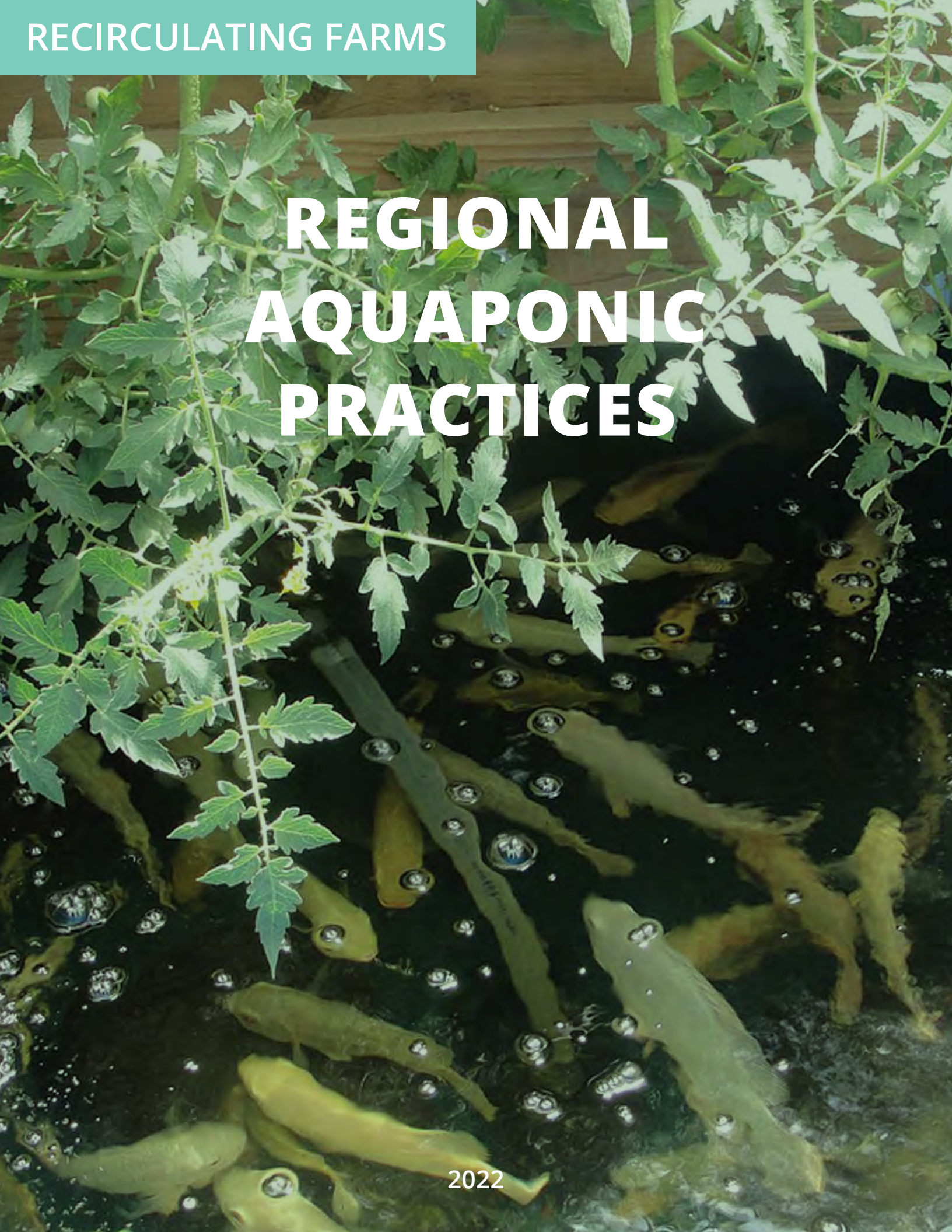
RECIRCULATING FARMS

REGIONAL AQUAPONIC PRACTICES



2022

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EXECUTIVE SUMMARY: PURPOSE OF REPORT

This report, **Regional Aquaponic Practices**, provides a roadmap and recommendations to support aquaponic businesses to increase the viability of their operations. The information provided is based on a survey of aquaponic operations that was created in collaboration with Recirculating Farms and Auburn University.[1] The results were analyzed to develop a firsthand, comprehensive understanding of the overall structures, operations, markets, economics, successes, and challenges in this industry. The data was then synthesized to provide aquaponic practitioners general recommendations to help their businesses thrive. As industrial-style recirculating systems are growing across the world, this report is intended to support system development for community-based, sustainable operations that build local economies and feed local communities.

Aquaponics are water-based growing systems that use continually cleaned, recycled water as a means of growing a wide range of aquatic and plant life for diverse purposes. Aquaponics conserve water and energy, have low food safety risks, can produce large amounts of fish and plants in small spaces, and pose low environmental impacts, while providing people with fresh, local food.

Aquaponic-grown vegetables often have bigger sales in the marketplace than fish. Farms have the potential to provide economic opportunities for the entire workforce: Farmworkers may earn good salaries and owners receive overall income. Areas of financial growth opportunities include training and education, as the industry is still developing and basic skills are needed. Additionally, start-up investments require a support system of equipment purchases, design input, and overall consultations. Based on our survey, among profitable farms, the average annual revenue from plant production is $483,585, while fish production nets $77,000. Additionally, revenue from equipment, supplies, and services averages $42,857.

Initial start-up costs can be daunting for some entrepreneurs, as infrastructure and building costs alone can be a high hurdle, depending on the system design. The survey showed that the average building cost is $74,277 with the highest being $600,000, most of which is financed by personal funds. Start-up investments can provide aquaponic farms with the necessary help to be efficient, productive, and sustainable. Starting small and scaling up over time help keep costs manageable.

Some of the biggest challenges for aquaponic producers are systems management and design. This consists of maintaining environmental controls,

Traders Hill Farm, Hilliard, FL

such as water pH and temperature, level of humidity, ratio of fish to plants, and equipment upkeep. Additionally, there is a general lack of information and resources on aquaponic systems, whether for education and training or materials for the system itself. A lack of skilled workers was another difficulty noted by aquaponic entrepreneurs.

In terms of regulatory roadblocks, local, state, and federal regulations create barriers for selling produce and fish. Specifically, sales permits, food processing, and food safety requirements can make it extremely challenging to attain profitability. Permits and licenses associated with importation and certain fish species, especially non-native fish, were another challenge. These are surmountable issues if the state and federal governments commit to lifting up recirculating farms.

Some towns and cities across the United States are creating local ordinances to support the development of aquaponic farms. This is no longer just a backyard hobby and is becoming a meaningful opportunity for food security and economic growth. Of those surveyed, nearly 25 percent of the farms are located in urban environments, 16 percent in suburban settings, 55 percent in rural areas, with two percent in industrial zones. Not every respondent indicated their location.

This report is organized based on the US Department of Agriculture's growing zones and the USDA's regional groupings of states within each set of zones. A hardiness zone is a geographic area defined to encompass a certain range of climatic conditions relevant to plant growth and survival. Many farmers and gardeners depend on the hardiness guides when planning their annual crops. Even when using hoophouses, greenhouses, and other enclosed systems, the growing zones are still used as a guide to take into account extreme temperatures. They are referred to as "hardiness" zones to reflect the coldest temperature a plant can withstand. Go to USDA Plant Hardiness Zone Map to search for your zone by zip code.

OVERVIEW

Aquaponic systems combine aquaculture (raising fish) with hydroponics (growing plants in a nutrient-rich liquid medium) in a symbiotic environment. In this type of system, the waste produced by farmed finfish, or other aquatic species, supplies nutrients for plants grown hydroponically, which, in absorbing the nutrients, in turn purify the water.[2] There are unique environmental, social, and economic benefits associated with aquaponic systems. Overall, they reuse water, recycle waste, use less space to grow more food, and can incorporate renewable energy strategies.

Some operations that use antibiotics and chemicals, often do so at a notably reduced rate than those typically associated with other forms of aquaculture. Any inputs are approved by the Food and Drug Administration (FDA) and/or the US Department of Agriculture (USDA) for animal husbandry or other organic substrates. Since it is an entirely contained system, there is less threat of harm to natural ecosystems. Furthermore, the diversity of fish raised does not compete with local fishing communities.

Aquaponic systems are well suited to urban areas since they can be established in neglected industrial buildings, thus utilizing spaces less likely to be used for residential purposes. They can also be located in awkwardly shaped, small, rocky or paved spaces, unsuitable for traditional agriculture in cities, as they can be designed vertically, creating more opportunity for local food. They create shorter supply chains, generate jobs, decrease transport cycles, reduce the need for refrigeration and storage costs.[3] All of this is important for increased urban food security, local economics, and addressing challenges — like overuse of fossil fuels — associated with a changing climate. Aquaponic systems use gas and electricity for heat and light, but by incorporating alternative energy, such as solar or wind, the systems can be fully sustainable and self-sufficient.

Cabbage Hill Farm, Mt. Kisco, NY

Recirculating systems are designed to raise large quantities of fish in recirculated water. In the process of reusing the water many times, non-toxic nutrients and organic matter accumulate. These metabolic by-products support the growth of marketable secondary crops — a variety of plants — and can also benefit the primary fish production system. Systems that grow secondary crops (plants) by using by-products from the production of the primary focus (fish) are referred to as integrated systems. If the secondary crops are aquatic or terrestrial plants grown in conjunction with fish, this integrated system is referred to as an aquaponic system.[4] In some instances, the plants are the primary crop and the fish are simply the means to provide regular, natural materials for healthy plant growth.

There are a few general principles of recirculating aquaponic systems. The first is to use any

nutrients in the system as efficiently as possible, benefiting the production of both fish and plants. The waste produced by fish is then a main source of nutrients for plants, made available for uptake by microflora, also present in the system. Though fish waste contains many necessary nutrients, others may be needed, such as iron or other vitamins to ensure proper plant growth.[5] The ideal feeding rate for aquaponic systems varies, based on the fish and plants cultivated.

A main component of all aquaponic systems is the effective use of water, with the purpose of optimizing growth of fish and plants. Based on water flow, systems can be divided in two groups: coupled and decoupled. Coupled, or fully recirculating systems, recycle the water completely, with full water transfer from fish tanks to plant tanks and back. Decoupled systems transfer the water containing fish waste from the fish tank to the plants, without recirculating back to the fish.[6]

Hollygrove Market and Farm in New Orleans, LA

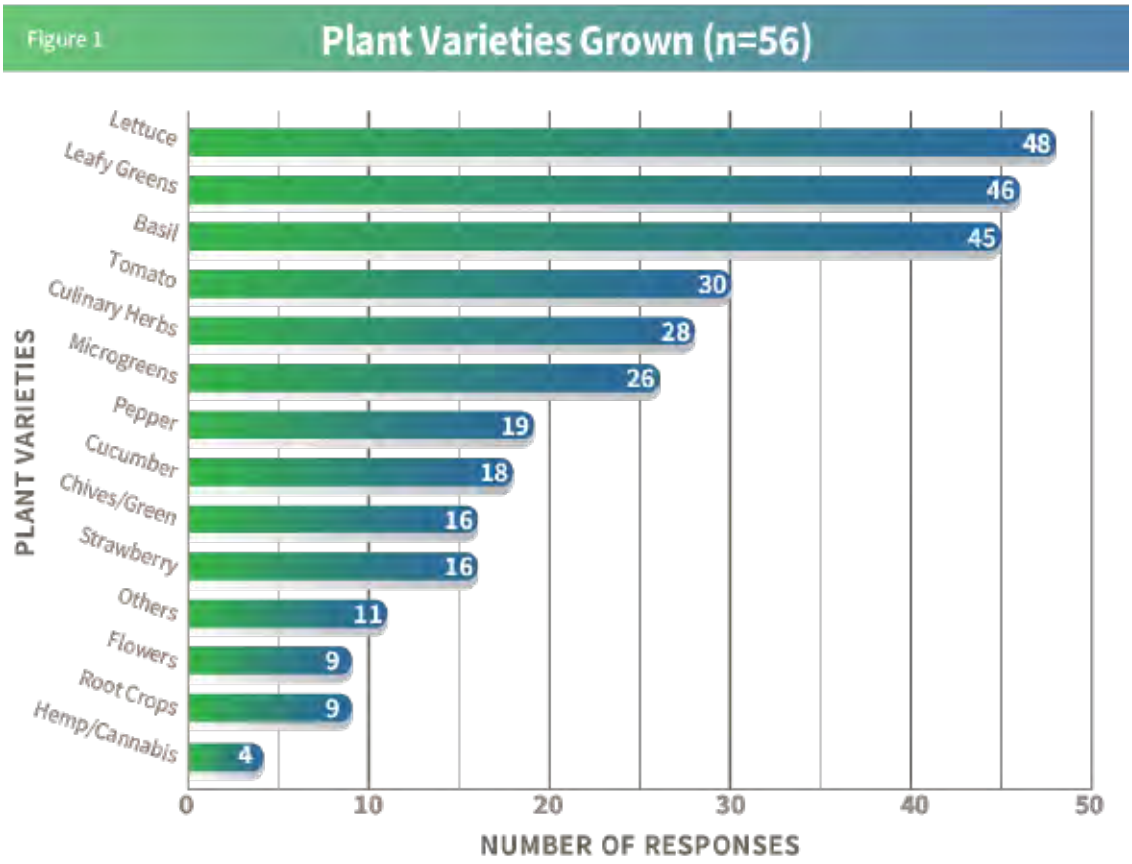
The materials and design of the system ensure that the nutrients and water can be recycled, unlike most other aquaculture systems, such as those that use earthen ponds. Common fish tank materials include plastic, fiberglass, and concrete. Most existing aquaponic systems are located within structures that have a level of environmental control, such as greenhouses. This environmental control can improve the productivity rate of the plants and fish.[7] However, it often requires the use of more energy.

