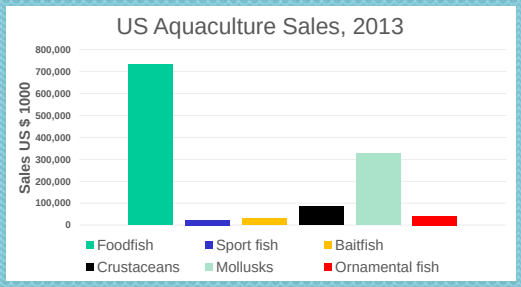
Value of US Aquaculture Production

Aquaculture Production of Fish, Crustaceans, and Mollusks, By Top Countries and by Continent, 2013

Country (ranked by volume)	Volume (metric tons)	Value (1000 US$)	Continent	Volume (metric tons)	Value (1000 US$)
China	43,549,738	70,037,317	Asia	62,546,664	116,705,426
India	4,549,607	10,355,807	Europe	2,781,125	13,124,316
Indonesia	3,819,732	8,779,298	South America	2,091,694	11,909,293
Viet Nam	3,207,200	6,198,422	Africa	1,615,608	3,627,109
Bangladesh	1,859,808	4,413,994	North America	977,062	3,707,850
Norway	1,247,865	6,896,891	Oceania	177,695	1,273,786
Egypt	1,097,544	2,088,867			
Thailand	1,056,944	3,165,809			
Chile	1,033,206	7,525,266			
Myanmar	929,180	1,714,771			
Philippines	815,008	1,976,898			
Japan	608,800	3,332,353			
Brazil	473,429	1,310,071			
United States of America	441,098	1,211,480			
South Korea	402,141	1,455,164			
All others	5,098,548	19,885,372			
Total	70,189,848	150,347,780		70,189,848	150,347,780

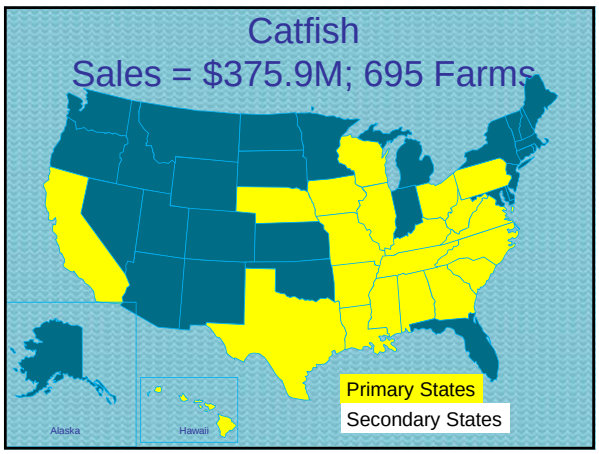
Source: NOAA/ Fisheries of the US 2014

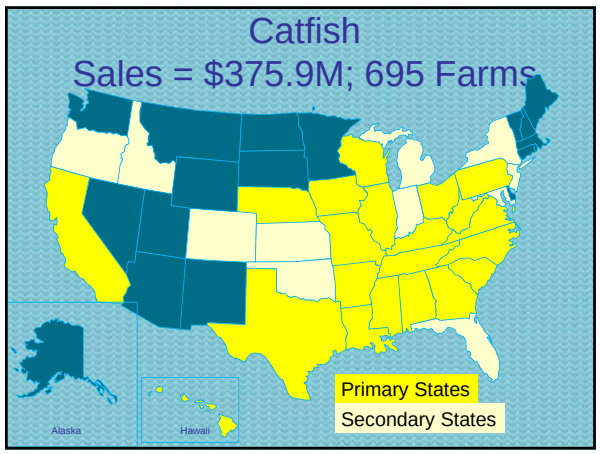


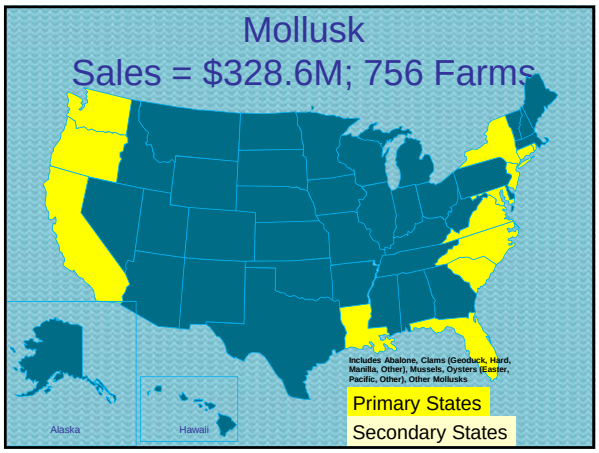


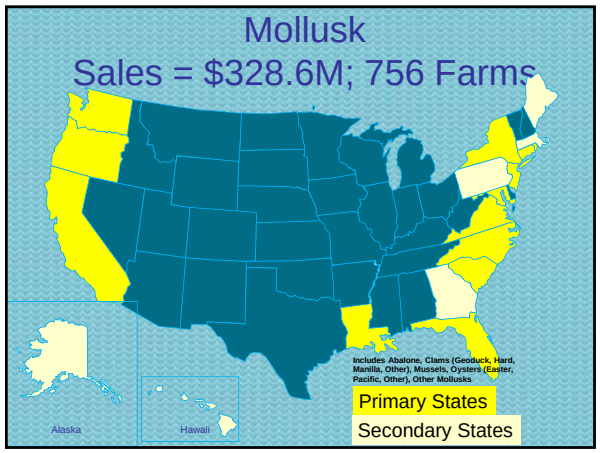
What Species are Raised in the US?