Today, commercial aquaponics exist primarily in controlled environments, such as greenhouses, or in outdoor locations in warm climates, using methods and equipment that draw from both the hydroponic and aquaculture disciplines.[8] Over time, the systems have become more efficient with greater economic potential. Currently, there is expanding interest in aquaponics as a form of sustainable aquaculture that can be used to produce food closer to urban centers, enhance food security, decrease supply chains, and provide opportunities for economic development.[9]

Tilapia

Production

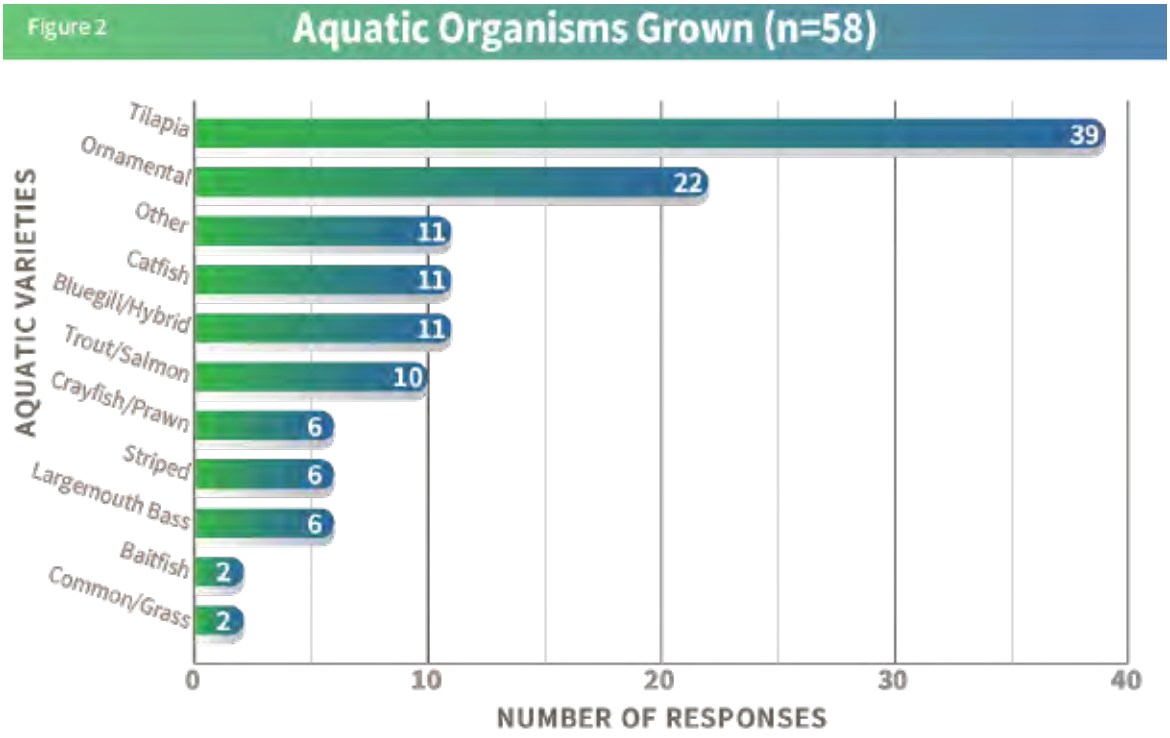
Lettuce, leafy greens, and basil are the most common plants cultivated in aquaponics, regardless of the hardiness zone of the farm. Most operations grow a variety of plants, rather than depend on monoculture. Figure 1 represents the plant varieties.



Aquatic varieties can provide both protein for local communities and ornamental fish. Of those surveyed, tilapia was the most common fish species. However, tilapia is invasive in many states and specific permits are required to grow them. As far as ornamental fish, koi, goldfish and aquarium fish are popular species. Figure 2 outlines the common fish grown in aquaponic operations.

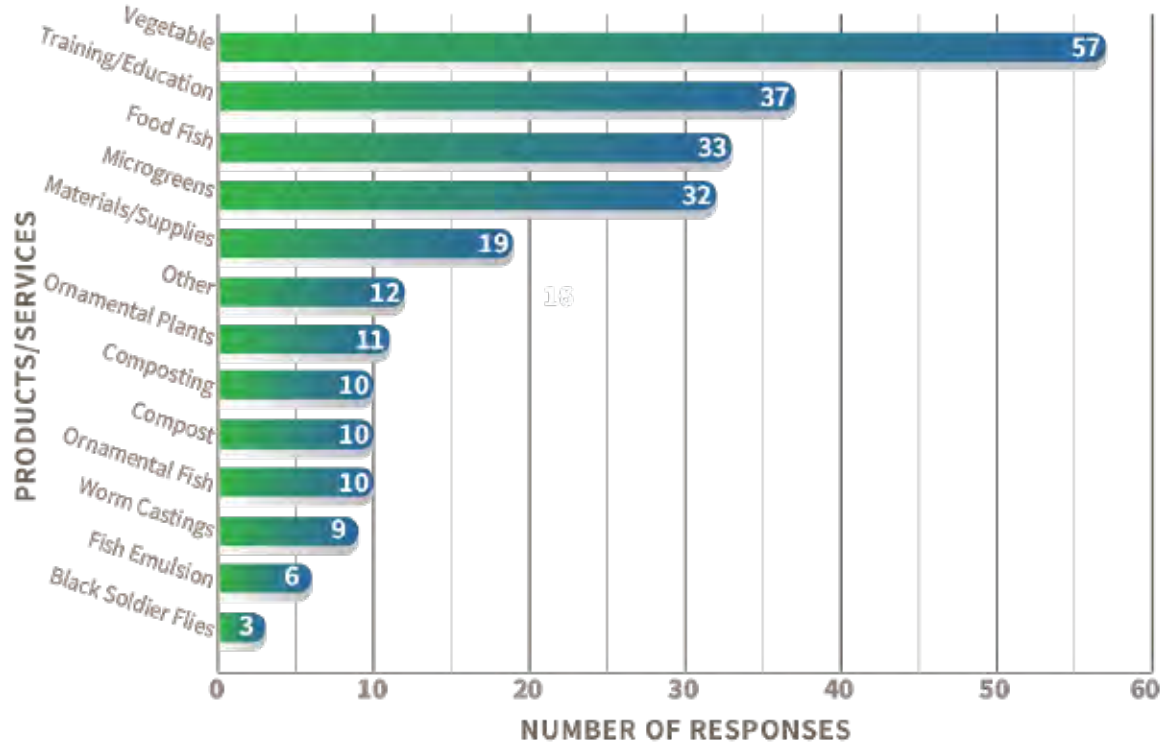
Growing Power

Figure 2



Aquaponic products sold range the gamut, from vegetables to services to fish to supplies. According to our survey, vegetables are the primary product sold, although not all operations enjoy a net profit from their operations. Of those surveyed, only 14 reported a profit. Figure 3 illustrates the overall aquaponic products and services sold.

Figure 3



Economics

Aquaponic farms provide economic growth for farm team salaries and owners' income when the operations are profitable and growth for the industry as a whole, even during developing stages, with equipment purchases, design, and consultations. Based on our survey, among profitable farms, the average annual revenue from plant production is $483,585, while fish production nets $77,000. Additionally, revenue from equipment, supplies, and services averages $42,857, annually.

Initial start-up costs can be daunting, depending on scale and design. The survey showed that the average building cost is $74,277 with the highest being $600,000, most of which is financed by personal funds. Start-up investments can provide aquaponic farms with the necessary help to be efficient, productive, and sustainable. Starting small and scaling up over time help to keep costs manageable. Aquaponic producers spent the most money on buildings, vehicles, greenhouses/high tunnels, land, and construction labor. Table 1 illustrates the initial investment costs and Table 2 illustrates the operational costs.

Recirculating Farms, New Orleans, LA

Table 1. Initial Investment Costs for Aquaponic Businesses (n=18)

PRODUCTS	MINIMUM	MAXIMUM	MEDIAN	MEAN	STD. DEVIATION
Buildings	**0.00**	**600,000**	**5,000**	**74,277.78**	**156,465.01**
Construction Labor	0.00	150,000	3,500	26,277.78	40,674.90
Fish System/ Equipment	0.00	130,000	3,000	22,241.94	37,709.24
Greenhouse/ High Tunnel	0.00	165,000	0	23,000.00	45,533.44
Land	0.00	150,000	0	15,733.33	39,272.62
Plant System/ Equipment	0.00	60,000	3,000	10,722.22	17,536.70
Tools	0.00	50,000	0	4,527.78	12,059.26
Vehicles	0.00	800,000	0	45,444.44	188,334.88
Other	0.00	1,100,000	0	62,777.78	258,924.37

Table 2. Operational Costs for Aquaponic Businesses (n=11)

PRODUCTS	MINIMUM	MAXIMUM	MEDIAN	MEAN	STD. DEVIATION
Electricity	0.00	26,000	3,000	5,763.64	7,776.41
Energy/Gas	0.00	3,000	0	600.00	1,019.80
Fish Inputs	0.00	65,000	400	6,495.45	19,417.50
Plant Inputs	0.00	39,000	750	4,186.36	11,562.03
Interest on Loans	0.00	24,000	0	2,227.27	7,222.75
Insurance	0.00	8,500	500	1,331.82	2,462.34
Labor	0.00	185,000	0	25,954.55	57,978.64
Management	0.00	20,000	0	1,818.18	6,030.23
Repairs/Maintenance	0.00	10,000	4,000	3,268.18	3,166.41
Taxes	0.00	8,000	0	927.27	2,387.09
Water	0.00	1,200	0	172.73	384.94

There are funding opportunities available through the specialty crop block grants, USDA Farm Service agencies, and state agriculture departments. Insurance has proven to be an obstacle, especially in larger operations. To address this issue, crop and livestock insurance is available through the federal government.

Markets

On average, within three to five years, a business can become profitable. According to the survey, the following revenue streams provide income:

- The average annual revenue from fish production is $77,000 USD.
- The average annual revenue from plant production is $483,585 USD.
- Revenue from equipment, supplies, and services averages $42,857 USD.

The following products are sold, although not all return a profit: food fish, ornamental fish, vegetable produce, microgreens, ornamental plants, materials/supplies, training/education, black soldier flies, compost, fish emulsion, composting worms, and worm castings.

Many aquaponic operations surveyed employ a diversified market distribution for both the vegetables and fish, including the following: farmers markets, supermarkets, restaurants, direct to consumer, and donations to food banks, shelters, and family and friends.

Recirculating Farms, New Orleans, LA

Plans, Procedures & Certifications

There are federal, state, and local regulatory obligations to consider when operating an aquaponic business. Depending on the fish species incorporated into the system, specific permits are required. The number one regulatory challenge identified in our survey was food processing, food safety, and sales requirements.

The Food Safety Modernization Act was passed in 2011 and focuses on foodborne illness. Several federal agencies have jurisdiction over development, implementation, and enforcement of specific regulatory requirements. In farm production, below is a list of federal regulations.[10]

- Good Agriculture Practice (GAP)
- Hazard Analysis and Critical Control Point (HACCP)
- Best Aquaculture Practices (BAP)
- Standard Operating Procedures (SOPs) — for plants & fish
- Sanitation Standard Operating Procedures — for plants and fish

Aside from federal requirements, many states have their own regulatory system, which is outlined within each regional section.

According to the survey, issues related to selling produce and fish were the highest regulatory roadblock, both at the state and federal levels. This included sales permits, food processing, and food safety. The second highest roadblock were permits and licenses associated with importation and use of fish species, especially non-native species. This is most common at the state level. Figure 4 indicates the identified regulatory roadblocks and Figure 5 outlines the necessary licenses and permits.

Figure 4

Specific Regulatory Roadblocks (n=27)

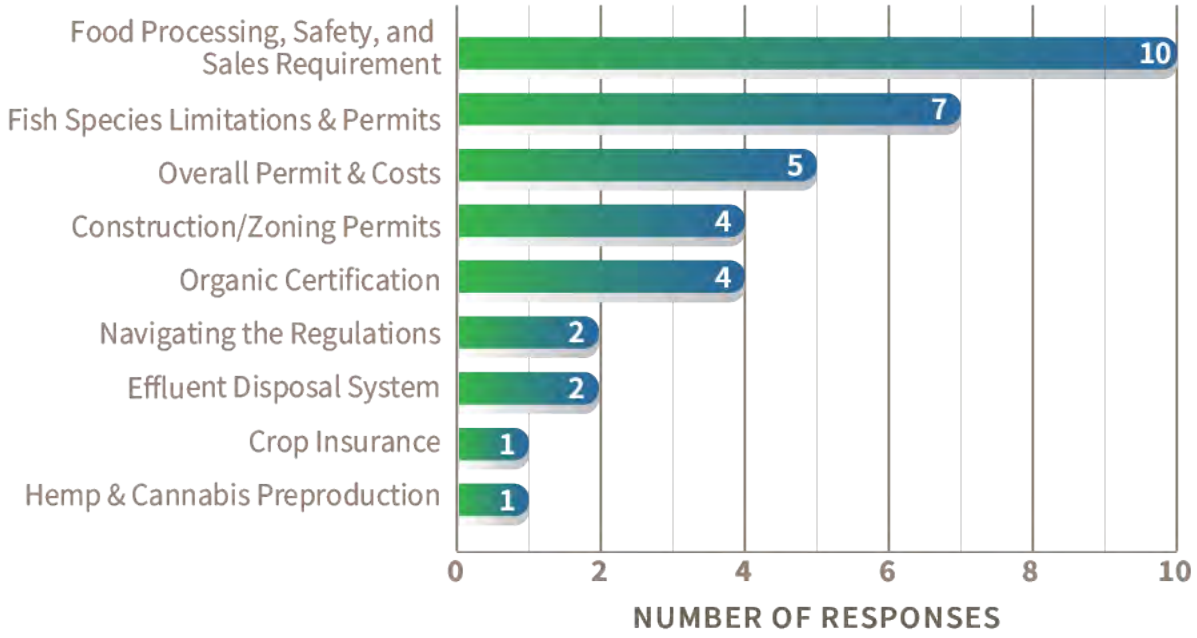
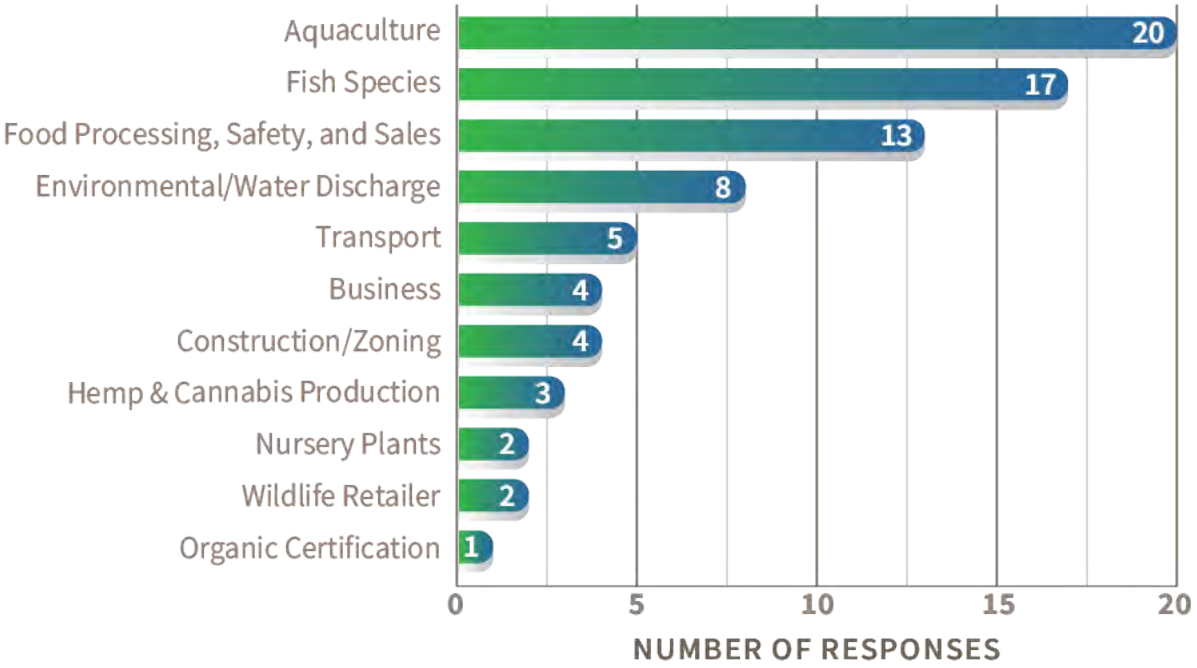


Figure 5

Necessary Licenses & Permits (n=46)



Many aquaponic operations are interested in marketing labels and certifications that verify their commitment to ecological and humane operations. These assist with communications and marketing to potential customers. Certified organic has shown to be of interest to aquaponic farmers. Certified Naturally Grown is another label to pursue.

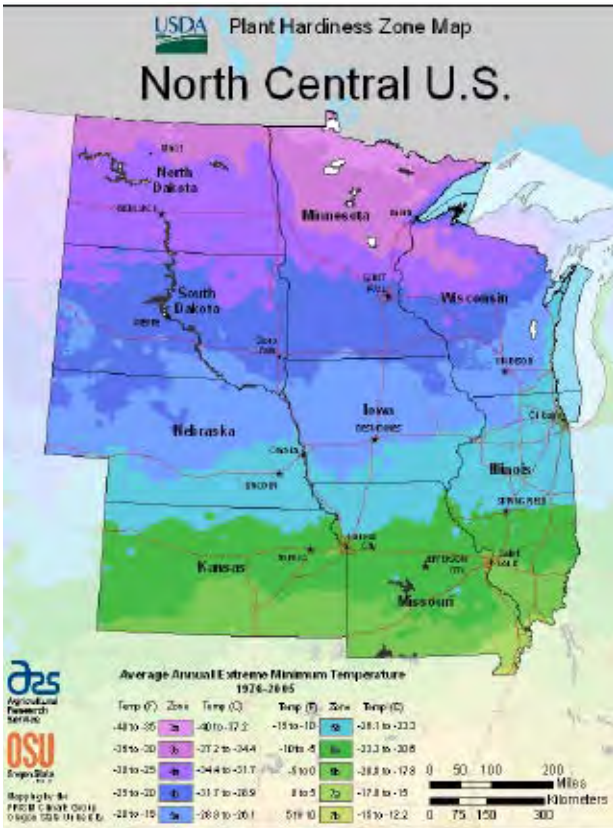
- Certified Organic: The USDA can certify the plants (only) in aquaponic production, providing that the certifier can demonstrate the operation follows the organic standards. Several organic certifiers certify plants produced hydroponically, and through aquaponics. You can find a list of all certifiers at USDA Certifier Locator.
- Certified Naturally Grown: A non-federally regulated certification program, which has specific standards regarding ecological production of aquaponic products. It has oversight by an Aquaponics Advisory Council. Qualified farms must be a member of Certified Naturally Grown, sign a declaration, and have an inspection.

Regions

Growing Zones: A hardiness zone is a geographic area that defines a range of climatic conditions relevant to plant growth and survival. In this report, we refer to hardiness zones as defined and developed by the USDA. There are 13 zones, each with sub zones that relate to micro-climates. Hardiness refers to the extreme minimum temperature at which a plant can survive and still thrive. Many farmers and gardeners depend on these hardiness zones to have prosperous seasons.

- Zone 1 and 2: Lower zones can be found in Alaska and Northern Plains
- Zones 3, 4, and 5: The far northern portion on the central interior of the mainland have some of the coldest zones and often have much less consistent range of temperatures in winter due to being more continental, and thus the zone map has its limitations in these areas.
- Zones 6, 7, and 8: The southern middle portion of the mainland and central coastal areas are in the middle zones.
- Zones 9, 10, and 11: These are located in the deep southern half of the country and on the southern coastal margins.
- Zones 12 and 13: Higher zones can be found in Hawaii and Puerto Rico.

NORTH CENTRAL



Zones 3a-7b: Illinois, Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, South Dakota, Wisconsin

Systems

A main component of all aquaponic systems is the effective use of the water in the system, with the purpose of optimizing growth of fish and plants. Based on water flow, systems can be divided into two groups: coupled and decoupled. Coupled, or fully recirculating systems, recycle the water completely, with full water transfer from fish tanks to plant tanks and back. Decoupled systems transfer the water containing fish waste from the fish tank to the plants, without recirculating back to the fish.[11] In the North Central region, both systems were preferred. In this region, aquaponic producers use either indoor or greenhouses, with 16 percent using a combination of both. This environmental control can improve the productivity rate of the plants and fish.[12]

Plant Production

The plant types that are grown depend on climate, seasonality, growing environment, plant production and plant production systems. In the North Central region, the most common plants are leafy greens, lettuces, microgreens, cucumbers, herbs, tomatoes, hops and hemp. It is best to refer to the hardiness zone recommendations when choosing which produce to grow.

There are several types of substrates to grow produce. Table 3 illustrates the preferred substrates for each state. If your state is not listed, this indicates that no aquaponic farm within that state participated in our survey.

Table 3: The North Central Region Preferred Substrates

STATE	METAL	PLAS-TIC	PVC	RUBBER/ PLASTIC LINER	FIBER-GLASS	SOIL	WOOD	CONCRETE	POLYSTY-RENE	SOILLESS	OTHER
Iowa	x	x	x	x							
Kansas											
Minnesota		x	x	x	x	x	x		x	x	
Missouri	x	x	x						x		
Wisconsin		x	x					x	x	x	x

Fish Production

The materials and design of the system ensure that the nutrients and water can be recycled, unlike most other aquaculture systems, such as those that use earthen ponds. In the North Central region, 62.5 percent indicated they use plastic tanks, while 37.5 percent use fiberglass. Most existing aquaponic systems are located within structures that have a level of environmental control, such as greenhouses. This environmental control can improve the overall productivity.

Figure 6 represents the fish species farmed in this region, and Figure 7 illustrates how those species were selected.