Where is Aquaculture Taking Place in the US?






Mollusk
Sales = $328.6M; 756 Farms
Includes Abalone, Clams (Geoduck, Hard, Manilla, Other), Mussels, Oysters (Easter, Pacific, Other), Other Mollusks
Primary States
Secondary States
Alaska
Hawaii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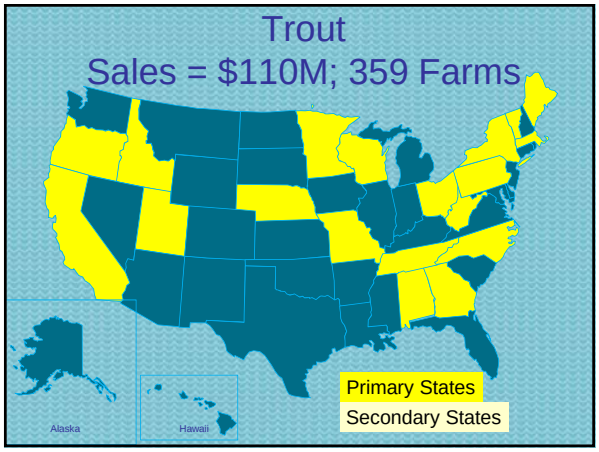
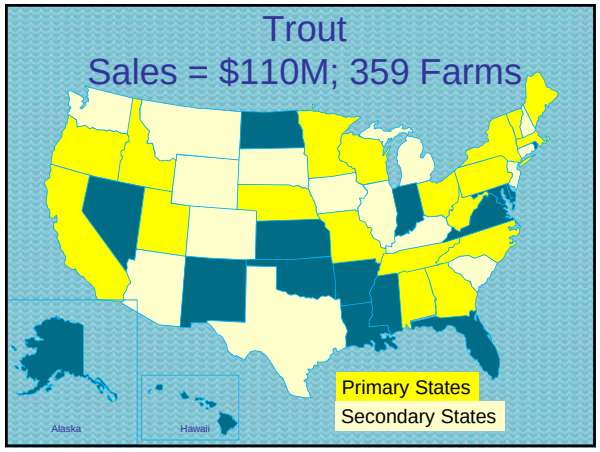

Trout
Sales = $110M; 359 Farms
Primary States
Secondary States
Alaska
Hawaii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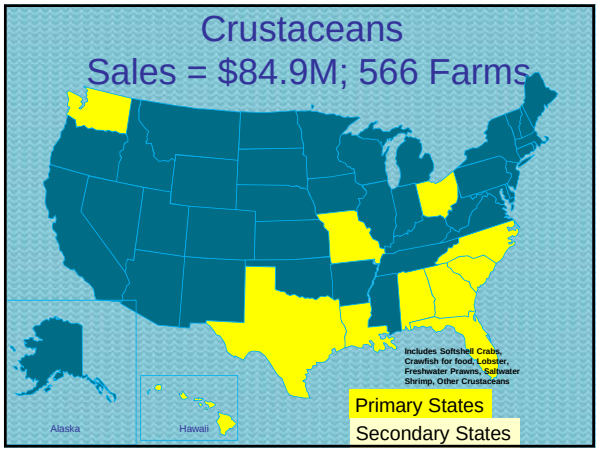
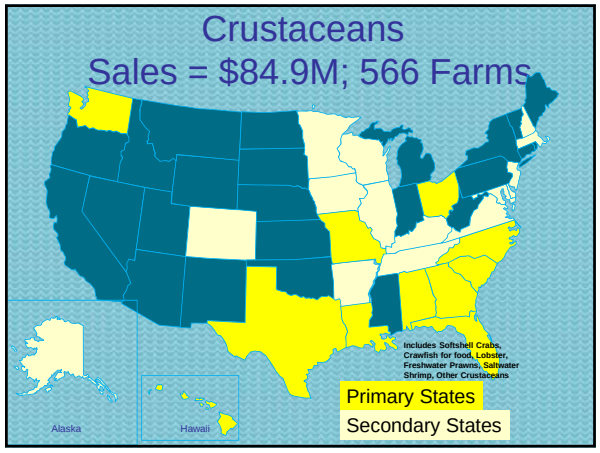
Hawaii