Figure 6 Fish Species Farmed in the North Central Region

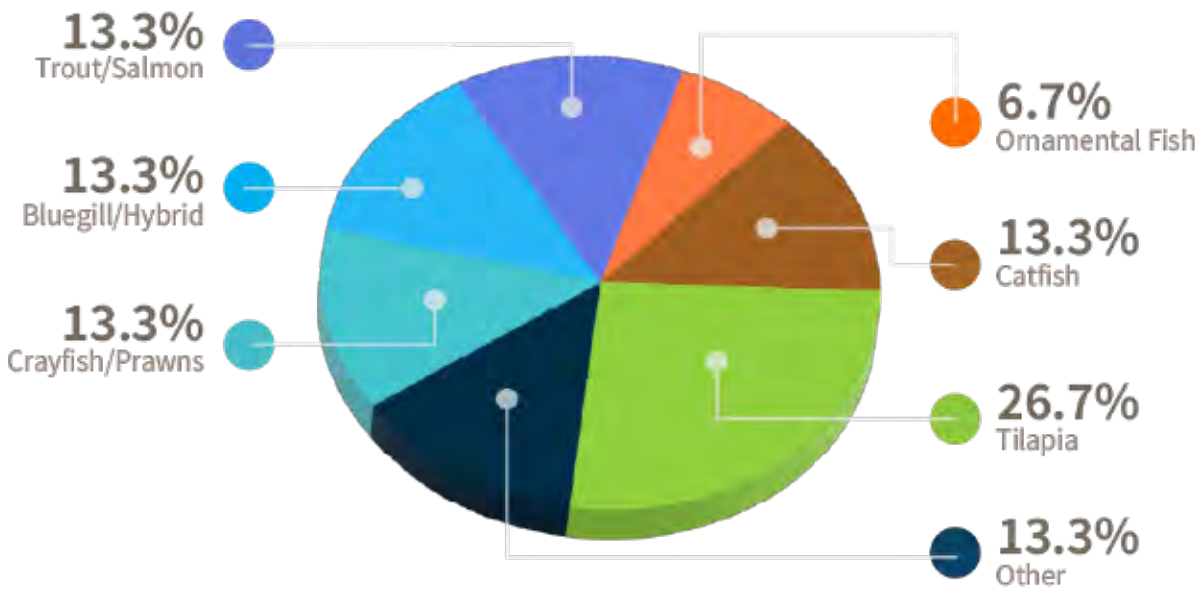
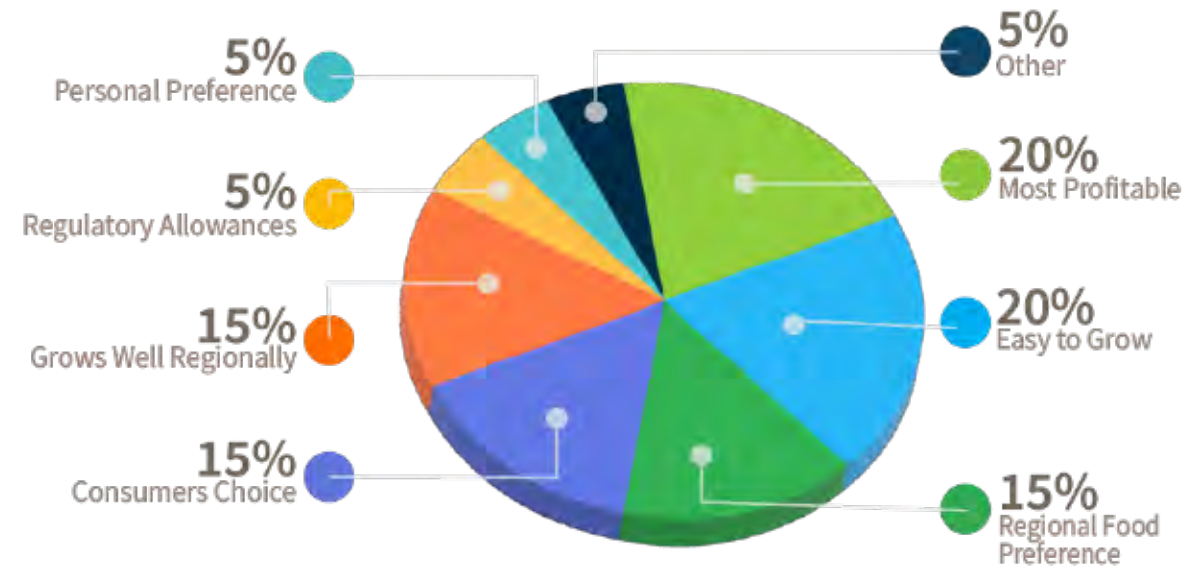


Figure 7 Selection Criteria for Fish Species in the North Central Region



Costs

Initial startup costs are often daunting. Aquaponic producers spend the most money on buildings, vehicles, greenhouses/high tunnels, land, and construction labor. The majority of respondents in our 2020 survey indicated that they use personal funds to support their business, and only 27 percent received government grant assistance. However, there are funding opportunities available through the specialty crop block grants, USDA Farm Service agencies, and your state agriculture department. Insurance has also proven to be an obstacle, especially in larger operations. Through the federal government, crop and livestock insurance is available.

Regulations

Many regulations and permits are at the state level, so you must check out your state's Department of Agriculture, Department of Natural Resources, and/or Department of Health. Some local ordinances may also exist, and you will want to check with your county and town. Below is a grid for individual states with links to relevant departments.

Table 4: Regulatory Departments by State in the North Central Region

STATE	AGRICULTURE	FOOD SAFETY	AQUACULTURE	USDA FARM SERVICE AGENCY
Illinois	A-Z License List	Dept of Agriculture Food Safety	Natural Resources Import Regulations	IL Farm Service
Iowa	Forms & Licensing	Produce Safety	Application for Aquaculture Import Regulations	IA Farm Service
Kansas	State Guide for Licensing		Import Regulations	KS Farm Service
Minnesota	Licenses & Inspections	Food Licenses	Aquatic Farm Licenses Import Regulations	MN Farm Service
Missouri	Forms & Licensing	Food Safety	Aquaculture Program Import Regulations	MO Farm Service
Nebraska	Licensing, Permits & Regulations	Produce Safety	Special Applications Import Regulations	NE Farm Service
North Dakota	Forms	Produce Safety	Import Regulations	ND Farm Service
South Dakota	Agriculture & Natural Resources	N/A	Import Regulations	SD Farm Service
Wisconsin	A-Z Licensing		Import Regulations	WI Farm Service

NORTHEAST

Zones 3a-8a: Connecticut, Delaware, Indiana, Kentucky, Maine, Maryland, Massachusetts, Michigan, New Hampshire, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, Vermont, Virginia, Washington DC, West Virginia

Systems

A main component of all aquaponic systems is the effective use of the water in the system, with the purpose of optimizing growth of fish and plants. Based on water flow, systems can be divided into two groups: coupled and decoupled. Coupled, or fully recirculating systems, recycle the water completely, with full water transfer from fish tanks to plant tanks and back. Decoupled systems transfer the water containing fish waste from the fish tank to the plants, without recirculating it back to the fish[13] In the Northeast, although both coupled and decoupled systems are used, 85 percent prefer coupled.

In this region, indoor or greenhouses are the most common overall structures. This environmental control can improve the productivity rate of the plants and fish[14] Other structures are used, as indicated in Table 5 below.

Table 5: Aquaponic Structures in the Northeast Region

STRUCTURE	PERCENTAGE OF FARMS
Greenhouse (with environmental control)	31.25
Indoor/Warehouse	15.63
Outdoors/Open Air	12.50
Shade House/Canopy	6.25
High Tunnel (no environmental control)	6.25
Other	9.38
Combination of Above	18.75

Plant Production

The plant types that are grown depend on climate, seasonality, growing environment, plant production and plant production systems. In the Northeast region, the most common plants are leafy greens, such as collards, bok choi, kale, and lettuce. Basil and other culinary herbs are also popular in the Northeast's aquaponic systems. Pumpkin, melons, tomatoes, and peppers are grown, but are not as popular. It is best to refer to the hardiness zone recommendations when choosing which produce to grow.

There are several types of substrates in which to grow produce. Table 6 illustrates the preferred substrates for each state. If your state is not listed, this indicates that no aquaponic farm within that state participated in our survey.

Table 6: Preferred Substrates for the Northeast Region

STATE	METAL	PLAS-TIC	PVC	RUBBER/ PLASTIC LINER	FIBER-GLASS	SOIL	WOOD	CONCRETE	POLYSTY-RENE	SOILLESS	SAND/ GRAVEL
Connecticut		x	x	x			x		x	x	
Delaware		x	x								
Kentucky	x	x	x	x	x	x	x		x	x	x
Maine		x	x		x					x	
Maryland			x	x				x	x		
Massachusetts		x	x							x	
Ohio		x		x		x	x		x		x
Pennsylvania		x	x	x							x
Virginia											
Washington, D.C.	x	x	x	x	x	x	x	x		x	x

Fish Production

The materials and design of the system ensure that the nutrients and water can be recycled, unlike most other aquaculture systems, such as those that use earthen ponds. Common fish tank materials include plastic, fiberglass, and concrete. In the Northeast, 57 percent used plastic, 36 percent used Fiberglass and seven percent used IBC Totes for the fish tanks. Most existing aquaponic systems are located within structures that have a level of environmental control, such as greenhouses.

Figure 8 illustrates the species farmed in the Northeast, while Figure 9 illustrates the selection criteria for the fish species grown.

Figure 8 Fish Species Farmed in the Northeast Region

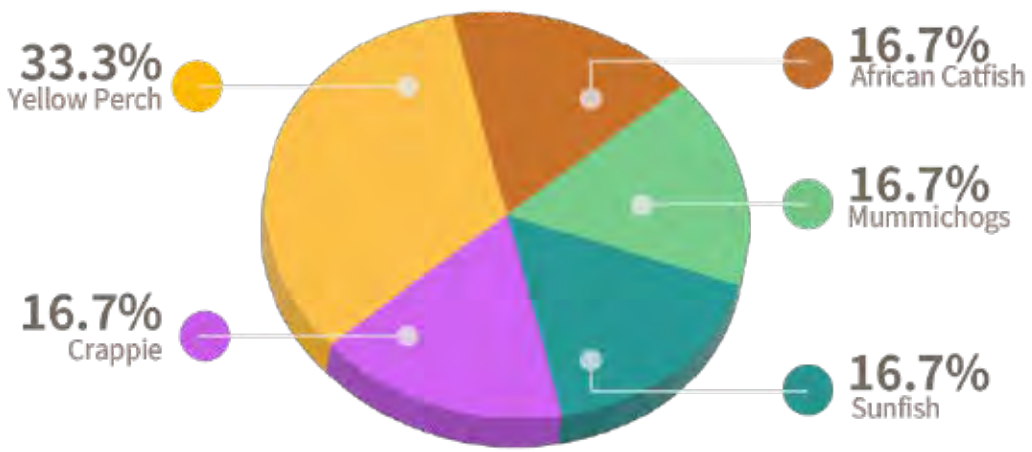
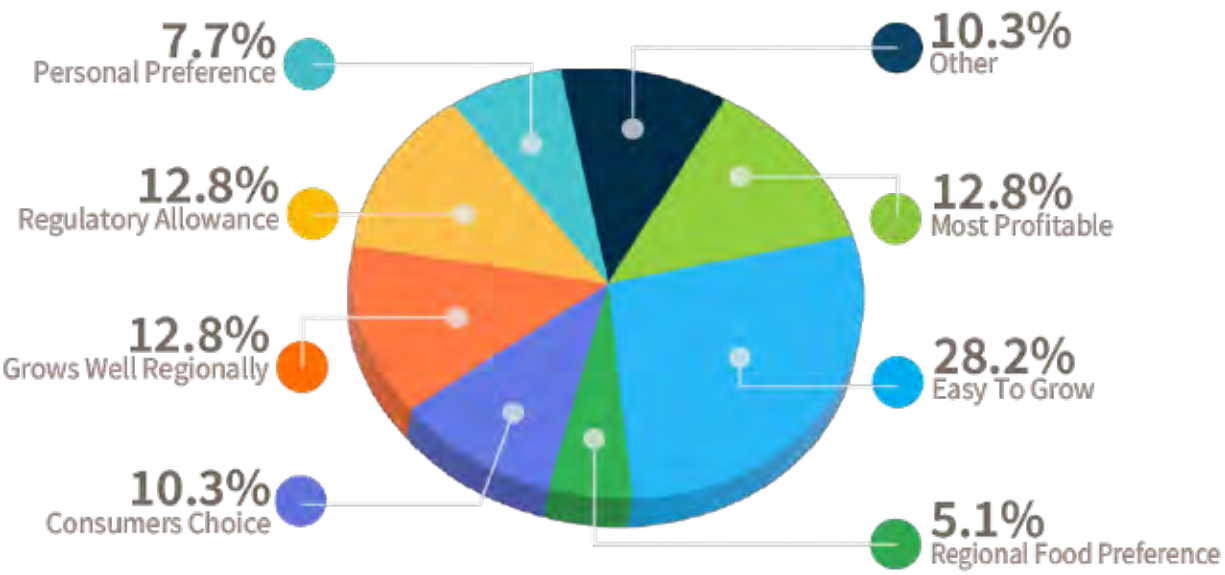


Figure 9 **Selection Criteria for Fish Species in the Northeast Region**



Costs

Initial startup costs are often daunting. Aquaponic producers spend the most money on buildings, vehicles, greenhouses/high tunnels, land, and construction labor. The majority of respondents in our 2020 survey indicated that they use personal funds to support their business, and only 27 percent received any government grant assistance. However, there are funding opportunities available through the specialty crop block grants, USDA Farm Service agencies, and your state agriculture department. Insurance has also proven to be an obstacle, especially in larger operations. Through the federal government, crop and livestock insurance is available.

Regulations

Many regulations and permits are at the state level, so you must check out your state's Department of Agriculture, Department of Natural Resources, and/or Department of Health. There may also be valuable information and links at the Northeast Regional Aquaculture Center. Here is a PDF link to important aquaculture information and which species are permitted to farm in each of the Northeast states. Some local ordinances may also exist, and you will want to check with your county and town. Below is a grid for individual states with links to relevant departments.

Table 7: Regulatory Departments by State in the Northeast Region

STATE	AGRICULTURE	FOOD SAFETY	AQUACULTURE	USDA FARM SERVICE AGENCY
Connecticut	Bureau of Regulatory Services		Bureau of Aquaculture	CT Farm Service
Delaware	Licenses & Permits	Food Safety	N/A	DE Farm Service
Indiana	Dept of Agriculture	Certification of Food Handling	Permits & Commercial Licensing Import Regulations	IN Farm Service
Kentucky	Licensing & Laws	Health & Family Services Food Safety	Import Regulations	KY Farm Service
Maine	Permits & Licenses		Aquaculture Lease Applications	ME Farm Service
Maryland	Licenses & Permits	Food Processing	Dept of Natural Resources	MD Farm Service
Massachusetts	Dept of Agriculture	Produce Safety	EPA Aquaculture Permit	MA Farm Service
Michigan	Licensing	Food Licensing, Certifications & Permits	Aquaculture Facility Registration Import Regulations	MI Farm Service
New Hampshire	Licenses	Food Safety Food Protection	Fish & Game EPA Aquaculture Permit	NH Farm Service
New Jersey	Forms & Registration	Public Health & Food Protection	NJ Aquaculture	NJ Farm Service
New York	Licenses, Permits & Registration		Aquaculture Permits	NY Farm Service
Ohio	Licenses	Produce Safety	Aquaculture Permits Import Regulations	OH Farm Service
Pennsylvania	Plant Industry	Food Safety	Aquaculture Licensing Import Regulations	PA Farm Service
Rhode Island	Division of Agriculture		Coastal Resources Management	RI Farm Service
Vermont	License Registration	Food Safety	Fish Division EPA Aquaculture Permit	VT Farm Service
Virginia	Ag & Consumer Services	Produce Safety	Aquaculture & marine Products	VI Farm Service
Washington DC	Permits, Licenses & Certifications			
West Virginia	Licenses	Produce Safety	Application for Fish Processing Import Regulations	WV Farm Service

FARMER SPOTLIGHT
YEMI AMU

Oko Farms, Brooklyn, NY

Q: When did you start farming?

A: I started farming in 2010 and discovered aquaponics in 2011.

Q: When did you start Oko Farms?

A: We built the Oko Farms Aquaponics Farming and Education Center in 2013. Our second farm site was built in 2021.

Q: What made you choose aquaponic systems?

A: I chose aquaponics farming because I was drawn to the ecosystem approach to farming that it facilitates. It is also a way of farming that is adaptable for the environment, conserves water, and provides a way to raise fish in a sustainable manner.

Q: What has been your biggest challenge?

A: My biggest challenge is learning how to practice aquaponics in a way that is truly ecological and utilizes minimal inputs.

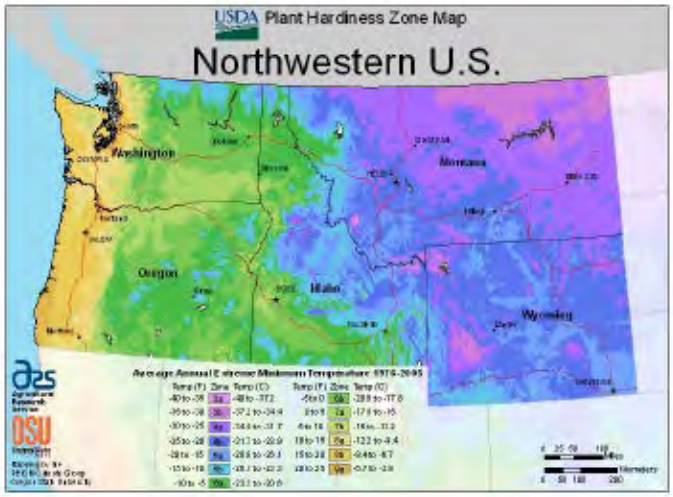
Q: What has been your biggest success?

A: My biggest success so far is being able to teach aquaponics farming to people in a way that is accessible, adaptable and intuitive.

Q: What advice would you give someone who is just starting?

A: My advice for anyone starting is to understand that the most productive aquaponics farmers have a good understanding of microbes. The same rules that apply to organic soil farming also apply to aquaponics. Microbes are your friend!

NORTHWEST



Zones 3a-9a: Idaho, Montana, Oregon, Washington, Wyoming

Systems

A main component of all aquaponic systems is the effective use of water in the system, with the purpose of optimizing growth of fish and plants. Based on water flow, systems can be divided into two groups: coupled and decoupled. Coupled, or fully recirculating systems, recycle the water completely, with full water transfer from fish tanks to plant tanks and back. Decoupled systems transfer the water containing fish waste from the fish tank to the plants, without recirculating back to the fish.[15] In the Northwest, coupled systems are preferred.

In this region, greenhouses (with environmental control), indoors/warehouse, and high tunnels (no environmental control) are all used equally in the operational structures. This environmental control can improve the productivity rate of the plants and fish.[16]

Plant Production

The plant type grown depend on climate, seasonality, growing environment, plant production and plant production systems. In the Northwest, a variety of plants are grown, including basil, culinary herbs, peppers, leafy greens, lettuce, strawberry, tomato and cucumber. It is best to refer to the hardiness zone recommendations when choosing which produce to grow.

There are several types of substrates to grow produce. Table 8 below illustrates the preferred substrates for each state. If your state is not listed, this indicates that no aquaponic farm within that state participated in our survey.

Table 8: Preferred Substrates for the Northwest Region

STATE	METAL	PLAS-TIC	PVC	RUBBER/ PLASTIC LINER	FIBER-GLASS	SOIL	WOOD	CONCRETE	POLYSTY-RENE	SOILLESS	SAND/ GRAVEL
Idaho				x			x				
Washington		x	x	x			x				x

Fish Production

The materials and design of the system ensure that the nutrients and water can be recycled, unlike most other aquaculture systems, such as those that use earthen ponds. Common fish tank materials include plastic, lined structure or IBC totes. Most existing aquaponic systems are located within structures that have a level of environmental control, such as greenhouses.

Figure 10 indicates the fish species farmed in the Northwest, while Figure 11 illustrates the selection criteria for the fish species grown.

Figure 10 **Fish Species Farmed in the Northwest Region**

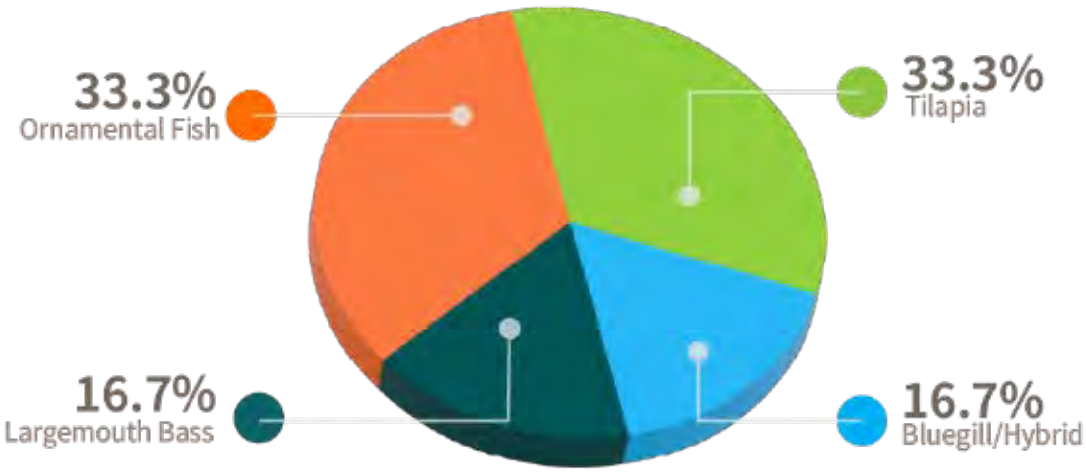
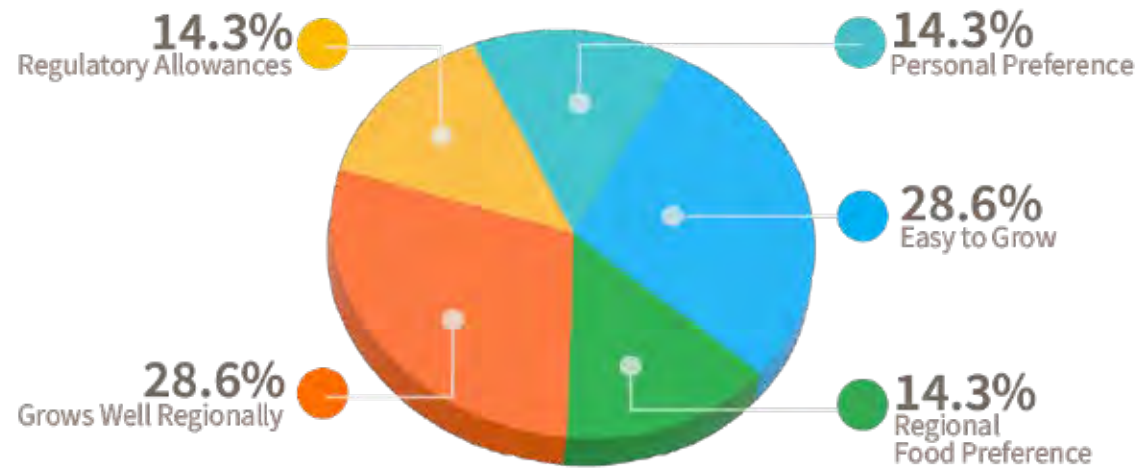


Figure 11 **Selection Criteria for Fish Species in the Northwest Region**



Costs

Initial startup costs are often daunting. Aquaponic producers spend the most money on buildings, vehicles, greenhouses/high tunnels, land, and construction labor. The majority of respondents in our 2020 survey indicated that they use personal funds to support their business, and only 27 percent received any government grant assistance. However, there are funding opportunities available through the specialty crop block grants, USDA Farm Service agencies, and your state agriculture department. Insurance has also proven to be an obstacle, especially in larger operations. Through the federal government, crop and livestock insurance is available.