Crustaceans
Sales = $84.9M; 566 Farms
Includes Softshell Crabs, Crawfish for food, Lobster, Freshwater Prawns, Saltwater Shrimp, Other Crustaceans
Primary States
Secondary States
Alaska
Hawaii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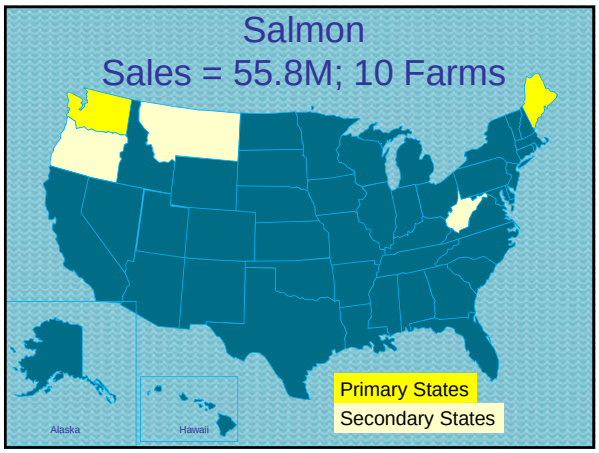
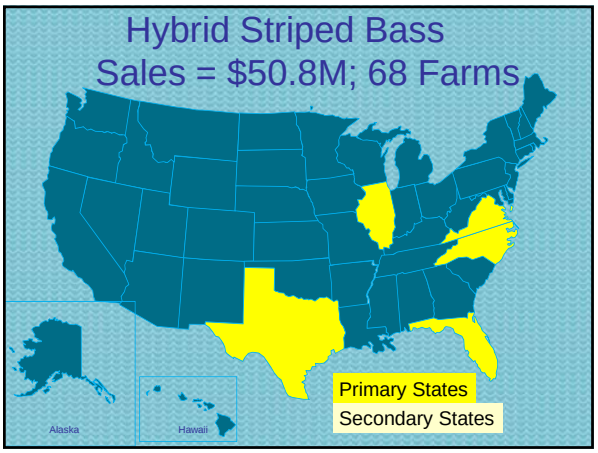
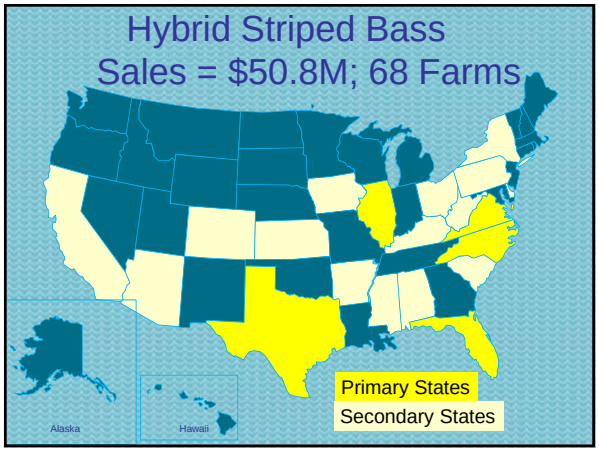

Salmon
Sales = 55.8M; 10 Farms
Primary States
Secondary States
Alaska
Hawaii


Hybrid Striped Bass
Sales = $50.8M; 68 Farms
Primary States
Secondary States
Alaska
Hawaii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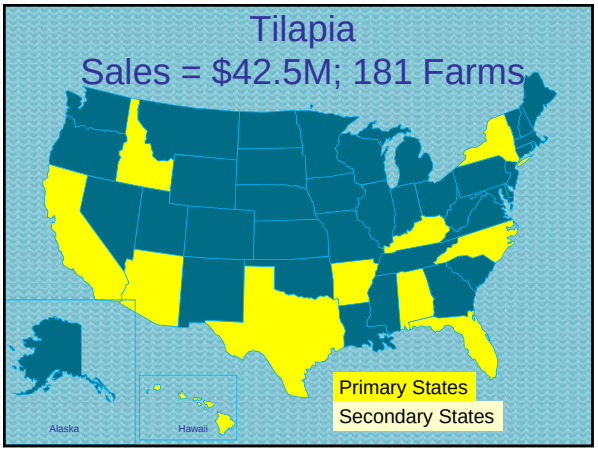
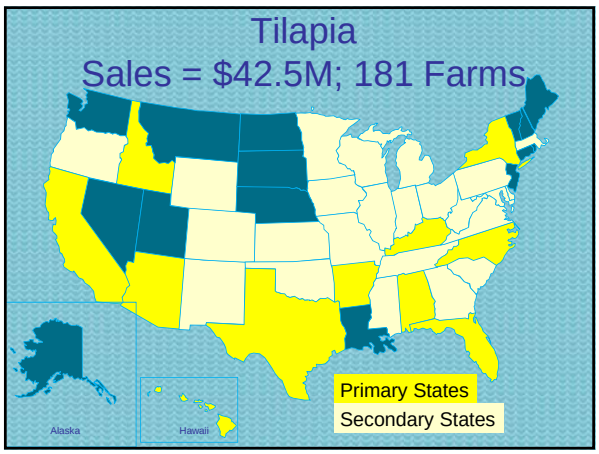

Tilapia
Sales = $42.5M; 181 Farms
Primary States
Secondary States
Alaska
Hawaii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Alaska
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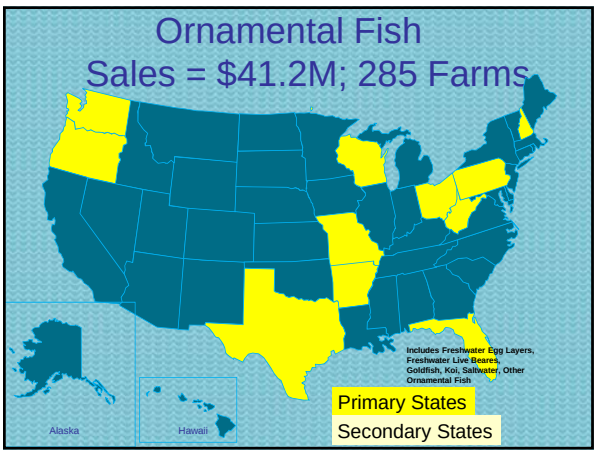
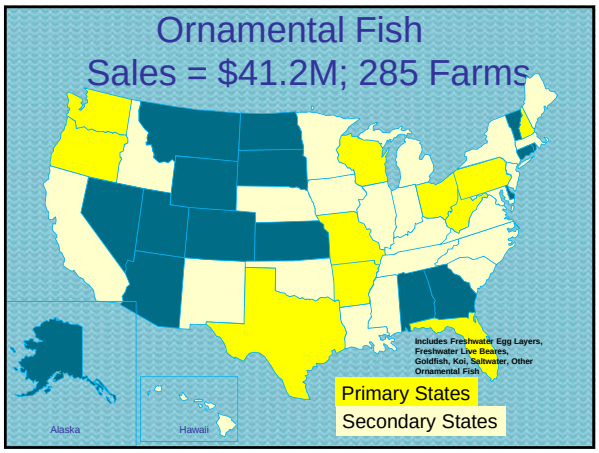