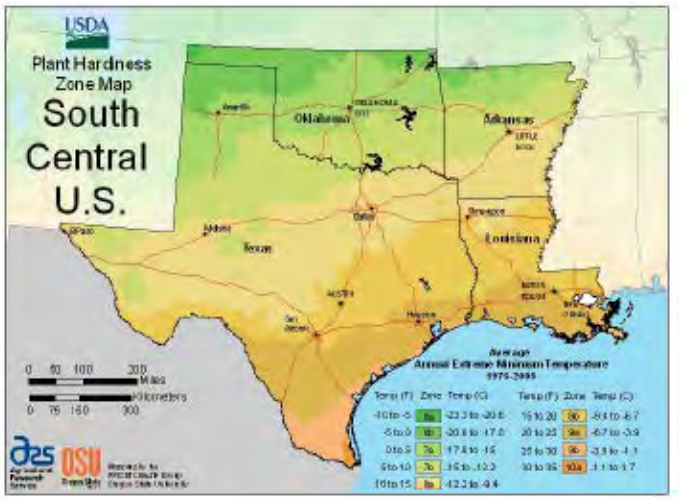
Regulations

Many regulations and permits are at the state level, so you must check out your state's Department of Agriculture, Department of Natural Resources, and/or Department of Health. Some local ordinances may also exist, and you will want to check with your county and town. Below is a grid for individual states with links to relevant departments.

Table 9: Regulatory Departments by State in the Northwest Region

STATE	AGRICULTURE	FOOD SAFETY	AQUACULTURE	USDA FARM SERVICE AGENCY
Idaho	Licensing & Registration	Food Safety	Commercial Fish Farms NPDES General Permits	ID Farm Service
Montana	Produce Program	Produce Safety Program	Import Regulations	MT Farm Service
Oregon	Dept of Agriculture Licenses	Food Safety	Aquaculture Guide	OR Farm Service
Washington	Licenses, Permits & Certificates	Food Safety	Upland Finfish Permit	WA Farm Service
Wyoming	Forms & Applications	Food Industry Guidance	Import Regulations	WY Farm Service

SOUTH CENTRAL



Zones 6a-10a: Arkansas, Louisiana, Oklahoma, Texas

Systems

A main component of all aquaponic systems is the effective use of water in the system, with the purpose of optimizing growth of fish and plants. Based on water flow, systems can be divided into two groups: coupled and decoupled. Coupled, or fully recirculating systems, recycle the water completely, with full water transfer from fish tanks to plant tanks and back. Decoupled systems transfer the water containing fish waste from the fish tank to the plants, without recirculating back to the fish.[17] In the South Central region, coupled systems are preferred.

In the South Central region, indoor or greenhouses are the most common overall structures. This environmental control can improve the productivity rate of the plants and fish.[18] All structures used are indicated in Table 10.

Table 10: Aquaponic Structures in the South Central Region

STRUCTURE	PERCENTAGE OF FARMS
Greenhouse (with environmental control)	31.25
Indoor / Warehouse	12.50
Outdoors / Open Air	12.50
Shade House / Canopy	6.25
High Tunnel (no environmental control)	12.50
Other	6.25
Combination	18.75

Plant Production

The plant types that are grown depend on climate, seasonality, growing environment, plant production and plant production systems. In the South Central region, a variety of plants are grown, including basil, chives/green onion, cucumber, culinary herbs, eggplant, pepper, leafy greens, lettuce, root crops, strawberry, tomato, and flowers. It is best to refer to the hardiness zone recommendations when choosing which produce to grow.

There are several types of substrates to grow produce. Only aquaponic operations in Texas responded to the substrates applied. The following is the list of the preferred substrates:

- Metal
- Plastic
- PVC
- Rubber / Plastic Liner
- Soil
- Wood
- Concrete
- Soilless
- Sand/Grave

Fish Production

The materials and design of the system ensure that the nutrients and water can be recycled, unlike most other aquaculture systems, such as those that use earthen ponds. Common fish tank materials include plastic, fiberglass, and concrete. In the South Central region, a variety of tank materials were used for various species, as illustrated in Table 11 and Figures 12 and 13.

Table 11: Tank Materials in the South Central Region

MATERIAL	PERCENTAGE OF FARMS
Plastic	37.50
Fiberglass	12.50
IBC Tote	12.50
Lined Structure	25.00
Other	12.50

Figure 12 Fish Species Farmed in the South Central Region

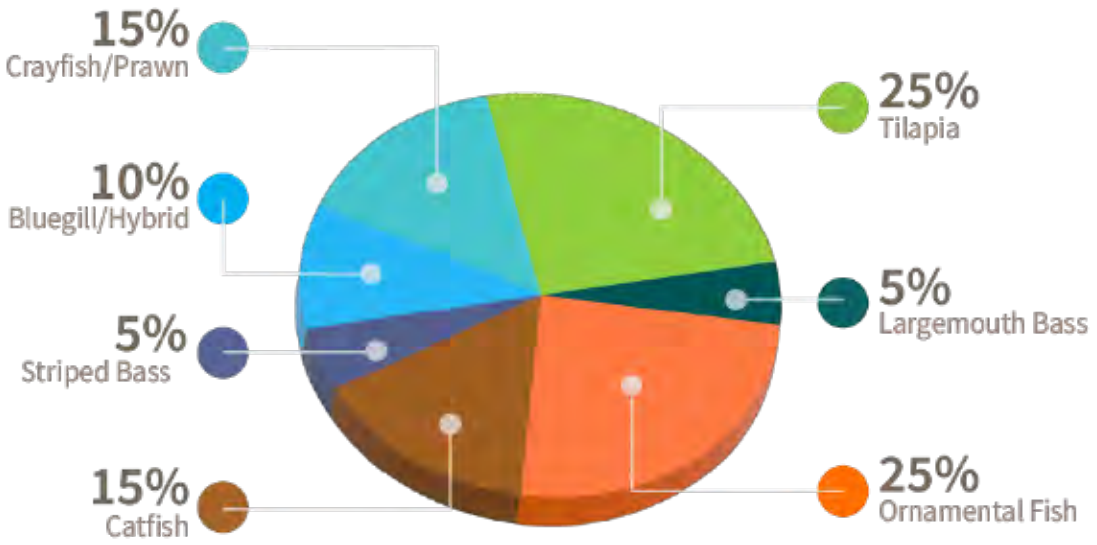
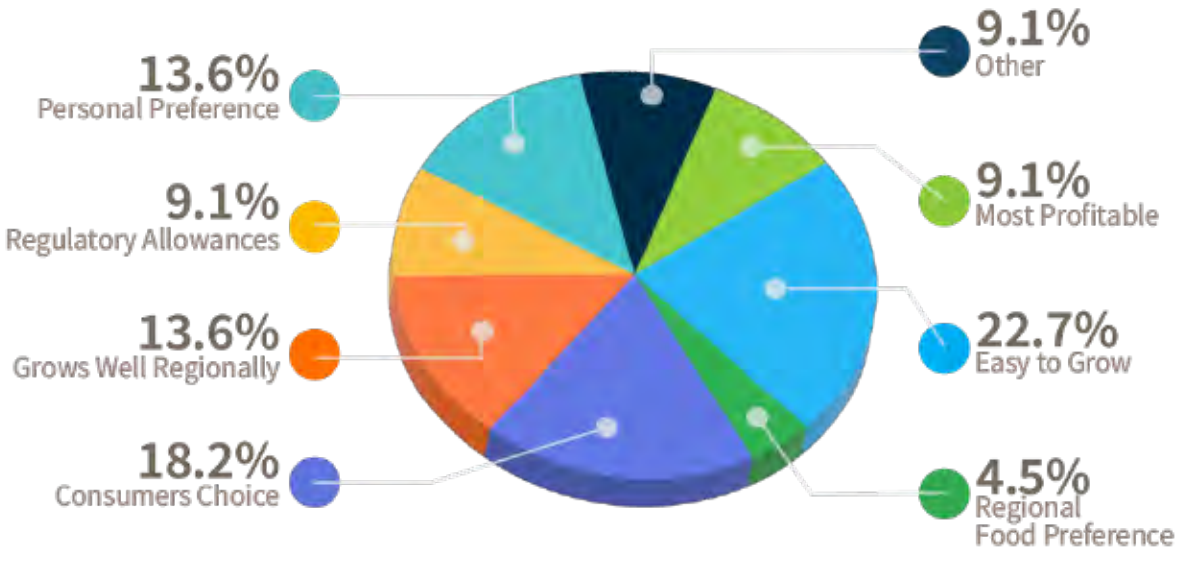


Figure 13 Selection Criteria for Fish Species in the South Central Region



Costs

Initial startup costs are often daunting. Aquaponic producers spend the most money on buildings, vehicles, greenhouses/high tunnels, land, and construction labor. The majority of respondents in our 2020 survey indicated that they use personal funds to support their business, and only 27 percent received any government grant assistance. However, there are funding opportunities available through the specialty crop block grants, USDA Farm Service agencies, and your state agriculture department. Insurance has also proven to be an obstacle, especially in larger operations. Through the federal government, crop and livestock insurance is available.

Regulations

Many regulations and permits are at the state level, so you must check out your state's Department of Agriculture, Department of Natural Resources, and/or Department of Health. Some local ordinances may also exist, and you will want to check with your county and town. Below is a grid for individual states with links to relevant departments.

Table 12: Regulatory Departments by State in the South Central Region

STATE	AGRICULTURE	FOOD SAFETY	AQUACULTURE	USDA FARM SERVICE AGENCY
Arkansas	Plant Industries	Produce Safety Program	Aquaculture Guidance Import Regulations	AR Farm Service
Louisiana	Licenses & Forms	Food Safety Guidance	N/A	LA Farm Service
Oklahoma	Licensing & Permits	Food Safety Guidance	Animal Programs Import Regulations	OK Farm Service
Texas	Licenses & Registrations	Produce Safety Rule	Aquaculture Guidance	TX Farm Service

SOUTHEAST

Zones 5b-11a: Alabama, Florida, Georgia, Mississippi, North Carolina, South Carolina, Tennessee

Systems

A main component of all aquaponic systems is the effective use of the water in the system, with the purpose of optimizing growth of fish and plants. Based on water flow, systems can be divided into two groups: coupled and decoupled. Coupled, or fully recirculating systems, recycle the water completely, with full water transfer from fish tanks to plant tanks and back. Decoupled systems transfer the water containing fish waste from the fish tank to the plants, without recirculating back to the fish.[19] In the Southeast, coupled systems are preferred.

In this region, greenhouses are the most common overall structures. This environmental control can improve the productivity rate of the plants and fish.[20] All structures used are in Table 13.

Table 13: Aquaponic Structures in the Southeast Region

STRUCTURE	PERCENTAGE OF FARMS
Greenhouse (with environmental control)	38
Indoor/Warehouse	8
Outdoors/Open Air	15
Shade House/Canopy	8
High Tunnel (no environmental control)	8
Combination	23

Plant Production

The plant types that are grown depend on climate, seasonality, growing environment, plant production and plant production systems. In the Southeast, a variety of plants are grown, including basil, chives/green onion, cucumber, culinary herbs, eggplant, flowers, pepper, leafy greens, lettuce, microgreens, root crops, strawberry, tomato, and others. It is best to refer to the hardiness zone recommendations when choosing which produce to grow.

There are several types of substrates to grow produce. Table 14 illustrates those substrates by state. If your state is not listed, this indicates that no aquaponic farm within that state participated in our survey.

Table 14: Preferred Substrates for the Southeast Region

STATE	METAL	PLAS-TIC	PVC	RUBBER/ PLASTIC LINER	FIBER-GLASS	SOIL	WOOD	CONCRETE	POLYSTY-RENE	SOILLESS	SAND/ GRAVEL
Alabama				x			x			x	
Florida	x	x	x	x					x	x	x
Georgia	x	x	x	x			x		x		
North Carolina		x	x	x	x			x	x	x	x

Fish Production

The materials and design of the system ensure that the nutrients and water can be recycled, unlike most other aquaculture systems, such as those that use earthen ponds. Common fish tank materials include plastic, fiberglass, and concrete. In the Southeast, the vast majority use plastic tanks. Most existing aquaponic systems are located within structures that have a level of environmental control, such as greenhouses.

Figure 14 illustrates the fish species farmed in the Southeast, while Figure 15 outlines the varieties used when choosing the species.

Figure 14 **Fish Species Farmed in the Southeast Region**

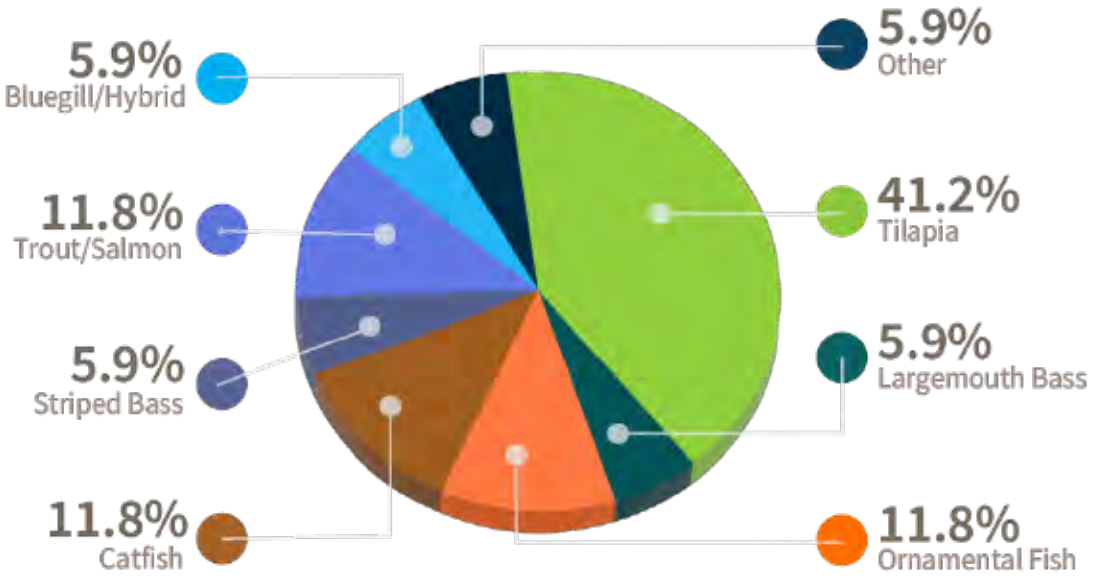
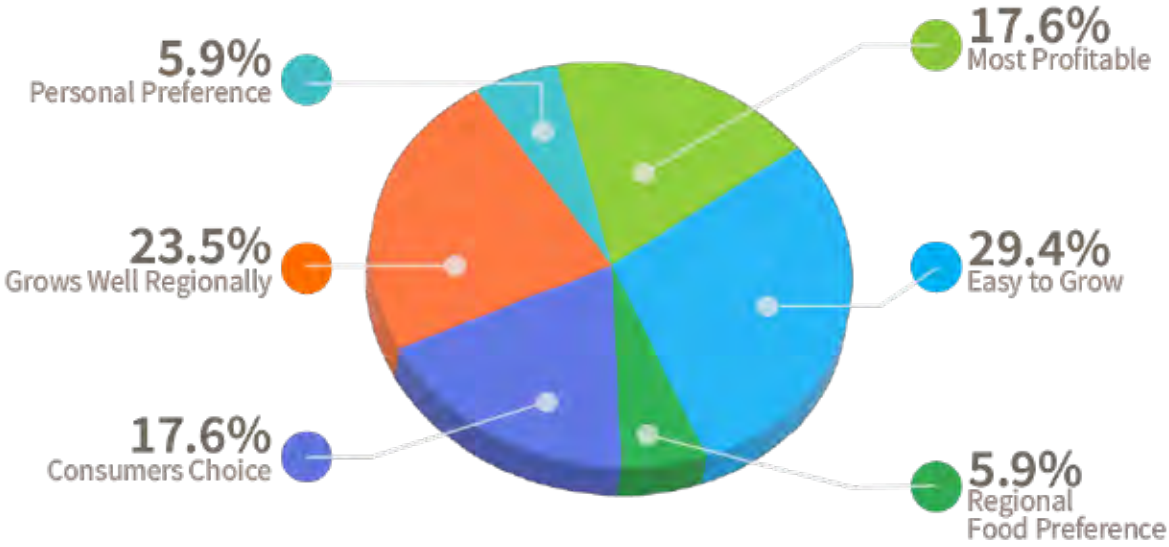


Figure 15 **Selection Criteria for Fish Species in the Southeast Region**



Costs

Initial costs are often daunting. Aquaponic producers spend the most money on buildings, vehicles, greenhouses/high tunnels, land, and construction labor. The majority of respondents in our 2020 survey indicated that they use personal funds to support their business, and only 27 percent received any government grant assistance. However, there are funding opportunities available through the specialty crop block grants, USDA Farm Service agencies, and your state agriculture department. Insurance has also proven to be an obstacle, especially in larger operations. Through the federal government, crop and livestock insurance is available.

Regulations

Many regulations and permits are at the state level, so you must check out your state's Department of Agriculture, Department of Natural Resources, and/or Department of Health. Some local ordinances may also exist, and you will want to check with your county and town. Below is a grid for individual states with links to relevant departments.

Table 15: Regulatory Departments by State in the Southeast Region

STATE	AGRICULTURE	FOOD SAFETY	AQUACULTURE	USDA FARM SERVICE AGENCY
Alabama	Agriculture Compliance	Food Safety Guidance	N/A	AL Farm Service
Florida	Agriculture Industry		Aquaculture Guidance	FL Farm Service
Georgia	Licensing	Food Safety Rules & Regulations	Aquaculture Regulations	GA Farm Service
Mississippi	Agriculture & Commerce Forms	Produce Safety Division	Aquaculture Regulatory Services	MS Farm Service
North Carolina	Licenses & Permits	Produce Safety Program	Aquaculture License	NC Farm Service
South Carolina	Agricultural Permits Forms	Food Safety Compliance	Aquaculture Programs	SC Farm Service
Tennessee	Payments, Licenses & Permits	Produce Safety	Import Regulations	TN Farm Service

FARMER SPOTLIGHT
TRACY NAZZARO

Traders Hill Farm, Hilliard, FL

Q: When did you start farming?

A: I came to Traders Hill in 2015.

Q: When did you start Traders Hill Farms?

A: R & D testing began in 2013. Commercial production began in July 2015.

Q: What made you choose aquaponic systems?

A: Water reuse! And, natural nitrogen source.

Q: What has been your biggest challenge?

A: I have had many challenges:

- Horticulture knowledge / experience – It is difficult to find staff with horticulture experience, particularly in Northeast Florida. Most "growers" or horticulture science experts are older (over 55 in age) and their background is in traditional agriculture. As a major in universities the Horticulture Science track is becoming more popular, but the students graduating do not have real world experience. Therefore, the knowledge gap is quite large.
- System Design – There is no blueprint for a commercial aquaponics system on the scale we operate. It has been a challenge to "learn as we go" and redesign for our needs.

- Industry Standards / KPIs (Key Performance Indicators) – The commercial greenhouse industry (both hydroponic and aquaponic) is both new and highly competitive. There are no published benchmarks to help a grower know if they are on track.
- Sales / Market Acceptance – The sales cycle for retail is long, often nine months to one year. A grower must first distribute DSD (direct store delivery) before a retailer will entertain a larger contract via their DC (distribution center). Once a grower is at that point then he must be able to ship consistent volume. Food service sales require a sales process that is very hands on throughout the lifecycle of the relationship. Wholesalers require the grower to participate actively in the sales process with them. Again, very time consuming.
- Staffing – Locating qualified staff has historically been a challenge. Additionally, pay rates for upper level staff have increased exponentially as cannabis growers in the US will pay higher salaries than what has been traditionally warranted. In 2021, we see staffing challenges at all levels. Currently, we have two entry level staff positions open and one management level staff. Unfortunately, the labor pool is small and local companies are willing to increase the hourly rate often by 50 percent to increase staffing.
- Funding – Starting a business is an expensive endeavor. The capital costs to build a greenhouse continues to increase with the price of materials. Returns in agriculture are historically small (~ 6 percent EBITDA), making it a challenge to raise investment capital.

Q: What has been your biggest success?

A: Beautiful green romaine head lettuce

Q: What advice would you give someone who is just starting?

A: Several bits of advice:

- Food Safety First – invest in a strict food safety scheme, maintain strict protocols and live it through your company culture.
- Network, network, network – make full utilization of resources available from universities. Also, other growers are often a source of knowledge.
- Whatever you think it will cost to build and operate your enterprise it is best to double your estimate.
- Buyers will only pay a very slight premium for the greenhouse grown product. Growers are benchmarked against traditional growers and that price point.

SOUTHWEST

Zones 3b-11a: Arizona, California, Colorado, Nevada, New Mexico, Utah

Systems

A main component of all aquaponic systems is the effective use of the water in the system, with the purpose of optimizing growth of fish and plants. Based on water flow, systems can be divided into two groups: coupled and decoupled. Coupled, or fully recirculating systems, recycle the water completely, with full water transfer from fish tanks to plant tanks and back. Decoupled systems transfer the water containing fish waste from the fish tank to the plants, without recirculating back to the fish.[21] In the Southwest, all aquaponic operations utilize coupled systems. In this region, indoor or greenhouses are the most common overall structures. This environmental control can improve the productivity rate of the plants and fish.[22]

Plant Production

The plant types that are grown depend on climate, seasonality, growing environment, plant production and plant production systems. In the Southwest, a variety of plants are grown, including basil, cucumber, culinary herbs, eggplant, leafy greens, lettuce, microgreens, pepper, strawberry, tomato. It is best to refer to the hardiness zone recommendations when choosing which produce to grow.

There are several types of substrates to grow produce. Table 16 illustrates the preferred substrates by state. If your state is not listed, this indicates that no aquaponic farm within that state participated in our survey.

Table 16: Preferred Substrates by State

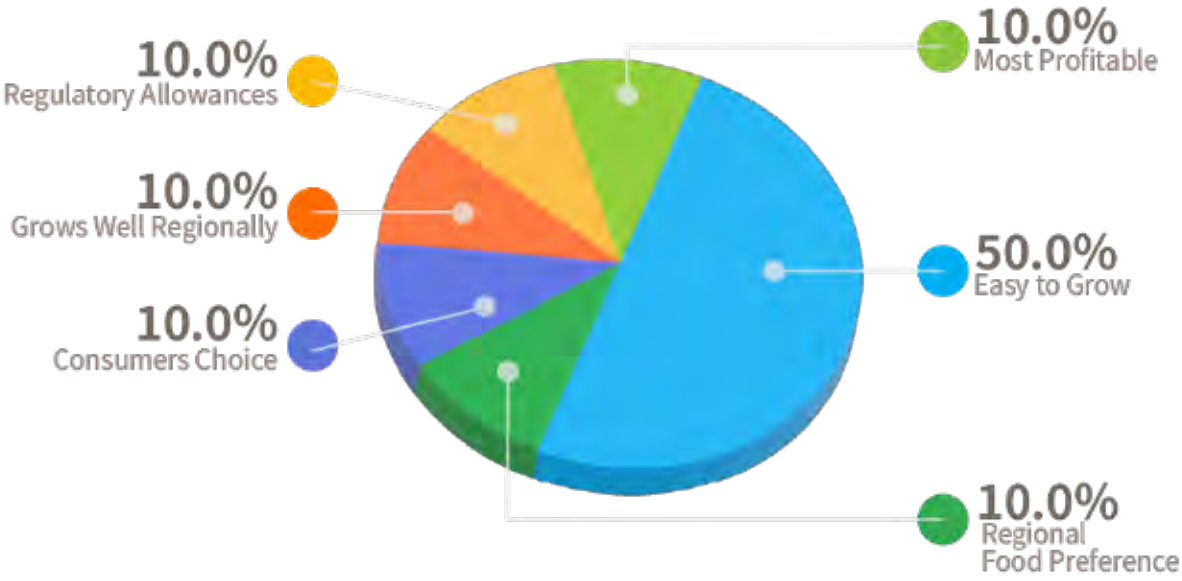
STATE	METAL	PLAS-TIC	PVC	RUBBER/ PLASTIC LINER	FIBER-GLASS	SOIL	WOOD	CONCRETE	POLYSTY-RENE	SOILLESS	SAND/ GRAVEL
California			x		x					x	
Colorado			x	x			x		x		
Nevada	x	x	x							x	x
New Mexico	x	x	x	x					x		x

Fish Production

The materials and design of the system ensure that the nutrients and water can be recycled, unlike most other aquaculture systems, such as those that use earthen ponds. Common fish tank materials include plastic, fiberglass, and concrete. In the Southwest, plastic tanks were preferred. Most existing aquaponic systems are located within structures that have a level of environmental control, such as greenhouses. Figure 16 illustrates the fish species grown in the Southwest, and Figure 17 provides the selection criteria for those species.