Ornamental Fish
Sales = $41.2M; 285 Farms
Includes Freshwater Egg Layers, Freshwater Live Bearers, Goldfish, Koi, Saltwater, Other Ornamental Fish
Primary States
Secondary States
Alaska
Hawaii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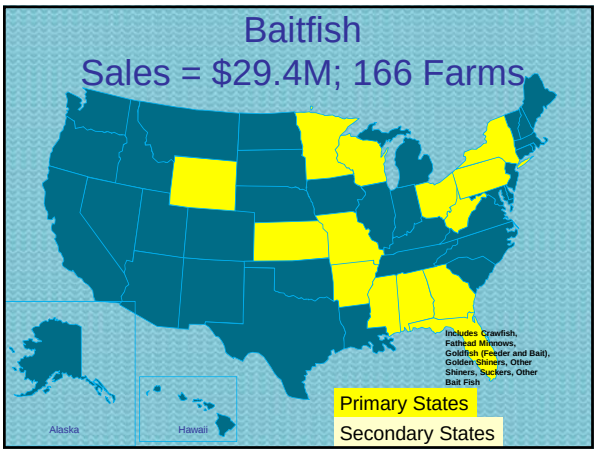
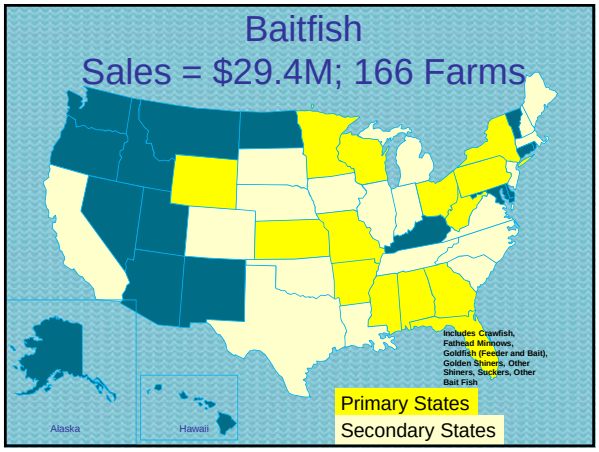

Baitfish
Sales = $29.4M; 166 Farms
Includes Crawfish, Fathead Minnows, Goldfish (Feeder and Bait), Golden Shiners, Other Shiners, Suckers, Other Bait Fish
Primary States
Secondary States
Alaska
Hawaii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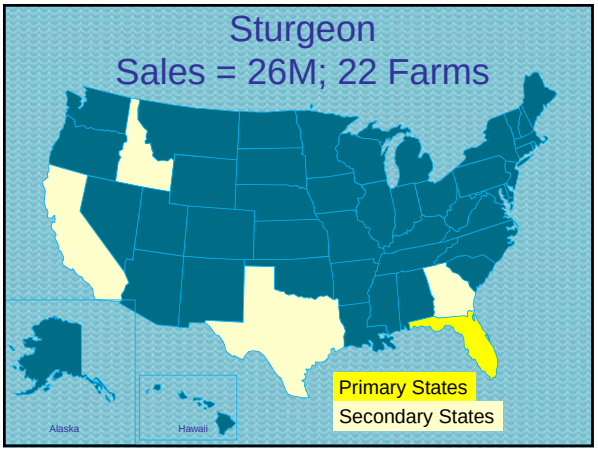
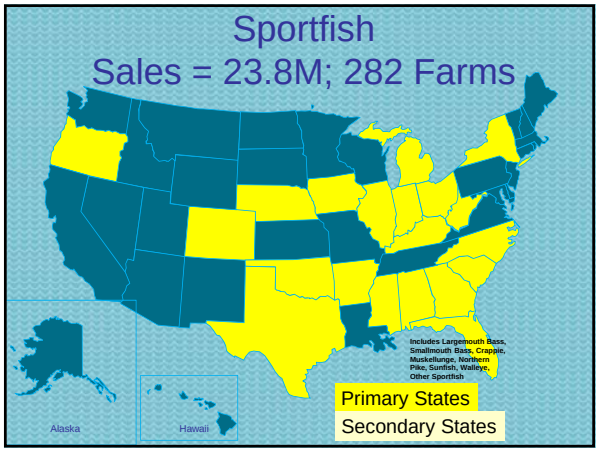
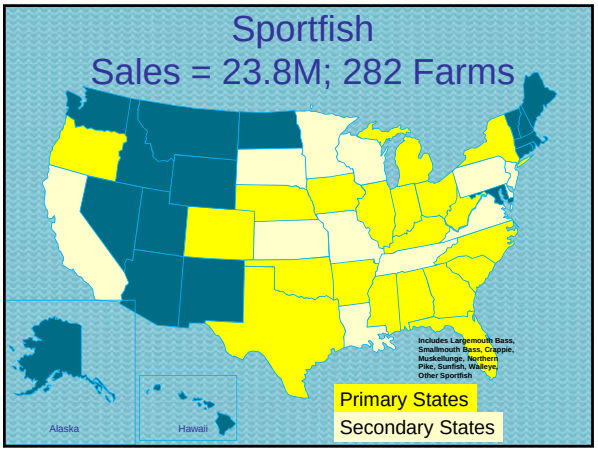

Sturgeon
Sales = 26M; 22 Farms
Primary States
Secondary States
Alaska
Hawaii


Sportfish
Sales = 23.8M; 282 Farms
Includes Largemouth Bass, Smallmouth Bass, Crappie, Muskellunge, Northern Pike, Sunfish, Walleye, Other Sportfish
Primary States
Secondary States
Alaska
Hawaii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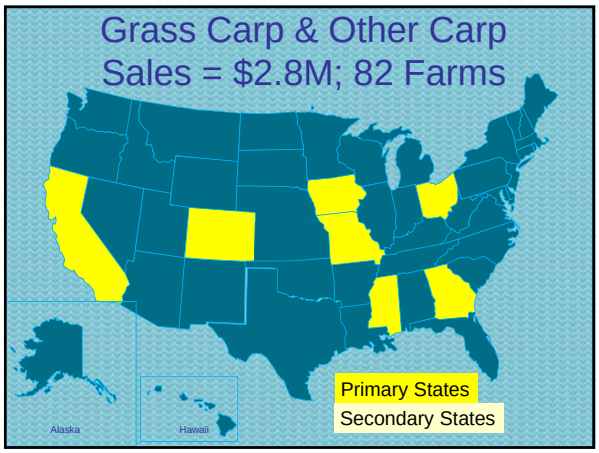
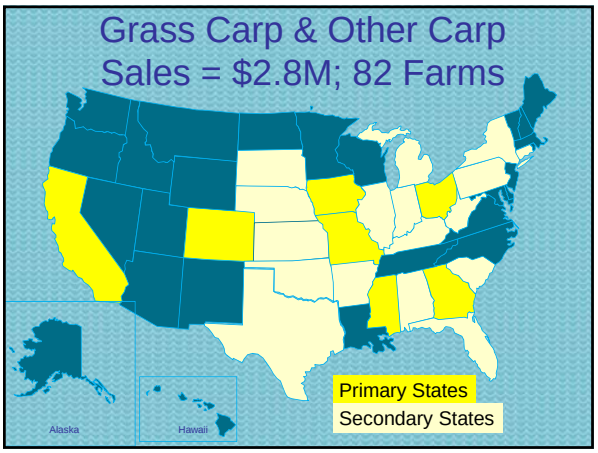

Grass Carp & Other Carp
Sales = $2.8M; 82 Farms
Primary States
Secondary States
Alaska
Hawaii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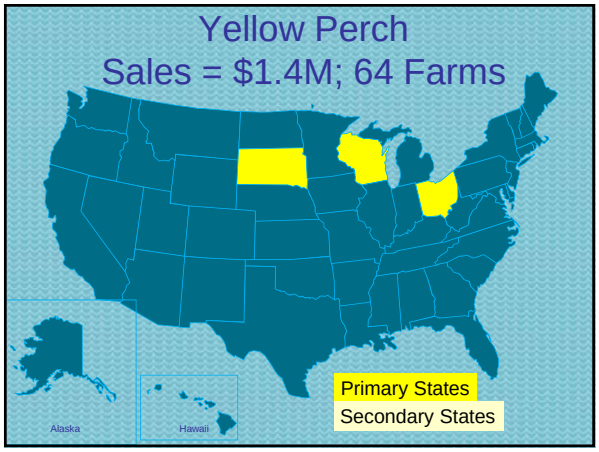
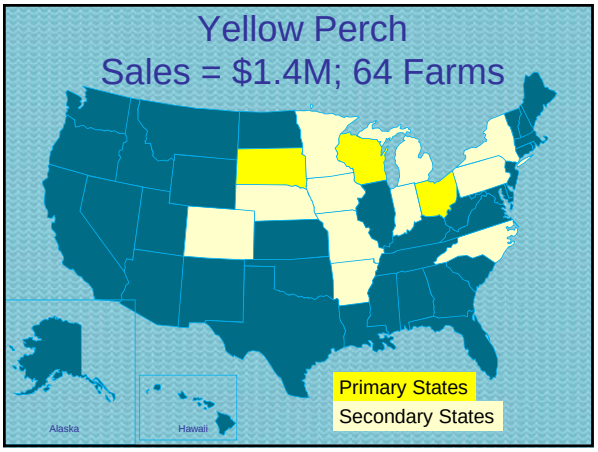