Figure 16 **Fish Species Farmed in the Southwest Region**

Figure 17 **Selection Criteria for Fish Species in the Southwest Region**



Costs

Initial startup costs are often daunting. Aquaponic producers spend the most money on buildings, vehicles, greenhouses/high tunnels, land, and construction labor. The majority of respondents in our 2020 survey indicated that they use personal funds to support their business, and only 27% received any government grant assistance. However, there are funding opportunities available through the specialty crop block grants, USDA Farm Service agencies, and your state agriculture department. Insurance has also proven to be an obstacle, especially in larger operations. Through the federal government, crop and livestock insurance is available.

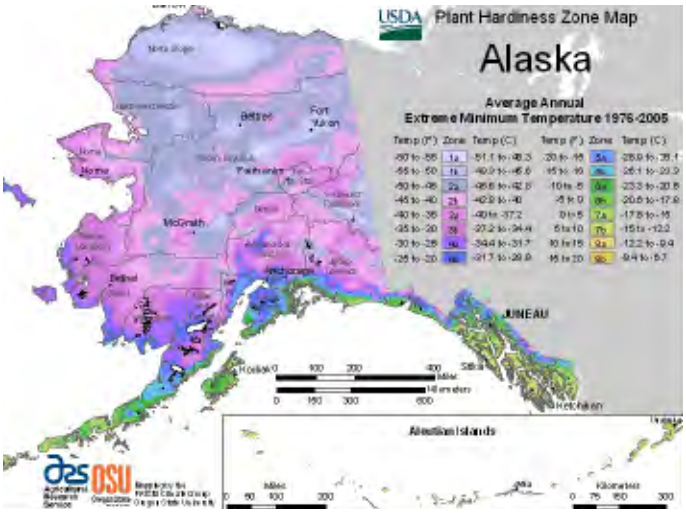
Regulations

Many regulations and permits are at the state level, so you must check out your state's Department of Agriculture, Department of Natural Resources, and/or Department of Health. Some local ordinances may also exist, and you will want to check with your county and town. Below is a grid for individual states with links to relevant departments.

Table 17: Regulatory Departments by State in the Southwest Region

STATE	AGRICULTURE	FOOD SAFETY	AQUACULTURE	USDA FARM SERVICE AGENCY
Arizona	Licensing & Payments	Food Safety Guidance	Downloadable Forms	AZ Farm Service
California	Regulations Activities	Food Safety Guidance	Aquaculture Registration	CA Farm Service
Colorado	Agriculture Licensing	Food Safety Resources	Import Regulations	CO Farm Service
Nevada	Division of Plant Health & Compliance		N/A	NV Farm Service
New Mexico	Forms & Applications	Food Safety Resources	Aquaculture Permit Information	NM Farm Service
Utah	Licenses & Permits	Produce Safety Program	Aquaculture (Fish Health)	UT Farm Service

ALASKA



Our survey did not include any aquaponic farmers from Alaska, so we provide you with overall recommendations, rather than any based on current operations.

Systems

A main component of all aquaponic systems is the effective use of water in the system, with the purpose of optimizing growth of fish and plants. Based on water flow, systems can be divided into two groups: coupled and decoupled. Coupled, or fully recirculating systems, recycle the water completely, with full water transfer from fish tanks to plant tanks and back. Decoupled systems transfer the water containing fish waste from the fish tank to the plants, without recirculating back to the fish.[23] In this region, indoor or greenhouses are the most common overall structures. This environmental control can improve the productivity rate of the plants and fish.[24]

Plant Production

The plant types that are grown depend on climate, seasonality, growing environment, plant production and plant production systems. It is best to refer to the Hardiness Map when determining which produce to grow.

There are several types of substrates to grow produce, as follows:

- Metal
- Plastic
- PVC
- Rubber/Plastic Liner
- Fiberglass
- Soil
- Wood
- Concrete
- Polystyrene
- Soilless

Fish Production

The materials and design of the system ensure that the nutrients and water can be recycled, unlike most other aquaculture systems, such as those that use earthen ponds. Common fish tank materials include plastic, fiberglass, and concrete. Most existing aquaponic systems are located within structures that have a level of environmental control, such as greenhouses.

Costs

Initial startup costs are often daunting. Aquaponic producers spend the most money on buildings, vehicles, greenhouses/high tunnels, land, and construction labor. The majority of respondents in our 2020 survey indicated that they use personal funds to support their business, and only 27 percent received any government grant assistance. However, there are funding opportunities available through the specialty crop block grants, USDA Farm Service agencies, and your state agriculture department. Insurance has also proven to be an obstacle, especially in larger operations. Through the federal government, crop and livestock insurance is available.

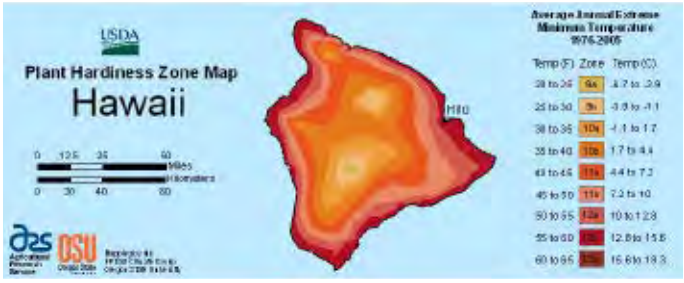
Regulations

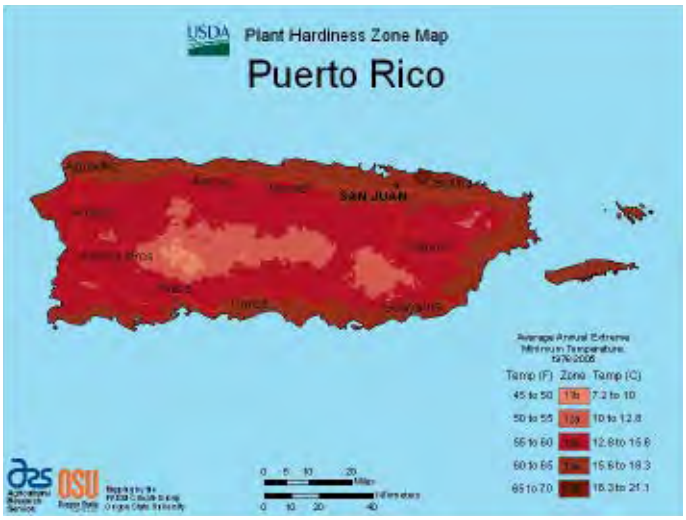
In Alaska, it is illegal to farm finfish for human consumption. Many regulations and permits are at the state level, so you must check out your state's Department of Agriculture, Department of Natural Resources, and/or Department of Health. Some local ordinances may also exist, and you will want to check with your county and town. Below is a grid for individual states with links to relevant departments.

Table 18: Regulatory Departments in Alaska

STATE	AGRICULTURE	FOOD SAFETY	AQUACULTURE	USDA FARM SERVICE AGENCY
Alaska	Division of Agriculture		Aquatic Farming Permits	AK Farm Service

HAWAII & PUERTO RICO





Zones 12 and 13

Systems

A main component of all aquaponic systems is the effective use of water in the system, with the purpose of optimizing growth of fish and plants. Based on water flow, systems can be divided into two groups: coupled and decoupled. Coupled, or fully recirculating systems, recycle the water completely, with full water transfer from fish tanks to plant tanks and back. Decoupled systems transfer the water containing fish waste from the fish tank to the plants, without recirculating back to the fish.[25] In Hawaii, all aquaponic operations utilize coupled systems.

In this region, indoor or greenhouses are the most common overall structures. In Hawaii, either indoor/warehouses or shade houses / canopy are operational structures utilized. This environmental control can improve the productivity rate of the plants and fish.[26]

Plant Production

The plant types that are grown depend on climate, seasonality, growing environment, plant production and plant production systems. In Hawaii, a variety of plants are grown, including basil, chives/green onion, cucumber, hemp/cannabis, leafy greens, lettuce, microgreens, and tomato. It is best to refer to the hardiness zone recommendations when choosing which produce to grow.

There are several types of substrates to grow produce. Below are the preferred substrates:

Concrete, Plastic, Polystyrene (Styrofoam), PVC, Rubber/Plastic Liner, Soilless Media, Wood, Fiberglass, Metal, and Plastic.

Fish Production

The materials and design of the system ensure that the nutrients and water can be recycled, unlike most other aquaculture systems, such as those that use earthen ponds. Common fish tank materials include plastic, fiberglass, and concrete. In Hawaii, the most popular is plastic. Most existing aquaponic systems are located within structures that have a level of environmental control, such as greenhouses.

Only aquaponic operators in Hawaii responded. They all grow Tilapia, because of regulatory allowances and because they are easy to grow.

Costs

Initial startup costs are often daunting. Aquaponic producers spend the most money on buildings, vehicles, greenhouses/high tunnels, land, and construction labor. The majority of respondents in our 2020 survey indicated that they use personal funds to support their business, and only 27 percent received any government grant assistance. However, there are funding opportunities available through the specialty crop block grants, USDA Farm Service agencies, and your state agriculture department. Insurance has also proven to be an obstacle, especially in larger operations. Through the federal government, crop and livestock insurance is available.

Regulations

Many regulations and permits are at the state level, so you must check out your state's Department of Agriculture, Department of Natural Resources, and/or Department of Health. Some local ordinances may also exist, and you will want to check with your county and town. Below is a grid for individual states with links to relevant departments.

Table 19: Regulatory Departments in Hawaii & Puerto Rico

STATE	AGRICULTURE	FOOD SAFETY	AQUACULTURE	USDA FARM SERVICE AGENCY
Hawaii	Agriculture Forms Application for Farm Produce On Farm Food Safety		Animal Industry Division: Aquaculture	HI Farm Service
Puerto Rico	Documents	Dept of Agriculture		PR Farm Service

CONCLUSION

The Regional Best Practices provide the necessary support and guidance for aquaponic ventures to launch into thriving businesses. This roadmap and recommendations are based on real life experiences, encouraging farmer to farmer education in the hopes that this approach continues well beyond the reading of this report. Every region holds its own unique ecosystems, opportunities and challenges, from hardiness zones to cultural preferences to particular architectures to regulatory guidelines.

We hope that you have now gained an understanding of the overall structures, operations, markets, economics, successes, and challenges in this industry within your region. With this knowledge, we can all develop local food economies to support all members of our communities, from producers to consumers and pass on the knowledge you have learned to the next aquaponic farmer.

ADDITIONAL RESOURCES

- **DIY Manuals** — A series of papers and manuals that will help you set up your own aquaponics system.
- **About Design Types** — Examples of some of the design types that can be used when setting up your own aquaponic system.
- **Build Your Own System** — Basic instructions on the equipment needed and how to set up a starter system that will grow tomatoes.
- **Which Fish Are Easiest To Raise** — Brief description of some of the more common, cold-water fish raised using aquaculture.
- **Which Plants Are Easiest To Grow** — A list of some of the plants that will grow best in your aquaponic system.
- **Community-Supported Wiki** — From the Urban Farming Guys. Provides DIY system plans as well as other tips on raising certain types of fish and produce.

ENDNOTES

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