Yellow Perch
Sales = $1.4M; 64 Farms
Primary States
Secondary States
Alaska
Hawaii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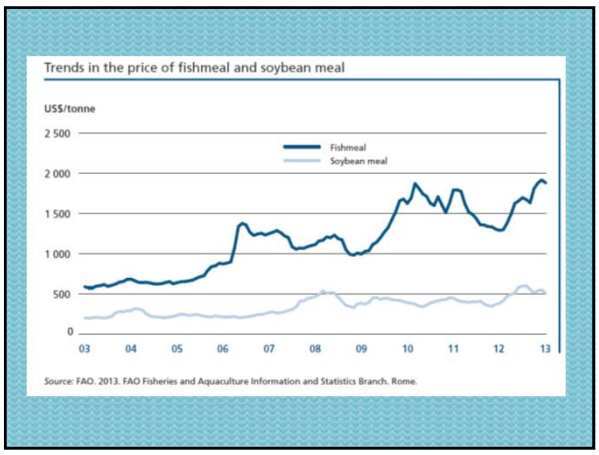
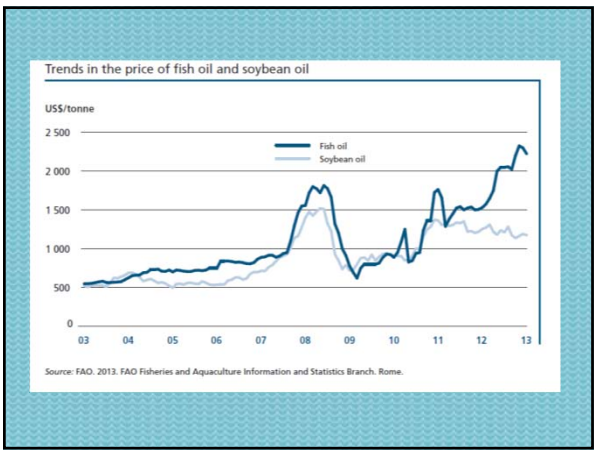
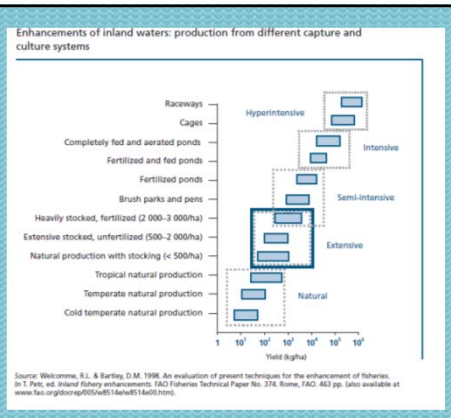

Trends in the price of fishmeal and soybean meal
US$/tonne
2 500
2 000
1 500
1 000
500
0
Fishmeal
Soybean meal
03
04
05
06
07
08
09
10
11
12
13
Source: FAO. 2013. FAO Fisheries and Aquaculture Information and Statistics Branch. Rome.


Trends in the price of fish oil and soybean oil
US$/tonne
2 500
2 000
1 500
1 000
500
0
Fish oil
Soybean oil
03
04
05
06
07
08
09
10
11
12
13
Source: FAO. 2013. FAO Fisheries and Aquaculture Information and Statistics Branch. Rome.



Dr. Jesse Chappell

Aquaculture Systems

AUBURN
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21st Century Advancements in Aquaculture

We are where poultry was in 1950!

The same economic drivers are re-shaping the aquaculture production business

While the family owned aquaculture business will likely survive for some years, the more competitive, advanced systems will be far more competitive in the near future

Current warm water aquaculture businesses are principally family owned businesses

A few are emerging as vertically and horizontally integrated businesses equipped to flourish in the 21st century

Production Aquaculture is developing along two primary routes…

Enhanced Pond Systems

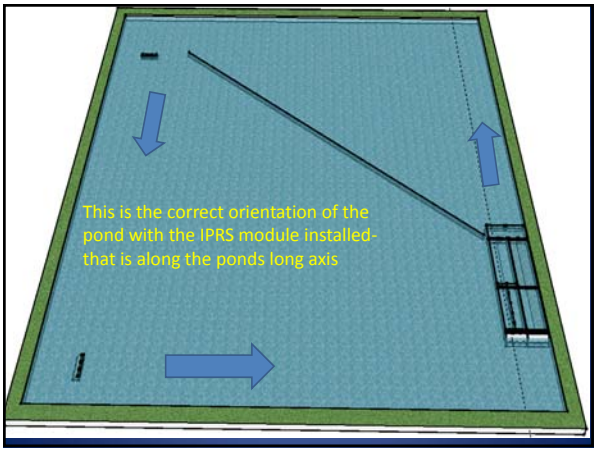
and

Recirculating Aquaculture Systems (RAS)

Advanced pond production approaches are using confinement of fed species coupled with continuous aeration, mixing and removal of waste solids produced by the fish

These enhanced pond systems have already demonstrated an effective and reliable doubling of production output while reducing cost of production by 30-40 percent

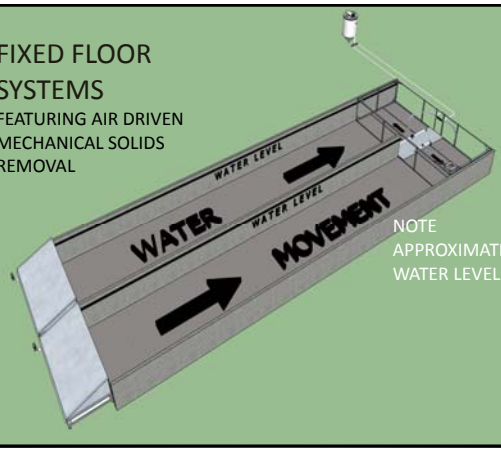
Better managed systems of this type are producing 3 times the traditional system annual yield with less risk and more managerial control



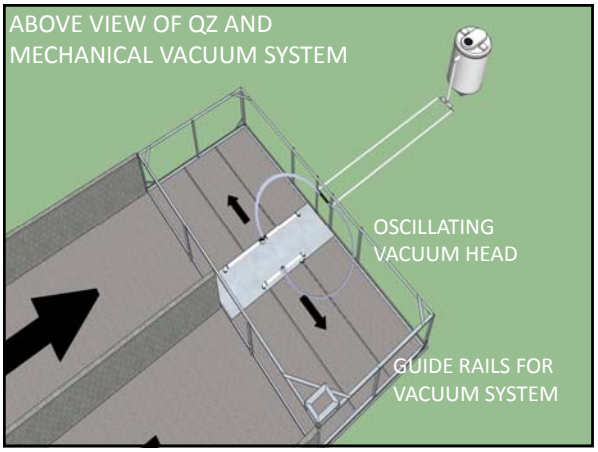
Completed unit with WW units in place and operating. Units are 16' by 80', 4 feet operating depth. Wall tops are wooden and painted orange with sand mixed into the paint to afford assess.

FIXED FLOOR SYSTEMS

FEATURING AIR DRIVEN MECHANICAL SOLIDS REMOVAL



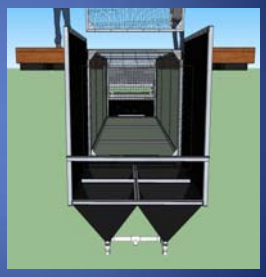
ABOVE VIEW OF QZ AND MECHANICAL VACUUM SYSTEM



Current Developments in Managing Waste Load

New whitewater/water moving device with diffuser grid

Current Developments in Managing Waste Load



Modern Recirculating Aquaculture Systems (RAS) suitable for commercial application are quietly advancing and are turning out high quality products at annual yield levels well above 1 million pounds per acre per year!

While commercial Recirculation Aquaculture Systems or RAS have continued to advance, there are still many hobby/family level approaches marketed that are not profitable nor industrially reliable…

Coupled with an appropriate scale feed mill and very similar to modern poultry and swine production, 21st century RAS are most economically operated at an industrial scale.

Development of modern industrial-scale RAS systems are next on the aqua-business horizon. These advanced systems will be the next steps in industrial aqua-food production.
They will emphasize resource conservation while minimizing risk and optimizing yield.

Current and near term advancements:

1. Fully integrated production systems;
2. Central to this approach is the on-site feed mill;
3. Immediately adjacent to feed milling are production, processing, by- product value recovery and enhancement;
4. Waste nutrients (solid and liquid) are now re-tasked at scale to secondary and tertiary production enterprises;
5. All leads to a balanced production ecosystem that efficiently uses water, nutrient inputs and energy.

Using this approach much akin to modern swine production systems great economies may be gained in:

1. Centralized management
2. Elimination of freight systems
3. Reduction in energy cost per unit output
4. Re-capture/re-use of nutrients and water
5. Year round production
6. Optimization of slaughter waste value recovery

ON-FARM COLLABORATIVE PROJECTS

Weissinger Lakes, Marion, AL

Butch Wilson $340,000 invested

Fish Barn Commercial tilapia production

12,000 square feet (0.275 acres)

10 systems, 2 system designs

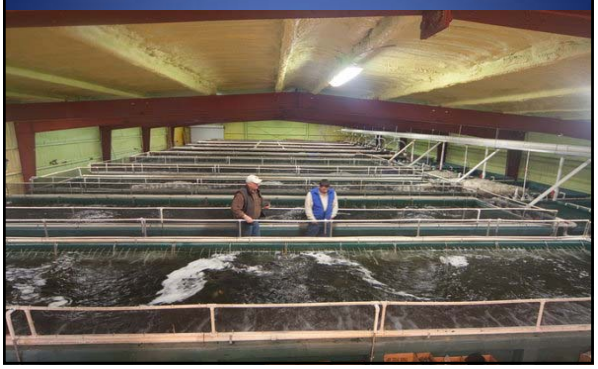
5 wood constructed plastic lined, 15,000 gallons each

5 fiberglass pre-manufactured tanks, 10,000 gallons each

Normal Production Capability 200,000 Pounds Annually **(728,000 pounds per acre)**

150 tons feed fed annually

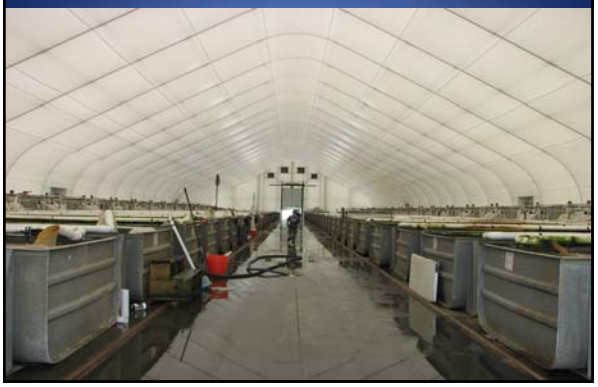
Weissinger Lakes Facility, west AL



ON-FARM COLLABORATIVE PROJECTS

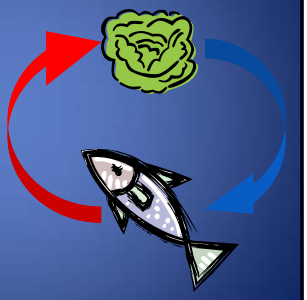
- Aqua Green Poplarville, MS
  - Walter Boasso **$3.3 million invested**
  - Fish Barn ~57,000 square feet (1.31 acres)
  - 60 production systems; 12,000 gallons each
  - Fresh and salt water systems
  - Producing Tilapia, red drum and pompano
  - Normal annual fish production capability 1,080,000 pounds **(845,000 pounds per acre-Tilapia)**
  - 750 tons of feed used annually

Aqua Green- South MS

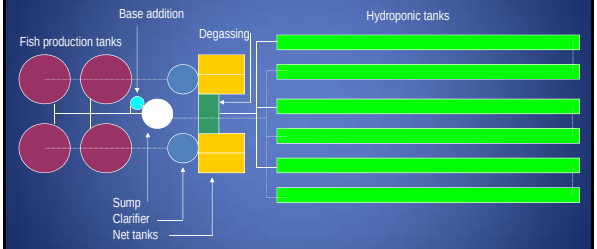


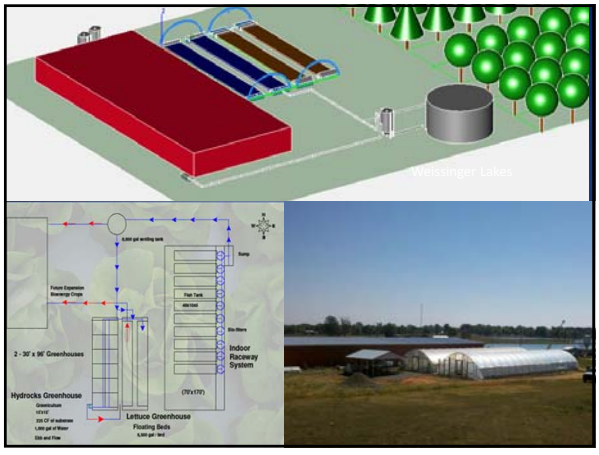
Aquaponics

- **Aquaponics is the integration of Hydroponics with Aquaculture production**
  - **Fish effluent is sent to plant component**
  - **Plants remove toxic nutrients**
  - **Treated water returns to the system**
  - **Fish replenish nutrients**
  - **Provides organic nutrient source for plant production in the form of dissolved nutrients**
  - **Organic liquid fertilizer**



Overhead View of Aquaponic System





Secondary Feeding Level

Plants Want Nitrates!

Integrated Aquaculture Approach in a Temperate Climate at Auburn

- Fish production system
  - 2- 27,500 gal tanks
  - Biofloc system
  - 24,000 lbs/year
  - Only discharges 30 - 60 gallons per day
  - 100 kwh per day

Why Integrate Intensive Aquaculture with Intensive Plant Production

- Water use for agriculture industries will likely become more strictly regulated and more costly over time.
- Commercial production of both fish and plants require significant quantities of water.
- Integration of fish and plant crop production has the potential to significantly reduce water use and associated costs as well as regulatory concerns
- Dissolved nutrients from fish system effluent can provide supplemental to complete nutrient needs for many horticulture crops.

Integrated Aquaculture and Horticulture = AQUAPONICS

- Recent work has linked intensive aquaculture and plant production systems like hydroponics and aquaponics,
- Nutrient concentrations in these systems are low compared to traditional concentrate fertilizer applications, BUT:
- With modified systems and culture approaches used in aquaponics, low nutrient levels in "fish production water" can turn out satisfactory or better yields at reduced costs for many crops

Aquaponics

- Aqua-ponic production efficiently utilizes low nutrient levels compared to conventional concentrate fertilizer applications
- Typical hydroponic systems use 200-300 ppm N so growers do not have to constantly apply costly fertilizers
- In most aquaponic systems nutrients levels are typically as low as 30-40 ppm N. (optimal is >75 ppm)
- In aquaponic systems nutrients are assimilated by the plants but are continually replenished as fish are fed and nutrients are released to system water.

Recent Work at Auburn

Main Campus

Integrated system at the E. W. Shell Fisheries Center, Auburn AL.

2 – 30 X 96 greenhouses

Constructed originally as a multi-disciplinary energy project FISH, HORT, BSEN Departments

Constructed in 2006

Modern Production of Fish in Intensive Systems

>1,000,000 pounds per acre per year
Water use cut by 50%
Energy used per unit reduced by 30-45%
Year Round Production
Outdoor Pestilence Removed
Marketing opportunities Expanded
Production location opportunities expanded

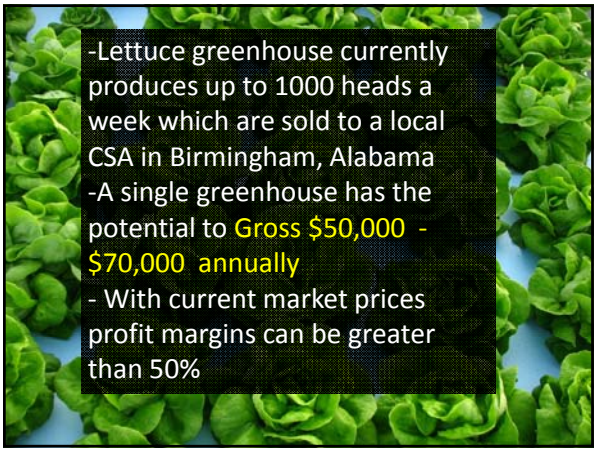
Key Ratio:

For each 100 pounds of feed fed to fish, area equal to 1 to 1.5 standard 32' x 100' greenhouse units can be adequately supplied with nutrient rich water for most plant production- depending on species in culture

Industry Partners Offer Leveraging Opportunities

Aquaponic Greenhouses

- 5 – 30 x 96 Quonset style greenhouses
- Floating House Raft culture of lettuce
  - > 5000 heads at a time
  - 1000 heads a week, possibly >5000 per week
  - Sold to a CSA
- Gravel media culture featuring ebb and flow nutrient administration



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